A Review of the Impact of Climate Change on Water and Food Security Concepts

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Abstract

Water scarcity is now a major obstacle to social and economic progress and a threat to survival in more regions of the world, there has been an urgent need to study the effects of water shortages and their impact on human security, which is directly related to water and food security. This article deals with the basic concepts and dimensions of water and food security and highlights the most important findings through local and international research and reports. On the other hand, climate change is the main component of the index for assessing water and food security in the long term, and this is manifested through increasing annual temperatures and fluctuating amounts of precipitation. In addition, the increase in population numbers and the industrial sector reduce the quantity and quality of water in the region under complex climatic conditions. There is already ample evidence of the projected effects of climate change on important agricultural crops. Globally, positive outcomes are less common than negative outcomes. The results obtained about the effects of climate change on agricultural production indicate that climate change has a significant impact on wheat and maize crops in a number of locations. Water security is designed to safeguard all aspects of water, from our everyday water use to water in our ecosystems, to even political and transboundary conflicts that may arise over water. Water security is critical to achieving sustainable and comprehensive growth.

Keywords: Climate Change, Food Security, Water Security, GCMs.

مراجعة تاثير التغير المناخي في مفاهيم الامن المائي والغذائي

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الخلاصة

أصبحت ندرة المياه الآن عقبة رئيسية أمام التقدم الاجتماعي والاقتصادي وتهديدًا للبقاء في المزيد من مناطق العالم ، كانت هناك حاجة ملحة لدراسة آثار نقص المياه وتأثيرها على الأمن البشري ، والذي يرتبط ارتباطًا مباشرًا بالأمن المائي والغذائي. تتطرق هذه المقالة الى المفاهيم والأبعاد الأساسية للأمن المائي والغذائي وتسلط الضوء على أهم النتائج من خلال البحوث والتقارير المحلية والدولية. من ناحية أخرى ، يعتبر تغير المناخ المكون الرئيسي لمؤشر تقييم المياه والأمن الغذائي على المدى الطويل ، ويتجلى ذلك من خلال زيادة درجات الحرارة السنوية وتقلب كميات هطول الأمطار. بالإضافة إلى ذلك ، فإن الزيادة في أعداد السكان والقطاع الصناعي تقلل من كمية ونوعية المياه في المنطقة في ظل ظروف مناخية معقدة. هناك بالفعل أدلة وافرة على الآثار المتوقعة لتغير المناخ على المحاصيل الزراعية الهامة. على الصعيد العالمي ، النتائج الإيجابية أقل شيوعًا من النتائج السلبية. تشير النتلئج المتحصل عليها آثار التغيرات المناخية على الإنتاج الزراعي إلى أن تغير المناخ له تأثير كبير على محاصيل القمح والذرة في عدد من المواقع تم تصميم الأمن المائي لحماية جميع جوانب المياه ، من استخدامنا اليومي للمياه إلى المياه في أنظمتنا البيئية ، وحتى النزاعات السياسية وعابرة الحدود التي قد تنشأ حول المياه. الأمن المائي أمر بالغ الأهمية لتحقيق النمو المستدام والشامل.

الكلمات المفتاحية : التغيير المناخي , الامن المائي , الامن الغذائي , نموذج التدوير العام للتغيير المناخي GCM

1. Introduction

Food, energy, and the environment all depend on water for essential human security. Almost every individual of human security will be affected by how water is managed, hence obtaining appropriate water and food security are the top concerns of government policy across the world (Babel and Shinde, 2018). Depending on the location, the frequency, and intensity of floods and droughts, the unpredictability of rainfall, the reduction in thesnowpack, and other changes all have a significant impact on the water cycle. Low-income populations are disproportionately impacted by these climate-related effects on the water cycle (IPCC, 2021; IPCC, 2018). In order to protect the world's freshwater resources, it is necessary to identify risks in a variety of sizes, from the global to the small, whose standards are linked with water and food security.

This review aims to present the impact of climate change on two global components entering human security: water and food security. This review relies on many researches and articles from all research download sites, scientific articles, and institutional reports that have clarified the role of climate change and its impact on water and food security concepts.

