Mesopotamia Journal of Agriculture

https://magrj.mosuljournals.com

CLIMATE CHANGE: CONSEQUENCES ON IRAQ'S ENVIRONMENT

Walid Nosir
Horticulture Department, Faculty of Agriculture, Zagazig University, Egypt

Article information
Article history:
Received:8/3/2023
Accepted:9/5/2023
Available:30/6/2023

Keywords:
level rise, water scarcities, drought, sand storms.

DOI:
https://doi.org/10.33899/magrj.2023.140391.1243

Correspondence Email:
w.nosir@gmail.com

ABSTRACT

Iraq is currently experiencing climate change impacts that are comparable to or even worse than those of many other nations. The effects of these climate changes are being felt in the form of global warming, changes to the elements that drive weather, and sea level rise. Iraq is experiencing water stress due to rising temperatures, declining precipitation rates, altered distribution patterns, and rising evaporation. However, they initiate a chain reaction of other changes, such as droughts, desertification, and sandstorms. The southern portion of the Tigris-Euphrates basin is threatened by flooding, and Iraq's ports and coastline are at risk due to the predicted rise in sea level. So far, the agricultural sector in Iraq has been severely impacted by the decreased water availability for arable lands. These discharges have already been exacerbated by the unequal distribution of water resources by Turkey, the primary source of water for the two rivers. All previous projections and studies indicate that the current negative climate change trends are likely to continue into the foreseeable future. Loss of cultivable land to desertification, recurrent droughts and sandstorms, and declining agriculture are the pattern of change in Iraq's already fragile environment; and this will inevitably lead to much more suffering for the population and social unrest in the future. These will contribute to the enormous pressures that all future governments will face if the government does not implement protective planning and solutions.

College of Agriculture and Forestry, University of Mosul.

INTRODUCTION

Geographically, Iraq is situated in the East Mediterranean region. It is bordered by Turkey to the north, Iran to the east and northeast, Syria and Jordan to the west, and Saudi Arabia, Kuwait, and the arabian Gulf to the south. (Figure 1). This geographical location, coupled with Iraq's diverse surface topography, carries with it numerous weather elements that are displaying varying degrees of variation as a result of the current Global Climate Change Chenoweth *et al*. (2011).

Countries and communities across the globe are already experiencing the intensified effects of climate change, such as rising temperatures, droughts, floods, shortages, more intense and frequent natural disasters, and sea-level rise.

The hardest affected are the most vulnerable nations among these. Iraq is one of these nations contending with significant and interconnected environmental, security, political, and economic challenges; the effects of climate change are likely to exacerbate the severity of these problems. The agricultural sector of Iraq has been harmed by rising temperatures, intense droughts, declining precipitation, desertification, salinization, and an increase in the frequency of dust storms. In

addition, Iraq's water security relies on two rivers in decline: the Tigris and the Euphrates. National and regional political unpredictability will make it very difficult to mitigate the effects of climate change and address transnational water management. USAID (2017) predicts that climatic changes such as rising temperatures, decreased precipitation, and expanding water scarcity will have long-term negative effects on Iraq. These modifications and their effects are discussed in greater depth in the following paragraphs.

Figure (1): Map of Iraq

Water Scarcities

The effects of global warming on climate change have impacted various weather determinants not only in Iraq but also in adjacent countries. The alterations encompass a rise in temperature, fluctuations in atmospheric pressure, intensities of precipitation, and their distribution in time and space. These factors have collectively impacted the annual stream flow volumes of the Tigris and Euphrates Rivers. Research conducted using models suggests that the aforementioned adverse patterns are expected to endure until the conclusion of the present century. Moreover, if greenhouse gas (GHG) emissions, encompassing CO2, persist at their current levels, the situation may worsen. The aforementioned models suggest that storm activity in the Eastern Mediterranean Region is a constituent of the North Atlantic Oscillation (NAO) pattern and is expected to diminish in the event of continued global warming throughout the 21st century. As per Adamo *et al*. (2018), a significant reduction in precipitation ranging from 15% to 25% is expected to occur in a vast area encompassing parts of Turkey, Syria, northern Iraq, and north-eastern Iran. This region also includes the crucial headwaters of the Euphrates and Tigris rivers.

Subsequent inquiries have demonstrated concerning reductions in rainfall throughout the various basins of the Tigris River's tributaries in Iraq. Furthermore, the aforementioned studies have demonstrated a reduction in precipitation during the time periods of 1980-1990, 1990-2000, and 2000-2010. This decline exhibited a spatial trend that decreased from upstream to downstream and from east to west within the basin. The topography of the northern and northeastern regions of the basin is characterized by mountainous terrain, which results in elevated levels of precipitation and snowfall. Conversely, the southern and western areas of the basin are relatively flat and experience lower levels of precipitation. Based on future

projections, it is anticipated that the Khabour River basin will experience a reduction in mean annual precipitation of 7% during the period spanning from 2046 to 2064, and a further decrease of 15% from 2080 to 2100, under the optimistic emission scenario (B1). According to the pessimistic emission scenario (A2), it is projected that reductions of 18% and 38% will occur during the same two time periods. According to the (B1) and (A2) scenarios, the Diyala River basin is expected to undergo precipitation reductions of 17% and 26% and 40% in two future periods. According to Adamo *et al*. (2018), the anticipated future scenarios and time periods will result in comparable reductions in the basins of the Greater Zab, Lesser Zab, and Al-Adhaim Rivers.

At present, the phenomenon of climate change is affecting the stream volumes of the Tigris and Euphrates rivers. The reduction in the natural stream flow of these rivers can be attributed to the impact of climatic variations on their watersheds, which are situated beyond the territorial boundaries of Iraq. In contemporary times, the situation has been further compounded by the escalating water withdrawals in adjacent nations, specifically Turkey, Iran, and to a lesser degree, Syria. As per the Iraqi Ministry of Water Resources, Figure (2) illustrates the countries in the vicinity that contribute to the water supply of the two rivers. Projections and assessments of the future regional water resources, with a focus on the Tigris and Euphrates, indicate a dire situation due to the anticipated impacts of Climate Change. Chenoweth and colleagues (2011) conducted a study.

