

Climate Change: Consequences on Iraq's Environment

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Abstract

Iraq as a country is now suffering from Climate Change Impacts in similar or even worse ways than many other countries of the world. The manifestations of these climate changes are being felt in global warming, changes to weather driving elements and sea level rise. Increasing temperatures, declining precipitation rates and changed distribution patterns together with increasing evaporation are causing water stress in Iraq. However, they trigger other changes in a sort of chain reaction; such as droughts, desertification and sand storms. Iraq is not even safe from the consequences of sea level rise where the southern part of the Tigris- Euphrates delta is threatened by inundation and Iraq's ports and sea coast line are endangered by such projected rise. So far the agricultural sector in Iraq has been hit very badly by the reduced water availability for arable lands; whether rain fed lands as in the northern part, or irrigated lands using the declining discharges of the Tigris and Euphrates Rivers as in the southern and middle parts. These discharges have already been additionally strained by the unfair sharing practiced by Turkey from which most of the two rivers' water resources originate. The present negative climate change trends seem to be continuing in the future as it is obvious from all projections and studies being performed so far. Loss of cultivable land to desertification, recurrent droughts and sand storms and declining agriculture are the pattern of change in Iraq's already fragile environment; and this will result inevitably in much more distress for the population in the future and will lead to social unrest. These will add to the great pressures facing all future governments unless the government takes protective planning and solutions.

Keywords: Climate Change, Global Warming, Sea level rise, Desertification, Droughts, Sand Storms.

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1 Introduction

Iraq is located; geographically in the East Mediterranean Region. Bound by South Anatolia in the north, Iran in the east and northeast, Syria and Jordan in the west; it opens on the Saudi Arabia, Kuwait and the Gulf at the south. (Figure 1). This geographical location added to Iraq's varied surface topography brings with it many changing weather elements which are showing in various degrees of variations due to the current Global Climate Change.



Figure 1: Map of Iraq.

Countries and communities around the world are already experiencing stepped-up climate change impacts; including rising temperatures, droughts, floods, shortages, more intense and frequent natural disasters, and sea-level rise. The most vulnerable countries of these are being hit the hardest. Iraq is one of such countries, which has been struggling with significant and interconnected environmental, security, political, and economic challenges; with the effects of climate change likely increasing the extent of these challenges. Rising temperatures, intense droughts, declining precipitation, desertification, salinization, and the increasing prevalence of dust storms have undermined Iraq's agricultural sector. Additionally, Iraq's water security is based on two declining rivers, the Tigris and Euphrates. National and regional political uncertainty will make mitigating the effects of climate changes and addressing transnational water management very difficult. Climatic changes such as increasing temperatures, reduced precipitation, and increasing water scarcity will likely have serious

implications on the state of Iraq for years to come (USAID 2017). These changes and their consequences are discussed in more details in the following paragraphs.

2 Water Scarcities

Climate changes due to global warming have influenced all the weather driving elements not only in Iraq but in all the surrounding countries. These changes include temperature rise, atmospheric pressure variations, rainfall intensities and its temporal and spatial distribution; which have contributed also to changes in annual stream flow volumes of the Tigris and Euphrates Rivers. Model studies have shown that these negative trends will continue at least to the end of this century and may be accentuated as long as the green house gases (GHG) emissions which include CO₂ continue at the present rates. These models indicate that storms activity in the Eastern Mediterranean Region is part of the North Atlantic Oscillation (NAO) pattern and it will decline this century if global warming continues. Therefore, rainfall will decrease by (15 to 25) % over large part of this region; encompassing parts of Turkey, Syria, northern Iraq and north-eastern Iran and including the strategically important headwaters of the Euphrates and Tigris rivers (Adamo et. al. 2018 a).

Other studies have indicated declining precipitation over all the Tigris River tributaries' basins in Iraq with alarming results. These studies also indicated that precipitation had already shown a general decline in the decades 1980- 1990, 1990- 2000 and 2000- 2010 with a decreasing spatial trend from upstream to downstream and from east to west of the basin. This is attributed to the fact that the northern and northeastern parts of the basin are mountainous with high precipitation and snowfall, while the lower and western parts are relatively flat with less precipitation. Future projections showed that under the optimistic emission scenario (B1) the mean annual precipitation over Khabour River basin will decrease by 7% during the future period 2046- 2064 and 15% during the period 2080-2100. However, the reductions are estimated to be 18% and 38% respectively under the pessimistic emission scenario (A2) during the same two periods. The Diyala River basin will undergo precipitation reduction of 17% in the two future periods under (B1) scenario and 26% and 40% under scenario (A2) in the two periods. The Greater Zab, Lesser Zab and Al-Adhaim Rivers' basins will undergo similar reductions under the same scenarios and in the same future periods (Adamo et. al. (2018 b).