2. Climate Change

Global warming-related climate changes have an impact on all weather-related factors not only in Iraq but in all the neighboring nations as well. These alterations include an increase in temperature, changes in air pressure, rainfall intensity, and temporal and geographical dispersion, which lead to fluctuations in the Tigris and Euphrates Rivers' yearly stream flow (Adamo , et.al.,2018). Changes in the availability of regional water will be one of the most constrain effects of future climate changes on society. Nearly every area of human well-being will be impacted by these hydrologic changes, from energy consumption and agricultural production to flood control, municipal, industrial water supply, fish and animal management. Given how vital water is to both humanity and the environment, it is crucial to comprehend how potential changes in the global climate can affect local water resources (Xu ,1999; Schmitt, 2010; Moss , et.al.,2010).

General circulation models (GCMs) simulate climate reactions by applying physical principles and historical geographic knowledge. They have an impartial personality, and to manage the massive amount of calculations, they need supercomputers. However, it is now feasible to compare outcomes from several GCMs for a variety of timeframes, as well as over a variety of parameterizations (Price , et.al.,1995). Numerical models (GCMs), representing physical processes in the atmosphere, ocean, cryosphere and land surface, are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations .While simpler models have also been used to provide globally- or regionally-averaged estimates of the climate response, only GCMs, possibly in conjunction with nested regional models, have the potential to provide geographically and physically consistent estimates of regional climate change which are required in impact analysis, thus fulfilling criterion. GCMs depict the climate using a three dimensional grid over the globe (see Figure (1)) (https://www.ipcc-data.org/guidelines/pages/gcm_guide.html).

Typically having a horizontal resolution of between 250 and 600 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as 30 layers in the oceans. Their resolution is thus quite coarse relative to the scale of exposure units in most impact assessments, hence only partially fulfilling criterion. Moreover, many physical processes, such as those related to clouds, also occur at smaller scales and cannot be properly modelled. Instead, their known properties must be averaged over the larger scale in a technique known as parameterization. This is one source of uncertainty in GCM-based simulations of future climate. Others relate to the simulation of various feedback mechanisms in models concerning, for example, water vapor and warming, clouds and radiation, ocean circulation and ice and snow albedo. For this reason, GCMs may simulate quite different responses to the same forcing, simply because of the way certain processes and feedbacks are modelled (https://www.ipcc-data.org/guidelines/pages/gcm_guide.html).

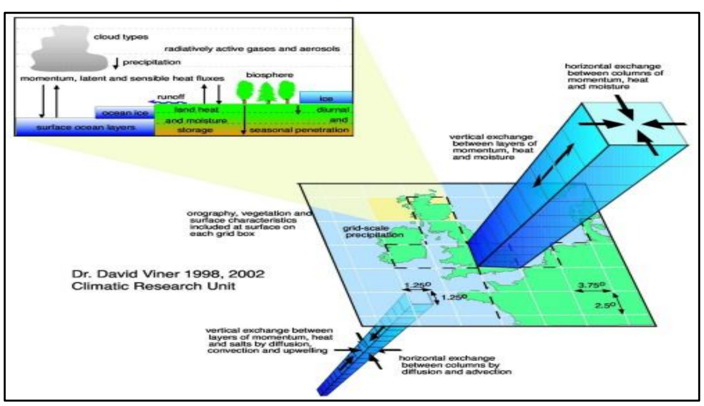

Figure (1): GCMs Components

GCMs and Earth System Models (ESM) provide a thorough representation of the scientific understanding of the earth's climate system including the crucial topic of how the climate system is expected to react to human-induced disturbances. Transparent assumptions about how the work is essential for diagnosing the simulated climate response and comparing responses across models. The implementation of GCM/ESM has been challenging, particularly because it may require subjective judgments and vary among modeling groups carrying out the same experiment (Jones , et.al.,2011). A coupled climate model (ESM) is a computer code that estimates the solution to differential equations of fluid motion and thermodynamics to obtain time and space dependent values for temperature, winds and currents, moisture and/or salinity and pressure in the atmosphere and ocean. Components of a climate model simulate the atmosphere, the ocean, sea, ice, the land surface and the vegetation on land and the biogeochemistry of the ocean(https://soccom.princeton.edu/content/what-earth-system-model-esm) .