The study conducted by Chenoweth and colleagues (2011) examined the potential impacts on water resources in the Eastern Mediterranean and Middle East regions. The findings revealed that there is a likelihood of a reduction in the average annual discharges of the Euphrates and Tigris Rivers by 9.5% within the period of 2040 to 2069. Additionally, the study indicated that the maximum decline in the discharges could be up to 12.0%. According to Kitoh *et al*. (2008), a study has projected a potential decline in the yearly discharge of the Euphrates River ranging from 29% to 73%. The escalating utilization of fertilizers and the unprocessed release of industrial effluent, domestic waste, and sewage have resulted in the ongoing pollution and salinization of the two rivers, thereby exacerbating the pressure on these vital resources.

The region is experiencing a growing scarcity of water resources, with Iraq being particularly affected. This can be attributed to the unchecked impacts of climate change and ongoing human exploitation.

Desertification, Drought, And Sand Storms

Decreased precipitation is one of the major factors that concurrently defines and exacerbates desertification. Climate change exacerbates desertification by altering spatial and temporal rainfall patterns. Changes in the land's vegetative cover occur as a consequence of varying amounts of dry years or seasons, resulting in very long drought periods. The rise in temperature as a result of climate change alters the soil's properties and processes, such as organic matter decomposition, greater leaching losses, decreased soil water, and degradation as a result of decreased soil moisture, as well as soil erosion in certain regions due to heavy rainfall and increased wind speed (IPCC, 2007). a. Climate change also accelerates desertification by

altering the regional water resource system's regime by upsetting the equilibrium between water outflow and inflow as a result of fluctuating precipitation amounts and rising temperatures, which increase evaporation and evapotranspiration. In recent years, the fact that Climate Changes Impact are causing droughts and increased desertification in what is known as the "Fertile Crescent" (Figure 3) in Iraq and Syria has become quite evident. Significant research utilizing a super-high-resolution atmospheric global climate model to reproduce the precipitation and stream-flow of the present-day "Fertile Crescent" and projecting the current trends in climate change on Middle East water resources until the end of the current century revealed significant reductions in the annual discharges of the region's rivers. As reported by Kitoh *et al*. (2008), the annual discharge of the Euphrates River and Jordan River could be reduced by (29 to 73)%, respectively. In the greater context of the Middle East, the study revealed that by the end of this century, the "Fertile Crescent" will lose its current form and may vanish entirely.

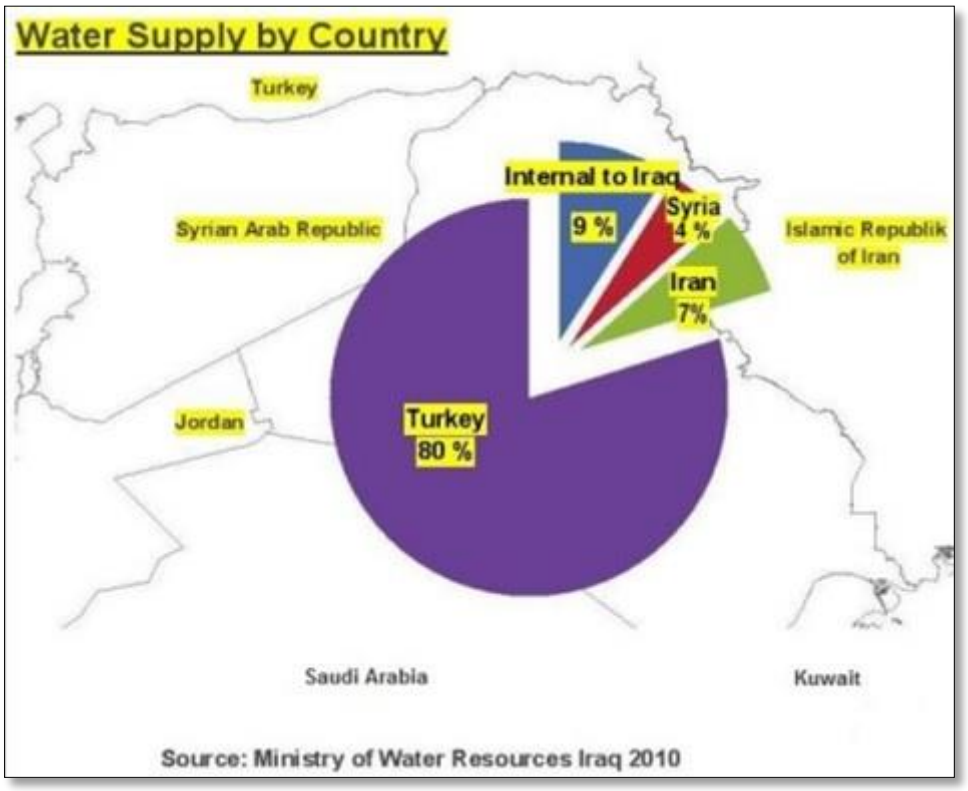

Figure (2): Water supply by country to Tigris and Euphrates water resources

The area illustrated in Figure (3) underwent a severe drought during the period of 2007-2008, which is considered to be one of the most catastrophic droughts in several years. This phenomenon is attributed to climate change by scientific experts. The prevalent drought had a significant impact on a vast area of Syria and northern Iraq, occurring during the period of highest precipitation. The region situated in the eastern part of Turkey, encompassing the origins of the Tigris and Euphrates rivers, experienced a precipitation and snowfall level that was below fifty percent of the mean value. The Mediterranean and Middle East Region is experiencing a persistent drought due to the effects of global warming, as noted by Holthaus (2014). According to Sivakumar (2007), the consequences of climate change will lead to the reduction of lake sizes, depletion of wetland regions, and modifications to the local ecosystem. The aforementioned trend has the potential to obstruct and undermine ongoing

endeavors aimed at rehabilitating the wetlands situated in the southern region of Iraq, and could ultimately culminate in their desiccation.

According to Schwartzstien (2015), due to the adverse impacts of inadequate precipitation and ineffective irrigation techniques in Iraq, experts in environmental studies anticipate that the marshlands will persist at a significantly reduced scale, or potentially vanish altogether. The impact of global warming on Iraq was documented in a report published by the United Nations Development Program (UNDP) in 2009. The report brought to attention the acute droughts that Iraq had experienced, along with the reduction in precipitation across the Tigris and Euphrates basins in the period of 5-10 years prior to the report. The levels of precipitation during this period were noted to be only 25-65% of the normal levels. The present investigation provides evidence that the principal driver of global warming and fluctuations in the North Atlantic Oscillation (NAO) is the impact of climate change (UNDP, 2009). According to the aforementioned study, the aforementioned alterations are anticipated to heighten the probability of substantial dust storms due to the depletion of soil moisture and vegetation coverage. Furthermore, it is projected that the consequences will intensify progressively, culminating in a further degradation of the physical and chemical attributes of the soil in both cultivable and non-cultivable areas in Iraq.