At the present, climate changes are having their toll also on the Tigris and Euphrates Rivers stream flows. The fact that these rivers originate out of Iraq's borders and that their watersheds fall in areas which are subject to the same climate changes' influences reflect on their declining natural stream flow. The situation is aggravated in recent decades and even now by the increasing water

withdrawals in the other riparian countries due to their increasing demand, namely Turkey and Iran, and to a lesser degree Syria. Figure (2) gives the riparian countries, which shares in the water supply of the two rive according to the Iraqi Ministry of Water Resources. Future projections and assessments of the regional water resources under Climate Changes future impacts and with Tigris and Euphrates at focus have shown that the situation is far from being bright. Chenoweth et al. (2011) investigated those likely effects on the water resources of the Eastern Mediterranean and Middle East and it was found that the average annual Euphrates- Tigris Rivers' discharges might decline by 9.5% between 2040 and 2069, with the greatest decline of (12%). Another study predicted that the Euphrates River annual flow could suffer a reduction of (29 – 73) %, (Kitoh et al., 2008). Further strain is put on these resources by the continued pollution and salinization of the two rivers due to increasing use of fertilizers and discharge of industry effluence and domestic waste and sewerage without enough treatment. Water is becoming with the passage of time more and more a scarce commodity in the whole region and especially in Iraq with Climate Changes unhampered impacts and continuous human misuse.

3 Desertification, Drought, and Sand Storms

Decreasing rainfall is one of the significant factors that simultaneously marks and intensifies desertification. Climate Changes exacerbates desertification through changing of spatial and temporal patterns of rainfall. The variation of rainfall amounts causes changes in the land vegetative cover through both numbers of dry years or seasons resulting in very long drought periods. The increase in the temperatures as a result of the Climate Changes causes the changing of the soil properties and processes, such as organic matter decomposition, greater leaching losses, decreased soil water, and degradation through reducing soil moisture, and soil erosion in some regions because of heavy rainfall and increased wind speed (IPCC, 2007) a. Climate Changes also accelerate desertification through changing the regional water resources' systems regime by disrupting the balance between water outflow and inflow due to the variation of rainfall amounts and increasing temperature, which increases evaporation and evapotranspiration. The fact that Climate Changes Impact are causing droughts and increased desertification is becoming quite evident in recent years in Iraq and Syria forming the two limbs of what is known as the "Fertile Crescent" (Figure 3). A significant study employed a super-high-resolution atmospheric global climate model to reproduce the precipitation and the stream-flow of the present day "Fertile Crescent" and projected the current trends in climate changes on the Middle East water resources till the end of the current century showed severe reductions of the annual discharges of the rivers in the region. The Euphrates River annual flow as one case might suffer a reduction of

(29 – 73) %, as well as the stream flow of the Jordan River (Kitoh et al., 2008). In the wider picture of the Middle East, the study showed that, by the end of this century, the “Fertile Crescent” would lose its current shape and could disappear altogether.

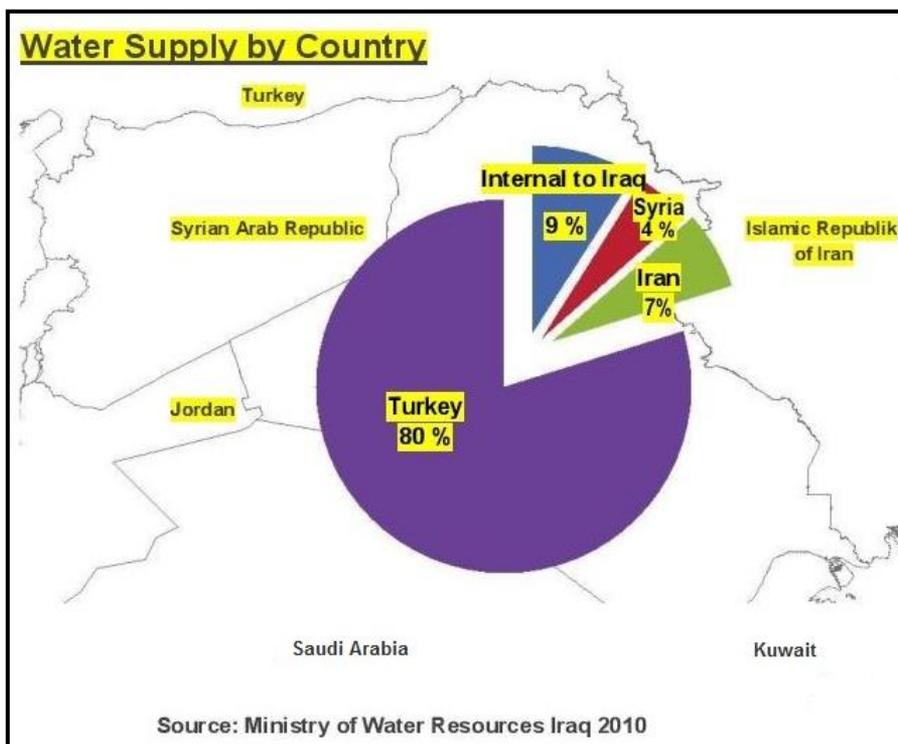


Figure 2: Water Supply by country to Tigris and Euphrates water resources
(After the Ministry of Water Resources-Iraq, 2010)

The area shown in Figure (3) witnessed one of the most devastating droughts in decades in (2007-2008) which scientists have linked to Climate Changes. This severe drought hit most of Syria and northern Iraq during what is normally the wettest time of the year. In the mountains of eastern Turkey, which form the headwaters of the Tigris and Euphrates rivers, snow and rain were less than half of the normal. Drought is becoming a fixture in this landscape, due to a drying trend of the Mediterranean and Middle East Region which is fueled by global warming (Holthaus, 2014). The current and future impacts of Climate Changes inevitably will lead to decreasing lake sizes, drying wetlands and changing the regional environment (Sivakumar, 2007). This trend will impede and hamper the current efforts to restore the marshes of southern Iraq and may result in their drying up. Given the impact of low rainfall and wasteful irrigation practices in Iraq, environmentalists predict the marshes will remain at a fraction of their typical size (Schwartzstien, 2015); if not disappear altogether. In 2009, a report by UNDP described the impacts of the global warming on Iraq and it underscored the severe

droughts it had experienced and the declining precipitation over the Tigris and Euphrates basins in the (5-10) years previous to the report, which amounted only to (25-65) % of normal levels. This study shows that the Climate Change Impact is the main reason expressed in the form of global warming and changes in the North Atlantic Oscillation (NAO) (UNDP, 2009). The same study goes on to explain that these changes will increase the likelihood of massive dust storms as a result of losing soil moisture and vegetation cover, and furthermore, the impacts are expected to be more severe as time passes and will lead to more destruction of physical and chemical characteristic of the soil in Iraq's arable and non-arable lands.