Subsequent inquiries have indicated significant reductions in rainfall throughout the various basins of the Tigris River in Iraq. Furthermore, the aforementioned studies have demonstrated a reduction in precipitation during the time periods of 1980-1990, 1990-2000, and 2000-2010. This decrease in precipitation exhibited a spatial trend that decreased from upstream to downstream and from east to west within the basin. The topography of the northern and northeastern regions of the basin is characterized by mountainous terrain, which results in elevated levels of precipitation and snowfall. Conversely, the southern and western regions of the basin are relatively flat and experience lower levels of precipitation. Based on future projections, it is anticipated that the Khabour River basin will experience a reduction in mean annual precipitation of 7% between 2046 and 2064, and a further decrease of 15% between 2080 and 2100, under the optimistic emission scenario (B1). According to the pessimistic emission scenario (A2), it is estimated that reductions of 18% and 38% will occur during the same two time periods. According to the (B1) and (A2) scenarios, the Diyala River basin is projected to undergo a decrease in precipitation of 17% and 26% and 40% in two future periods. According to Adamo *et al*. (2018), the future scenarios and time periods will result in equivalent reductions in the basins of the Greater Zab, Lesser Zab, and Al-Adhaim Rivers.

At present, the phenomenon of climate change is affecting the stream volumes of the Tigris and Euphrates rivers. The reduction in the natural stream flow of these rivers can be attributed to their external origins and the impact of similar climatic fluctuations on their respective watersheds. In recent decades, the situation has been aggravated by the escalating water withdrawals in neighboring countries such as Turkey, Iran, and to a lesser extent, Syria. This trend continues to persist. As per the Iraqi Ministry of Water Resources, Figure (2) illustrates the countries in proximity that provide water supply to the two rivers. Projections and assessments of regional water resources in light of the anticipated effects of Climate Change, with particular

emphasis on the Tigris and Euphrates rivers, have revealed a concerning outlook. Chenoweth and colleagues (2011) conducted a study.

The study conducted by Chenoweth and colleagues (2011) examined the potential impacts on water resources in the Eastern Mediterranean and Middle East regions. The findings revealed that the mean yearly discharges of the Euphrates and Tigris Rivers may experience a reduction of 9.5% during the period of 2040 to 2069, with a maximum decline of 12.0%. According to Kitoh *et al*. (2008), a study has projected a potential decline in the yearly discharge of the Euphrates River ranging from 29% to 73%. The escalating utilization of fertilizers and the unprocessed release of industrial effluent, domestic waste, and sewage have resulted in the ongoing contamination and salinization of the two rivers, thereby exacerbating the pressure on these vital resources.

The region is experiencing a growing scarcity of water, with Iraq being particularly affected. This can be attributed to the unchecked impacts of climate change and ongoing human exploitation.

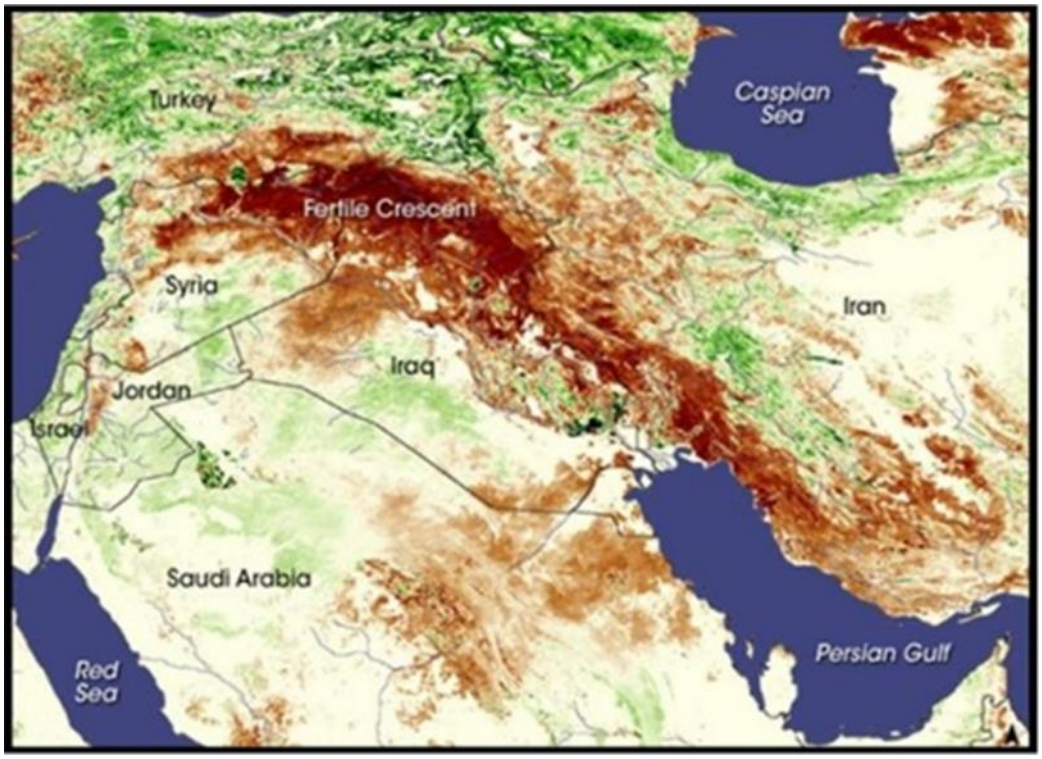

Figure (3): The so-called “Fertile Crescent” in a NASA image

Taking into account all predictions of the future Climate Change Impact on the Tigris and Euphrates River basins, the productive land, particularly in Iraq, will be reduced to arid, desert terrain, with only narrow irrigated sections remaining along the two rivers. The occurrence of sandstorms is a direct consequence of the intensely felt increase in aridity, which is accompanied by the occurrence of sandstorms. A study of sand and dust storms in Iraq by Sissakian *et al*. (2013) revealed that the frequency of dust storms has increased dramatically over the past decade and is continuing to rise. According to a report by the United Nations, the Iraqi Ministry of Environment recorded 122 dust cyclones and 283 dusty days in 2012, and it predicts that this number will rise to 300 dusty days per year within the next ten years. (UN. 2013). Figure (4) depicts a typical illustration of such an event.