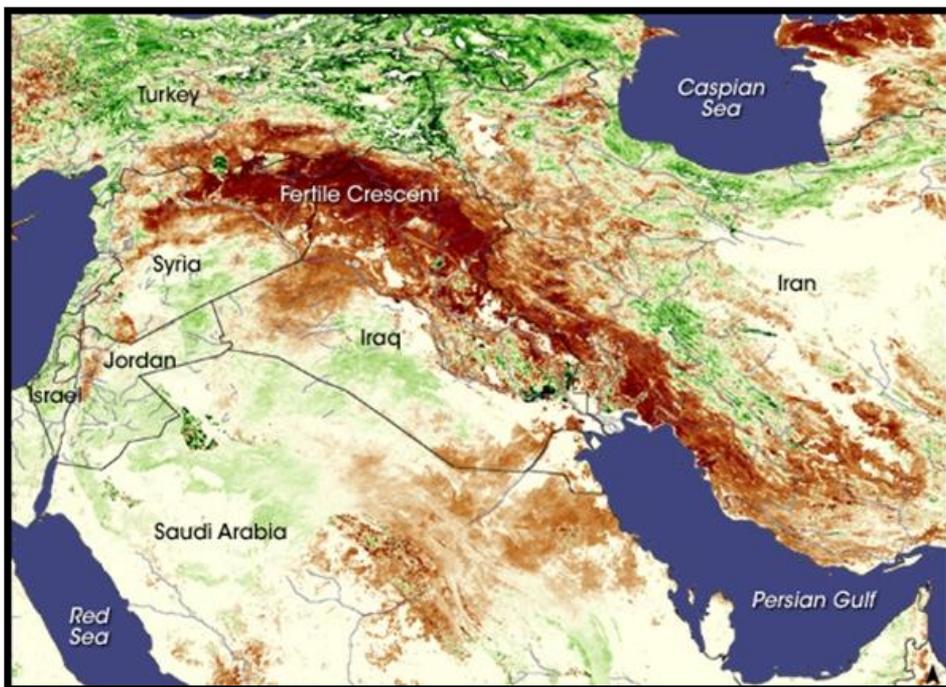


Figure 3: The so-called "Fertile Crescent" in a NASA image

Taking all the predictions of the future Climate Change Impact on the Tigris and Euphrates rivers' basins, the productive land, especially in Iraq will be reduced to a barren land with extensive deserts, and only narrow strips of irrigated stretches along the two rivers will remain.

A direct consequence of the increased aridity, which is strongly felt, is the occurrence of sandstorms. A study of sand and dust storms events in Iraq by Sissakian et al. (2013) indicated that the frequency of occurrence of dust storms has increased drastically during the last decade and it is increasing continuously. According to the United Nations report, it indicates that the Iraqi Ministry of Environment has recorded 122 dust storms and 283 dusty days in 2012 and it estimates that this will increase to 300 dusty days per year in the next ten years.

(UN. 2013). A typical image of such an event is shown in Figure (4).

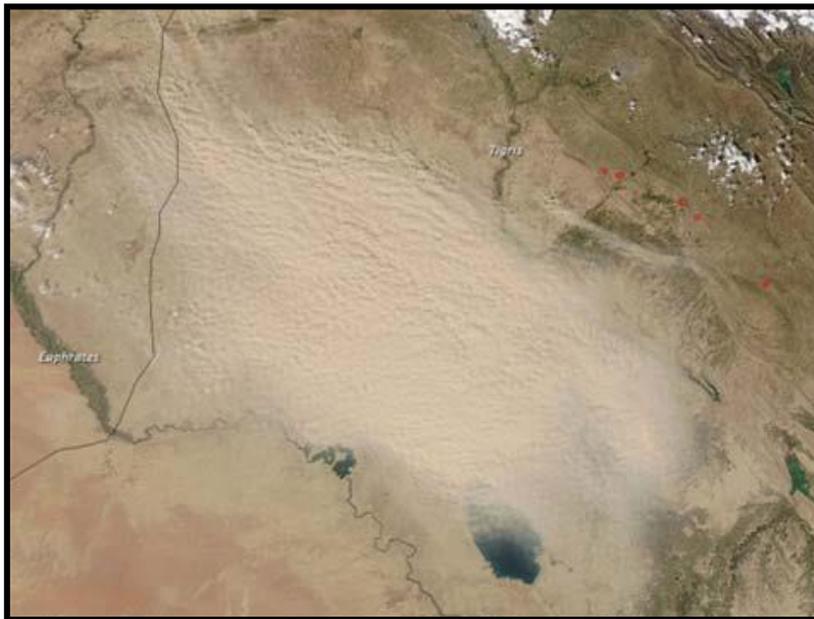


Figure 4: Aerial view of a dust storm. Note it had started just in the northwestern borders of Iraq (The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite captured this natural-color image on March 3, 2011).

The recent changes on the different climatic factors in the Middle East are mostly attributed to the Global Climate Change Impact. The area has experienced enormous changes in the average annual temperatures and the average annual precipitation contributing to increased desertification followed by increased sand and dust storms events. A large part of Iraqi territory has changed into a Very High Potential Zone for the occurrence of such storms as a direct consequence, and only a small area in the extreme northeastern part shows -Moderate Potential- for dust storms. A global dust potential map published by the Desert Research Institute (DRI, 2013) is shown in Figure (5) which shows clearly this fact. Taking the current trends of the future Climate Change Impact on the Tigris and Euphrates rivers' basins, which have just been explained; the phenomenon of increased sand and dust storms will reach unimaginable limits and worsen life quality and bring it to very low levels by the end of the century; unless some corrective measures are taken on the regional and local scales. Such measures may include stabilization of sand dunes, creating wide and extensive green zones around cities, large scale afforestation using trees and shrubs with high tolerance to moisture deficiency, and by applying modern practices in conserving water and soil resources. It also requires the cooperation of neighboring countries in performing similar actions.

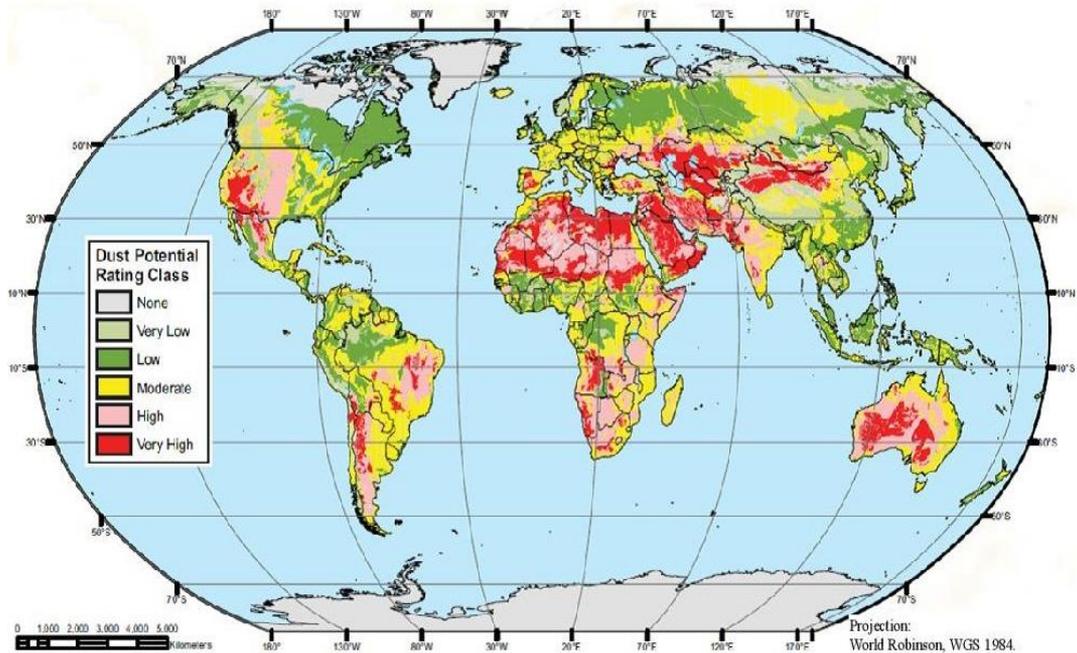


Figure 5: Global Dust Potential Map

4 Sea Level Rise (SLR)

Sea level rise (SLR) is another obvious impact caused by climate changes which are leaving their mark on many countries in the world that have coastal areas. It is very likely that the 20th-century global warming has caused an increase in the size of seas and oceans as well as loss of land ice (IPCC, 2001 b). During the period 1961-1993 there was an observed global sea level rise of about 1.8 mm/year as an average, while during the period 1993-2003 the rate was 3.1 mm/year (IPCC, 2007a) and it is still on the rise. The Middle East and North Africa Region (MENA) countries are vulnerable to the impacts of SLR as most of the other countries of the world with coast lines. But despite of the fact that their coastlines are subjected to these impacts, this will be more noticeable in countries that have deltaic areas, such as Egypt (Nile River delta) and Iraq (Tigris and Euphrates delta) (Figure 6). These two areas are the most vulnerable within the MENA countries by sea level rise (Ghoneim, 2009)