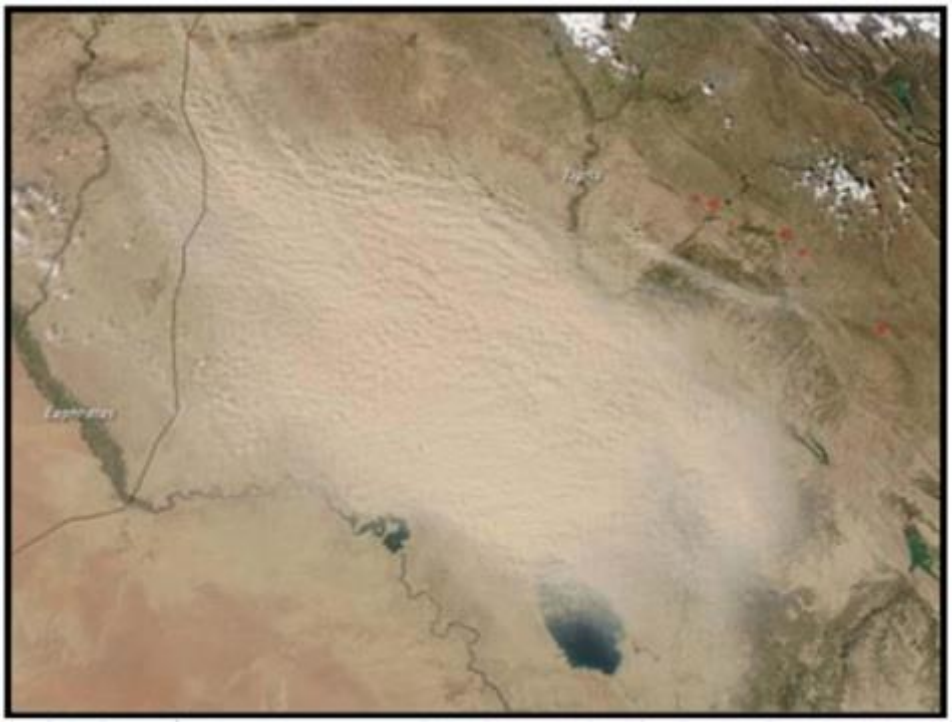

Figure (4): Aerial view of a dust storm.

Recent variations in the Middle East's various climatic factors are primarily attributable to the Global Climate Change Impact. Changes in average annual temperatures and average annual precipitation have led to an increase in desertification, followed by an increase in sand and dust cyclones in the region. As a direct result, a large portion of Iraqi territory has become a Very High Potential Zone for the occurrence of dust storms, while only a tiny area in the extreme northeastern part has a Moderate Potential for dust storms. Figure (5) depicts a depiction of the global dust potential that was published by the Desert Research Institute in 2013 (DRI, 2013) to illustrate this point.

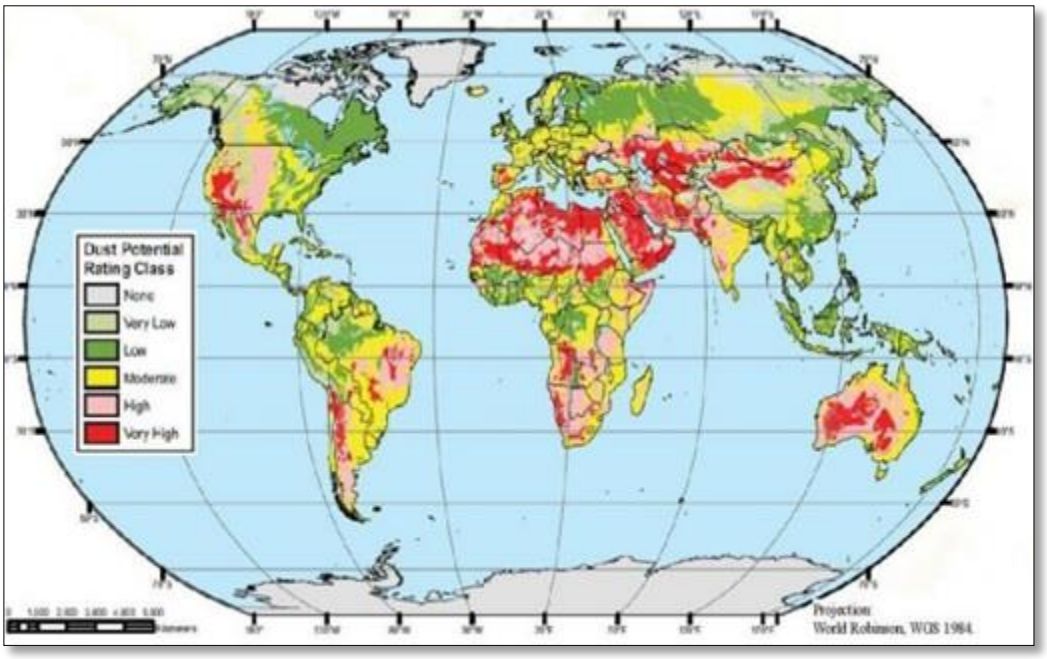

Figure (5): global dust potential map.

Taking into account the just-explained current trends of the future Climate Change Impact on the Tigris and Euphrates river basins, the phenomenon of increased sand and dust storms will reach unimaginable limits and bring life quality to very low levels by the end of the century unless regional and local corrective measures are taken. These measures may include stabilization of sand dunes, creation of wide and extensive green zones around cities, large-scale afforestation utilizing trees and vegetation with a high tolerance for moisture deficiency, and the implementation of modern techniques for conserving water and soil resources. It also necessitates the cooperation of neighboring nations in carrying out comparable actions.