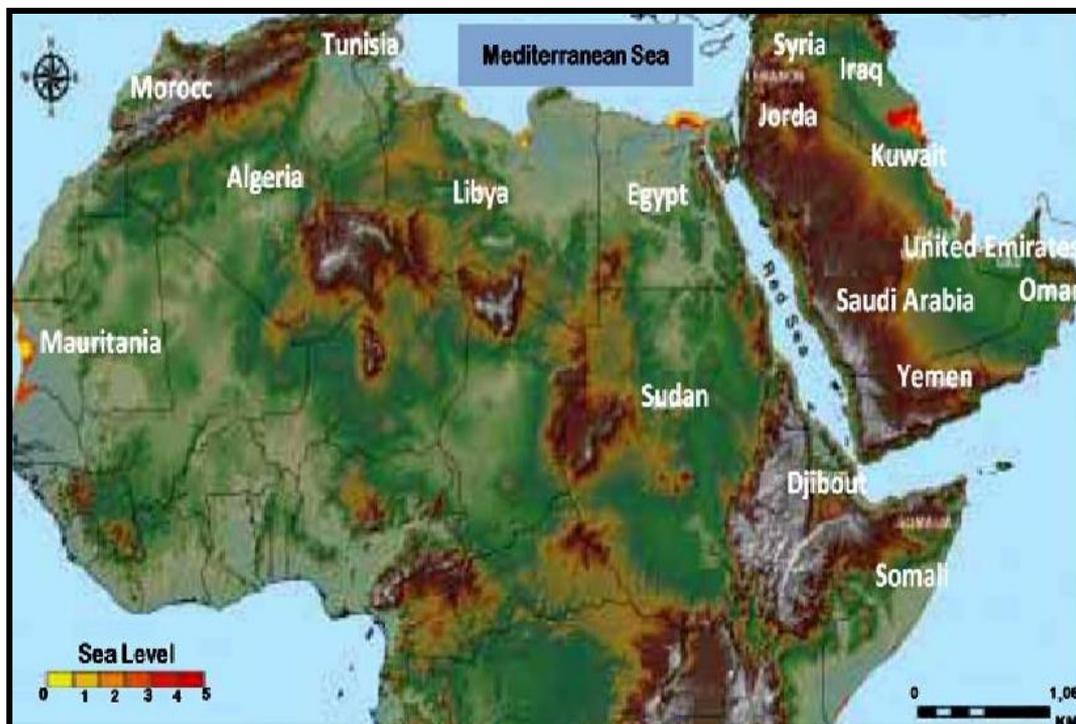


Figure 6: The Situation of the sea level rise for Egypt (Nile River delta and Iraq (Tigris and Euphrates delta) (Shown in red and yellow colors) (Ghoneim, 2009)

Climate Change Computer Modeling also projects sea level rising by over 0.5 meters by the end of the century. One report indicates that this will place low-lying coastal areas in the Gulf and Shatt-al-Arab area and North Africa at particular risk with specific mention of Iraq (World Bank, 2013).

One study, which was made on the implications of the global warming on coastal zones of the Arab Region highlighted the vulnerability of the Arab countries to potential impacts of the sea level rise. (El Raey, 2010). The study indicated that most of these countries, if not all of them, are extremely vulnerable to the impacts of the sea level rise; not only through direct inundation but also due to salt water intrusion. Another study looked into the impacts of SLR on the Arabian coastline and highlighted those countries with high potential risk of SLR (Ghoneim, 2009). One simulation model study of SLR has been conducted using the Geographical Information System (GIS) and the Shuttle Radar Topography Mission (SRTM) data. Under the 1 m SLR scenario, the simulation revealed that approximately 41500 km² of the territory of the Arab countries would be directly influenced by the rise of the sea level. But taking into consideration the full “likely” range of the predicted increases in temperature, SLR could even be amplified up to 1.4 m by the year 2100.

In dealing with the Shatt al-Arab estuary at the head of the Arabian Gulf, the shoreline of Iraq is very limited; however, it is considered one of the most

threatened areas in the region because of its low elevation with respect to the sea level. The low elevation areas appear to extend through Basra City and to the north of it even for the 1 m sea level rise. The potential impact may affect soil salinity by salt water intrusion and may cause serious inundation of many parts of the Tigris and Euphrates delta and drive the population out and cause loss of the infrastructures. For a 3 m sea rise, the intrusion of the sea can reach Amarah city and beyond Nasiriyah city. Figure (7) shows the extent of inundation that could be caused by the sea level rise in Iraq as depicted by the scenario of sea level rise of +1 m and Figure (8) shows this extent for the scenario of 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

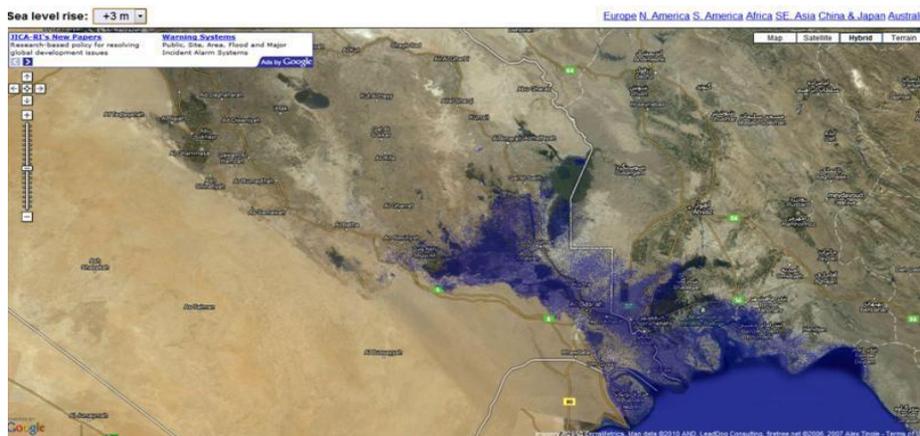


Figure 8: Extension of Sea Level Rise in Iraq as represented by the scenario of + 3 m sea level rise

On the coast line, Umm Qasr and Al-Faw the two Iraqi ports are shown in Figure (9). They are the only Iraqi sea ports which support trade, shipments, and various businesses and industries including oil exporting and storage. But, they both are vulnerable to sea level rise and changing weather patterns that may increase erosive action on the natural features of the coast, as well as infrastructures.



Figure 9: The coast line between Um Qasr and Al Faw

This already described area is very low-lying and susceptible to any amount of sea level rise, as well as being subjected to redistribution of coastal and marine sediments during extreme storm events, which clogs shipping channels and forces frequent dredging. The sea level rise, and constant movement of the lowest low-water mark, which defines the maritime borders with Kuwait and Iran has the potential to create international conflict with regard to the location of shipping corridors; there have already been several incidents related to this in recent years between Iran and Iraq. In addition, Shatt al-Arab is already suffering from salt water intrusion mostly related to lack of freshwater discharge and sea level rise will exacerbate this problem.

Almost all the possible impacts of climate variability in Iraq are currently being felt in the Marshlands and adjacent areas in the south, due to the fact that this area is a receptacle for all rivers discharge and irrigation drainage in Iraq. It is also exposed to the influences of the sea level rise which results in increasing salinity in the southern fringes, through the Shatt al-Arab and into portions of the Hammar Marsh. Thus, it is a globally significant area (wetlands with high biodiversity and traditional cultures) that is being assaulted on two fronts (from the north and from the south) (El Raey, 2010).

5 Socio-economic Impacts Due to Climate Change

Climate changes in general, act as a threat multiplier, exacerbating existing sociopolitical and economic vulnerabilities, undermining livelihoods, inflating the risk of conflict and making it difficult for people to remain in situ. Socio-economic conditions in the world as a whole, and taking Iraq as an example, are influenced by the impacts of the rapid climate changes on its natural resources. Such impacts include the increase in frequency and severity of extreme weather events and other manifestations such as sea levels rise; All these impacts, if they are left unmanaged or controlled will increase stresses on the critical resources and infrastructures that support water and food security, transport and energy systems, and impinge directly on life quality as a whole. These climate changes threats coupled with other negative factors may highlight the dangers to social security and undermine the ability of governments to manage volatile situations; leading to what can be described as a failing state. In a recent report entitled "Epicenters of Climate Change and Security: The New Geostrategic Landscapes and the Anthropocene" (Werrell et al., 2017), the authors emphasize that climate change impacts contribute to a broad range of destabilizing trends within states, including population displacement, migration, political unrest, state fragility, internal conflicts, and they imply also that the transboundary nature of some climate change impacts may lead to conflicts between states. In the last case, the Tigris and Euphrates Rivers' flows may be cited as an example. The decrease of water resources due to natural climate change impacts coupled with the unfair sharing of water by Turkey and Iran may lead to armed conflicts between Iraq and these two countries or with the other riparian country namely Syria. Such actions may be taken in desperation and under popular pressures and unrest.

In looking into the socio-economic developments in Iraq, it is very clear that the climate change impacts are negatively affecting the country with much more severe negative changes expected in the future. Agriculture in Iraq for one thing has been declining in recent years for variety of reasons with climate changes as being one of the major negative actors. Agricultural output and cultivated farm land area have been showing negative trends which are clearly indicated by the escalated migration from the country side to urban centers and the soaring imports of food and agricultural products. A study, which was done by Cline (2007) treated the global warming effects on agriculture and listed these impacts for most of the countries of the world including Iraq. Agricultural impact models of two types, "Ricardian" statistical economic models were used with process-based agronomic crop models, combined with leading climate model projections. A set of geographically detailed estimates for changes in temperature and precipitation by the 2080's were developed and applied to the chosen agricultural impact model; i.e. The Agriculture Mendelson- Schlesinger Model. These estimates were obtained and used for 116 countries, regions and subzones taking their 1961-1990 climatic values as base period, and then comparing the changes in the predicted