Sea Level Rise (SLR)

The phenomenon of sea level rise (SLR) is a conspicuous outcome of climate change that is significantly impacting numerous coastal nations across the world. It is highly probable that the rise in global temperatures during the 20th century has resulted in a rise in the surface area of seas and oceans, coupled with a decline in land ice (IPCC, 2001 b). Between 1961 and 1993, the mean global sea level rise was estimated to be around 1.8 mm/year. However, from 1993 to 2003, this rate escalated to 3.1 mm/year, as reported by the Intergovernmental Panel on Climate Change (IPCC, 2007a), and this trend has persisted. The MENA countries are equally vulnerable to the impacts of sea level rise (SLR) as most of the other coastal nations across the globe. Notwithstanding the susceptibility of their coastlines to these effects, deltaic regions in nations such as Egypt (specifically, the Nile River delta) and Iraq (namely, the Tigris and Euphrates delta) will experience greater repercussions (refer to Figure 6). Among the countries in the MENA region, these two areas are the most vulnerable to the potential impacts of rising sea levels. The citation provided is attributed to Ghoneim in the context of academic writing.

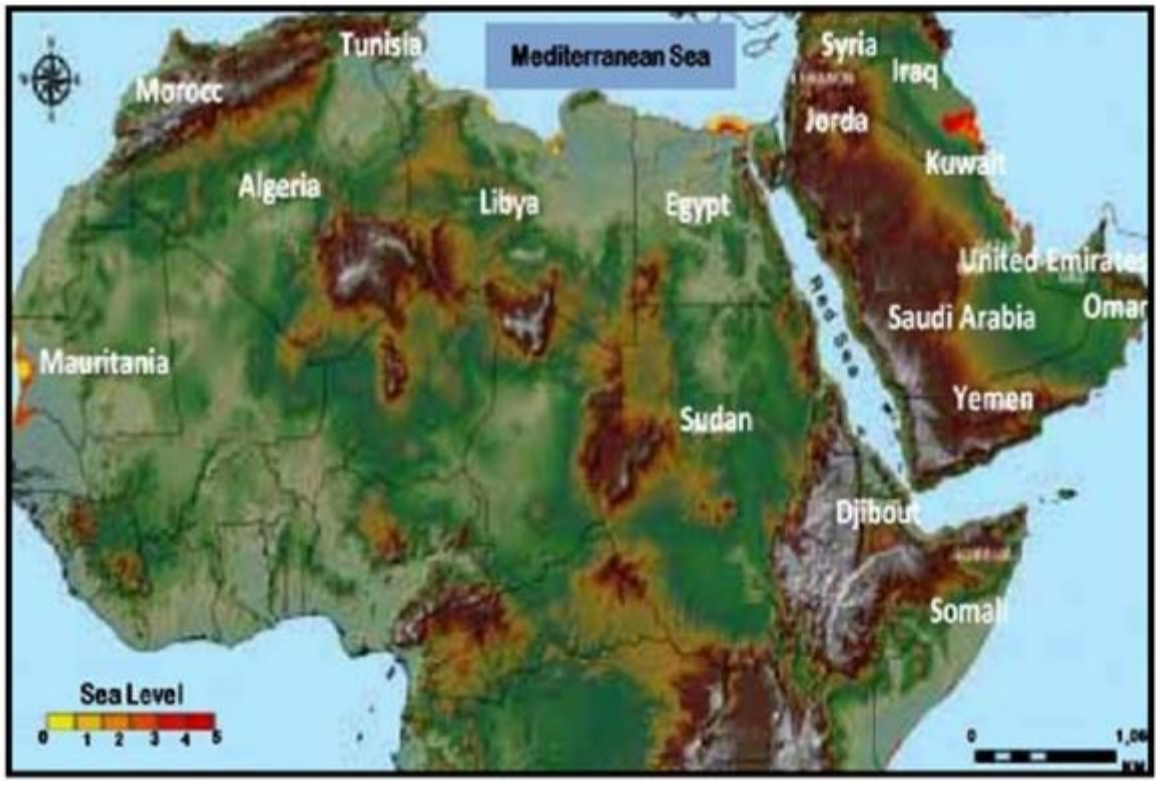

Figure (6): The situation of the sea level rise for Egypt.

In addition, climate change computer modeling predicts that the sea level will rise by more than 0.5 meters by the end of the century. According to one report, this will put low-lying coastal areas in the Gulf and Shatt-al-Arab region and North Africa at peril, with Iraq in particular (World Bank, 2013).

One study on the effects of global warming on the littoral zones of the Arab Region highlighted the Arab countries' susceptibility to the potential effects of sea level rise. (El Raey, 2010). According to the study, the majority of these nations, if not all of them, are exceedingly vulnerable to the effects of sea level rise, not only due to direct inundation but also due to salt water intrusion. Another study examined the effects of SLR on the Arabian littoral and identified countries with a high risk of SLR (Ghoneim, 2009). Using data from the Geographical Information System (GIS) and the Shuttle Radar Topography Mission (SRTM), a simulation model study of SLR has been conducted. Under the 1 m SLR scenario, the simulation revealed that approximately 41,500 km2 of Arab country territory would be directly affected by the sea level rise. Taking into account the entire "likely" range of predicted temperature increases, SLR could increase to as much as 1.4 meters by 2100.

In relation to the Shatt al-Arab estuary at the head of the Arabian Gulf, the Iraqi coastline is extremely limited; however, due to its low elevation relative to the sea level, it is considered one of the most vulnerable regions in the region. Even with the 1 m sea level rise, the low-lying areas appear to extend through Basra City and to the north of it. The potential impact may alter the salinity of the soil due to the intrusion of saline water and may result in the severe flooding of large portions of the Tigris and Euphrates delta, displacing the population and causing the destruction of infrastructures. With a 3 m sea level rise, the sea may reach Amarah city and even Nasiriyah city. Figure (7) depicts the extent of flooding that could be caused by a sea level rise of +1 m in Iraq, while Figure (8) depicts the same for a sea level rise of +3 m.

Figure (7): Extension of sea level rise in Iraq as represented by the scenario of +1 m sea level rise.