agricultural outputs' values against the actual outputs values in 2003 which then were compared to those values in 2007 and then projected to the future period 2070- 2099. In this report Iraq was indicated as one of the most badly hit countries of the world together with 30 more countries. The detailed results given for Iraq showed that according to changes in temperature and precipitation and agricultural output values averages of the base period 1961-1990 taken together with the actual agriculture output value of 370 million dollars in 2003; this output value declined to an amount of 266 million dollars in 2007. The projected values for the future period 2070-2099 will decline even further 728 million dollars (without Carbon fertilization) or 685 million dollars (with carbon fertilization) depicting a decline of more than 100 percent from base period in 1961- 1990. Such decline can only be described as catastrophic and it will have deep and extensive negative outcomes on the state of Iraq.

The migration from rural areas to urban centers due to the shrinkage of cultivated land areas and the declining output will be exasperated and adds further difficulties to the local authorities and strain their capacities to meet population demands for services such as sanitation, potable water supply, clean environment and basic health services. Such services are already inadequate now due to variety of reasons which include among other things incompetent management and lack of resources. Competing over irrigation water between different users has strained social relationships and caused the eruption of armed skirmishes between various clans in southern Iraq which even required the intervention of security forces to calm down such situations. These can only be seen as warning signs of the worst to come if these trends continue at the expected rates.

6 Discussion and Recommendations

Iraq is facing today great challenges due to climate change impacts on the whole world. Iraq role to combat these however, is limited. The country has already signed the Paris Agreement on climate change in December 2015, pledging to reduce greenhouse gas emissions by 15% between 2020 and 2035, the equivalent of 90 million tons of carbon dioxide. According to an article by Abu Zaid (2016) and published in *Al-Monitor* however, "The country does not have such a large number of industrial facilities or power plants or even so much use of fossil fuel, as it is the case in industrialized countries, and the rates of fuel combustion in Iraq are much less than those of said countries". It follows that corrective and protective actions should be taken in to consideration immediately within Iraq itself to limit and reduce future negative consequences. The only meaningful action taken so far in the context of the environmental changes was the launching of the National Action Program to Combat Desertification in 2015 by the Ministry of Health and Environment with support from the United Nations Environmental Program (UNEP) and some other regional organizations. But although this addresses only one of the many aspects of climate change, it is

believed that the recommended actions in this program have not been fulfilled so far due to variety of reasons; of which lack of financial resources and instability in some parts of Iraq are to be mentioned. However, and in view of the colossal problems facing Iraq there is the need to develop a comprehensive and continuous plan to limit the expected consequences of Global Change Impacts and to put it into application immediately. One of the elements of this plan is to introduce radical changes to all water and soil management policies and practices. The water sector in Iraq at the moment is suffering from endemic problems. The wide spectrum of these problems includes among other things the wasteful use of water, use of old and traditional irrigation practices, deterioration of irrigation infrastructures, illiteracy of farmers and their lack of modern technical skills, weak administrative frame works in addition to the lack of meaningful legislations to control water use. In this field the government has a challenging task to revolutionize this sector even if this is done on stages of 5 or ten years. Water scarcity in Irrigated lands requires saving every drop of water and put it to the best use. This requires sorting out the better quality lands for cultivation and crop production while the other lower quality lands should be set aside for afforestation, converting all the existing irrigation projects to the use of modern methods by changing to closed irrigation systems, drip irrigation and sprinklers especially in the north of the country where this can be used as a complementary measure, rehabilitation of all the irrigation structures and use of automation, strengthening the administrative and management framework with better monitoring and control of water sharing and supported by effective legislations and strong authority for their implementation. Better and fair pricing of water is strongly recommended to stop the current waste of this limited resource not only in the agricultural sector but in the domestic and sanitation sectors also. Use of recycled water and desalinization of salty water should be considered seriously to help in the abatement and mitigation future increased shortage. While all these actions shall be planed and implemented the government attention must at the same time be fixed on getting a fairer and better sharing of the Tigris and Euphrates water from the countries of origin; namely Turkey and Iran. This can be done through continuous negotiations based on exchanging benefits. In combating the sea level rise impacts on the southern delta and sea coast line it is necessary to carry out much more studies to define in a more accurate way and refined details of the exact changes and their locations. Based on these suggested studies plans can be prepared for staged implementing of protective works in the form of dikes and sea shore revetments. Settlements in areas that cannot be protected shall be delineated and no permanent works are allowed on them; while settled population has to be moved to other safe areas after providing all good living conditions there.

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