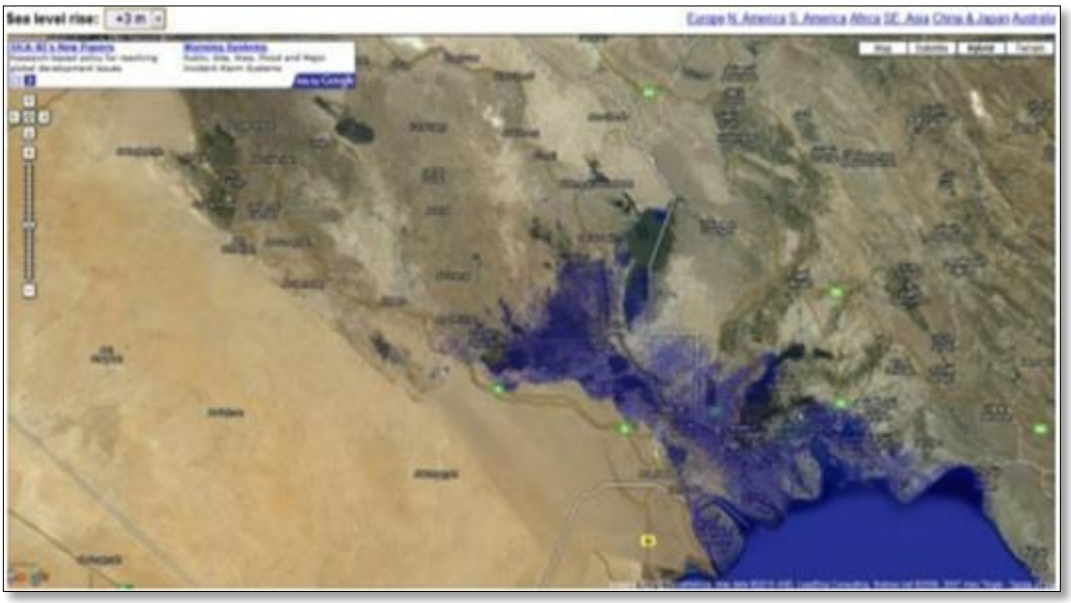

Figure (8): Extension of sea level rise in Iraq as represented by the scenario of +3 m sea level rise.

Figure (9) depicts Umm Qasr and Al-Faw, the two Iraqi terminals, on the coast. They are the only Iraqi seaports that facilitate trade, shipments, and a variety of businesses and industries, including crude exportation and storage. However, they are both susceptible to sea level rise and altering weather patterns, which may increase erosive action on natural coastal features and infrastructure.

Figure (9): The coast line between Um Qasr and Al-Faw.

The region in question exhibits a significantly low elevation and is highly susceptible to even minor increments in sea level. Additionally, it is prone to the displacement of coastal and marine sediments during severe storm occurrences, leading to the obstruction of shipping channels and necessitating frequent excavation. The potential for international conflict over the location of shipping corridors exists due to the rising sea level and the constant movement of the lowest low-water mark, which serve as the defining factors for the maritime borders with Kuwait and Iran. In recent years, there have been several incidents related to this matter between Iran and Iraq. Furthermore, the Shatt al-Arab region is currently experiencing the detrimental effects of saline water intrusion, primarily attributed to insufficient freshwater discharge. The rise in sea level is expected to intensify this predicament.

The Marshlands and surrounding regions in southern Iraq are subject to a wide range of climate variability impacts due to their role as a basin for all river discharge and irrigation drainage in the country. The region under consideration is vulnerable to the impacts of elevated sea levels, leading to a surge in salinity levels along the southern peripheries, via the Shatt al-Arab, and extending to certain sections of the Hammar Marsh. Hence, the wetlands that possess high biodiversity and traditional cultures are a region of great global significance. Regrettably, this area is currently facing threats from both the northern and southern directions, as noted by El Raey (2010).

Socio-economic Impacts due to Climate Change

The phenomenon of climate change has the potential to amplify the effects of pre-existing sociopolitical and economic vulnerabilities, leading to the destabilization of livelihoods, an increase in the likelihood of conflict, and a reduction in the feasibility of maintaining current residence. The impact of rapid climate change on Iraq's natural resources has a significant influence on the country's global socioeconomic conditions.

The effects encompass the escalation in frequency and intensity of anomalous weather phenomena and other indications, such as the elevation of ocean levels. In the absence of effective management or regulation, the aforementioned consequences will exacerbate pressures on essential resources and infrastructure that underpin the security of water and food, transportation and energy systems, and ultimately, the general standard of living. In conjunction with other adverse factors, the potential consequences of climate change may intensify the risks to societal stability and compromise the ability of governing bodies to navigate precarious circumstances, ultimately culminating in a state of failure. The authors of a report titled "Epicenters of Climate Change and Security: The New Geostrategic Landscapes and the Anthropocene" (Werrell *et al*., 2017) underscore the fact that the effects of climate change are responsible for a diverse array of disruptive patterns within nations, including but not limited to the displacement of populations, migration, political turmoil, the fragility of states, and domestic conflicts. The suggestion is made that certain impacts of climate change, which transcend national boundaries, have the potential to incite conflict. Ultimately, the courses of the Tigris and Euphrates Rivers can be cited as an illustrative example. The potential depletion of water resources resulting from natural climate change, in conjunction with the uneven allocation of water resources by Turkey and Iran, may give rise to armed conflict between Iraq and

these two nations, as well as with Syria, which is also a riparian state. These measures could potentially be implemented as a result of desperation, in reaction to public pressure and social turmoil.

Upon analyzing the socioeconomic advancements in Iraq, it becomes apparent that the repercussions of climate change are exerting an adverse influence on the nation, with the possibility of even more severe detrimental consequences in the times to come. The agricultural sector in Iraq has experienced a decline in recent years due to various factors, with climate change being a significant contributing factor. The agricultural sector has been experiencing unfavorable patterns, as evidenced by the rise in urban migration from rural areas and the surge in imports of food and agricultural commodities. Additionally, there has been a decline in agricultural output and cultivated land area. Cline (2007) conducted a study examining the impact of global warming on agriculture and identified its effects on numerous nations worldwide, including Iraq. The study employed two distinct types of agricultural impact models, namely "Ricardian" statistical economic models and process-based agronomic crop models, in combination with prominent climate model projections. The Agriculture Mendelson-Schlesinger Model was utilized to evaluate the effects of changes in temperature and precipitation on agriculture in a particular geographic area until the 2080s. The study obtained and applied estimates for 116 countries, regions, and subzones, utilizing their climatic values from 1961-1990 as the reference period. The study then compared the variations in the anticipated agricultural outputs' values to the factual agricultural outputs' values in 2003, which were further compared to the values in 2007 and projected for the future period of 2070-2099. The report has identified Iraq, among thirty other countries, as one of the most severely impacted nations globally. Based on the fluctuations in temperature and precipitation, as well as the mean agricultural output value during the reference period of 1961-1990, and the recorded agricultural output value of 370 million dollars in 2003, a decline in agricultural output value was observed, with a recorded value of 266 million dollars in 2007. The anticipated figures for the forthcoming timeframe spanning from 2070 to 2099 are expected to decrease by 728 million dollars (in the absence of carbon fertilization) or 685 million dollars (with carbon fertilization), indicating a decline of over 100 percent from the reference period of 1961-1990. The observed decrease can be characterized as catastrophic, and its repercussions are expected to be extensive and detrimental to Iraq.

The movement of individuals from rural regions to urban hubs due to the decrease in cultivated land and agricultural productivity will be intensified, thereby compounding the difficulties encountered by local governing bodies and placing a burden on their capacity to satisfy the populace's requirements for amenities such as sanitation, access to clean drinking water, a hygienic environment, and fundamental healthcare. Presently, these services are deemed insufficient owing to various factors, such as ineffective administration and insufficient allocation of resources. The competition for irrigation water among diverse users has resulted in social tensions and armed conflicts between multiple clans in southern Iraq, necessitating the intervention of security forces to de-escalate such situations. These phenomena may be construed as foreboding indications of future events if the aforementioned patterns persist at their present magnitudes.

RESULTS & DISCUSSION

Effect of Silicone and Glutathione on root rot percentage:

Iraq is currently facing considerable challenges as a result of the worldwide impacts of climate change. Nonetheless, Iraq's contribution to the fight against these issues is restricted. The nation ratified the Paris Agreement on climate change in December 2015, committing to a reduction of 15 percent in greenhouse gas emissions from 2020 to 2035. This reduction is equivalent to a decrease of 90 million tons of carbon dioxide. Abu Zaid (2016) stated in an article published in Al-Monitor that Iraq's industrial and power plant infrastructure is not as extensive as that of industrialized countries, and its utilization of fossil fuels is comparatively lower. Additionally, the rates of fuel combustion in Iraq are considerably lower than those observed in industrialized nations. Hence, it is imperative to contemplate prompt remedial and safeguarding actions within Iraq to curtail and mitigate forthcoming adverse ramifications. The National Action Program to Combat Desertification was launched in 2015 by the Ministry of Health and Environment, with the assistance of the United Nations Environment Program (UNEP) and several other regional organizations. This program represents the sole noteworthy measure taken thus far in response to environmental shifts.

Despite its limited scope in addressing climate change, it is widely believed that the recommended measures outlined in this program have yet to be executed due to a multitude of factors, such as insufficient financial resources and instability in specific regions of Iraq. Despite the aforementioned circumstances and considering the significant challenges faced by Iraq, it is imperative to develop and execute a thorough and continuous strategy aimed at alleviating the anticipated impacts of worldwide transformation. Incorporating comprehensive modifications to all policies and practices related to water and soil management constitutes a fundamental aspect of this plan. The water industry in Iraq is presently beset by widespread challenges. The plethora of issues encompassing this subject matter comprises, inter alia, the profligate utilization of water, the utilization of antiquated and customary irrigation techniques, the degradation of irrigation infrastructures, the low literacy levels of farmers and their dearth of contemporary technical proficiencies, and the inadequacy of efficacious regulations governing water usage. The government is confronted with a daunting task of transforming this industry within a span of five to ten years. The need to conserve every molecule of water and apply it optimally arises due to the scarcity of water in irrigated regions. The task at hand involves the segregation of superior grade lands suitable for agricultural purposes and crop yield, while simultaneously reserving inferior grade lands for the purpose of afforestation. The implementation of agroforestry practices involves the conversion of current irrigation projects to contemporary techniques such as closed irrigation systems, drip irrigation, and sprinklers. This approach is particularly relevant in the northern region of the country where it can serve as a supplementary measure. Additionally, the restoration of all irrigation structures and the adoption of automated irrigation systems are recommended. In order to address the ongoing issue of water waste in the agricultural, domestic, and sanitation sectors, it is highly recommended that there be an enhancement and equitable distribution of water pricing. The implementation of recycled water and desalinization of saline water should be taken into account as potential solutions for the purpose of minimizing and alleviating forthcoming water

scarcity. During the process of strategizing and implementing these measures, it is imperative for the government to prioritize negotiations aimed at achieving a just and impartial allocation of Tigris and Euphrates water resources originating from Turkey and Iran. Achieving this outcome is feasible by means of continuous negotiations that rely on the reciprocal exchange of advantages. To mitigate the impacts of rising sea levels on the southern delta and coastline, further extensive research is required to accurately identify the specific types and areas of modifications. Based on the aforementioned studies, it is possible to formulate a strategy for the gradual execution of dikes and seashore revetments. It is imperative to demarcate settlements in regions that are deemed vulnerable and incapable of being safeguarded. Furthermore, it is essential to prohibit any permanent construction in such areas. The inhabitants of these settlements must be resettled to other secure regions only after ensuring the availability of adequate living conditions.

CONCLUSIONS

Iraq is presently encountering the impacts of climate change that are equivalent to or possibly more severe than those experienced by numerous other countries. The impacts of these alterations in climate are manifesting as a rise in global temperatures, modifications to the factors that propel atmospheric conditions, and an increase in oceanic water levels. The nation of Iraq is currently facing a state of water stress, which can be attributed to a combination of factors such as increasing temperatures, reduced precipitation levels, changes in distribution patterns, and heightened rates of evaporation. Nonetheless, they trigger a cascade of subsequent alterations, including arid spells, land degradation, and atmospheric disturbances. The Tigris-Euphrates basin's southern region is facing a potential hazard of flooding, while the ports and coastline of Iraq are in peril due to the anticipated escalation in sea level. The reduced water availability for arable lands has had a significant impact on the agricultural sector in Iraq. The unequal allocation of water resources by Turkey, which serves as the main water source for the two rivers, has already aggravated the aforementioned discharges. The available projections and studies suggest that the existing adverse climate change patterns are expected to persist in the foreseeable future. The degradation of arable land due to desertification, frequent droughts and sandstorms, and a decrease in agricultural productivity are the prevailing trends in Iraq's already vulnerable ecosystem. These factors are likely to result in increased hardship for the populace and heightened social instability in the years to come. If appropriate protective planning and solutions are not implemented, the aforementioned factors will exert significant pressure on all future governments.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to all the individuals and organizations that have contributed to the publication of this research paper.

CONFLICT OF INTEREST

The authors state that there are no conflicts of interest with the publication of this work.

تغير المناخ: التداعيات على بيئة العراق

وليد نصير
قسم البساتين / كلية الزراعة / جامعة الزقازيق / مصر

الخلاصة

يشهد العراق حاليًا تأثيرات تغير المناخ التي يمكن مقارنتها أو حتى أسوأ من تأثيرات العديد من الدول الأخرى. يتم الشعور بآثار هذه التغيرات المناخية في شكل الاحتباس الحراري، والتغيرات في العناصر التي تحرك الطقس، وارتفاع مستوى سطح البحر. يعاني العراق من إجهاد مائي بسبب ارتفاع درجات الحرارة، وانخفاض معدلات هطول الأمطار، وتغير أنماط التوزيع، وزيادة التبخر. ومع ذلك، فإنها تبدأ في تفاعل متسلسل من التغييرات الأخرى، مثل الجفاف والتصحر والعواصف الرملية. يتعرض الجزء الجنوبي من حوض دجلة والفرات لخطر الفيضانات، وموانئ العراق وسواحل العراق معرضة للخطر بسبب الارتفاع المتوقع في مستوى سطح البحر. حتى الآن، تأثر القطاع الزراعي في العراق بشدة بسبب نقص المياه المتاحة للأراضي الصالحة للزراعة. وقد تفاقمت هذه التصريفات بالفعل بسبب التوزيع غير المتكافئ للموارد المائية من قبل تركيا، المصدر الرئيسي للمياه للنهرين. تشير جميع التوقعات والدراسات السابقة إلى أن الاتجاهات السلبية الحالية لتغير المناخ من المرجح أن تستمر في المستقبل المنظور. إن فقدان الأراضي الصالحة للزراعة بسبب التصحر والجفاف المتكرر والعواصف الرملية وتدهور الزراعة هي نمط التغيير في بيئة العراق الهشة بالفعل؛ وسيؤدي هذا حتما إلى المزيد من المعاناة للسكان والاضطرابات الاجتماعية في المستقبل. ستساهم هذه في الضغوط الهائلة التي ستواجهها جميع الحكومات المستقبلية إذا لم تنفذ الحكومة التخطيط والحلول الوقائية.

الكلمات المفتاحية: ارتفاع المستوى، ندرة المياه، الجفاف، العواصف الرملية.

REFERENCES

Adopted, I. P. C. C. (2014). Climate change 2014 synthesis report. *IPCC: Geneva, Szwitzerland*. https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf

Adamo, N., Al-Ansari, N., Sissakian, V. K., Knutsson, S., & Laue, J. (2018). Climate change: consequences on Iraq's environment. *Journal of earth sciences and geotechnical engineering*, 8(3), 43-58. https://iraqi-forum2014.com/wp-content/uploads/2018/05/Vol-8_3_3.pdf

Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., & Riahi, K. (2008). IPCC, 2007: climate change 2007: synthesis report. https://www.ipcc.ch/site/assets/uploads/2018/02/ar4_syr.pdf

Chenoweth, J., Hadjinicolaou, P., Bruggeman, A., Lelieveld, J., Levin, Z., Lange, M. A., ... & Hadjikakou, M. (2011). Impact of climate change on the water resources of the eastern Mediterranean and Middle East region: Modeled 21st century changes and implications. *Water Resources Research*, 47(6). https://doi.org/10.1029/2010WR010269

Cline, W. R. (2007). Global warming and agriculture: *Impact estimates by country*. Peterson Institute. Global warming and agriculture Book.html

El Raey, M. (2010). Impact of sea level rise on the Arab Region. *University of Alexandria. Arab Academy of Science, Technology, and Maritime*. Impact of sea level rise on the Arab Region.pdf

Ghoneim, E. (2009). A remote sensing study of some impacts of global warming on the Arab Region. *Arab Environment: Climate Change*, 31. https://www.climamed.eu/wp-content/uploads/files/Arab-World-and-Climate-Change.pdf#page=54

Holthaus, E. (2014). Is climate change destabilizing Iraq?. *Slate, Future Tense*.

Kitoh, A., Yatagai, A., & Alpert, P. (2008). First super-high-resolution model projection that the ancient "Fertile Crescent" will disappear in this century. *Hydrological Research Letters*, 2, 1-4. https://doi.org/10.3178/hrl.2.1

Schwartzstein, P. (2015). Iraq's Famed Marshes Are Disappearing—Again. National Geographic, 9. Iraq's Famed Marshes Are Disappearing.html.

Sowers, J., Vengosh, A., & Weinthal, E. (2011). Climate change, water resources, and the politics of adaptation in the Middle East and North Africa. *Climatic Change*, 104(3-4), 599-627. https://doi.org/10.1007/s10584-010-9835-4

Sissakian, V., Al-Ansari, N., & Knutsson, S. (2013). Sand and dust storm events in Iraq. *Journal of Natural Science*, 5(10), 1084-1094. https://doi.org/10.4236/ns.2013.510133

Sivakumar, M. V. K. (2007). Interactions between climate and desertification. *Agricultural and forest meteorology*, 142(2-4), 143-155. https://doi.org/10.1016/j.agrformet.2006.03.025

Terink, W., Immerzeel, W. W., & Droogers, P. (2013). Climate change projections of precipitation and reference evapotranspiration for the Middle East and Northern Africa until 2050. *International journal of climatology*, 33(14), 3055-3072. https://doi.org/10.1002/joc.3650

Werrell, C. E., & Femia, F. (2016). Climate change, the erosion of state sovereignty, and world order. *The Brown Journal of World Affairs*, 22(2), 221-235. https://www.jstor.org/stable/26534704

Zereini, F. (2008). Climatic changes and water resources in the Middle East and North Africa. H. Hötzl (Ed.). Berlin: *Springer-Verlag*. https://link.springer.com/book/10.1007/978-3-540-85047-2