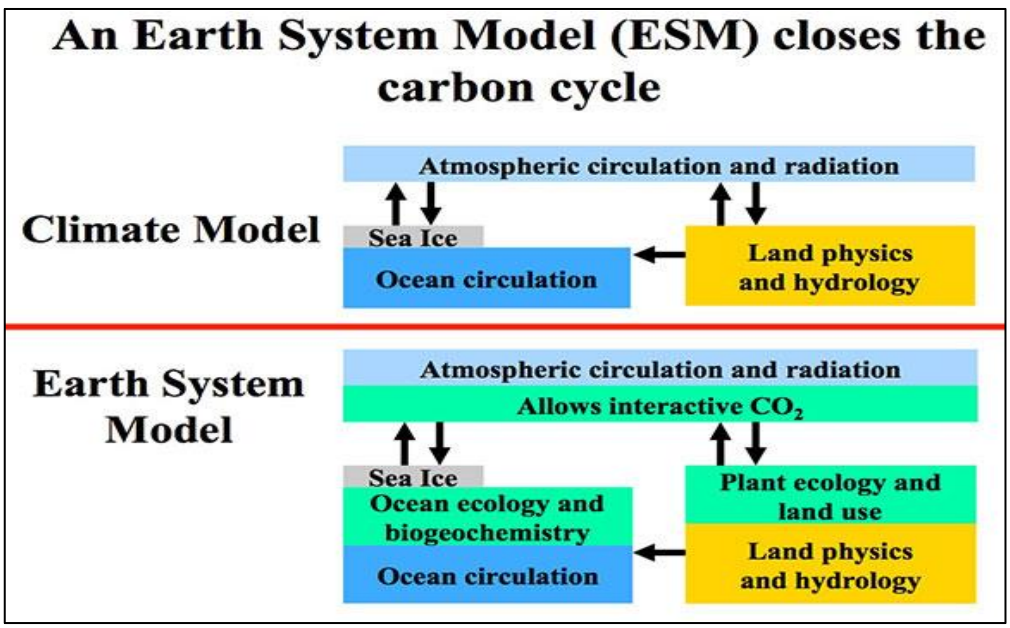

Figure (2): ESM Components

Future greenhouse gas concentrations according to four Representative Concentration Pathways (RCPs) predicted by the Intergovernmental Panel on Climate Change (IPCC).Climate change scenarios of varying speeds and magnitudes give a framework for evaluating the danger of exceeding recognizable thresholds in both physical change and repercussions on biological and human systems(Wayne 2013; Meinshausen , et.al.,2011; Hanssen-Bauer , et.al.,2017). A record amount of data, including new ESM with more accurate representations of forcing, (RCP) scenarios RCP.2.6, RCP.4.5, RCP.6, and RCP.8.5, and more output available for study, is provided by the Coupled Model Intercomparison Project Phase 5 (CMIP5)(Collins and Knutti 2013). RCP is a significant advancement in climate research that aids scientists in looking at impact and emission reduction analysis (Vuuren , et.al.,2011; Kim, et.al.,2011).

By examining some GCM models, Khayyun , et.al.,2020 investigated how to choose the best source for potential future precipitation and temperature time series data sets. The results revealed that the Hadley Centre Global Environment Model HadGEM2-ES and HadGEM2- AO were the best model for data projections and suitable for studying scenarios involving future water resources in Iraq. The HadGEM2 family of climate models represents the second generation of HadGEM configurations, with additional functionality including a well-resolved stratosphere and Earth System components. The HadGEM2 family of models comprises a range of specific model configurations incorporating different levels of complexity but with a common physical framework. 0.The HadGEM2 family includes a coupled atmosphere-ocean configuration, with or without a vertical extension in the atmosphere to include a well-resolved stratosphere, and an Earth-System configuration which includes dynamic vegetation, ocean biology and atmospheric chemistry. Members of the HadGEM2 family will be used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. The standard atmospheric component has 38 levels extending to ~40km height, with a horizontal resolution of 1.25 degrees of latitude by 1.875 degrees of longitude, which produces a global grid of 192 x 145 grid cells. This is equivalent to a surface resolution of about 208 km x 139 km at the Equator, reducing to 120 km x 139 km at 55 degrees of latitude. A vertically-extended version, with 60 levels extending to 85km height, is also used for investigating stratospheric processes and their influence on global climate (https://data.globalchange.gov/model/hadgem2) .

In order to project climate change in the Khabour River basin under four potential scenarios of RCPs (RCP.2.6, RCP.4.5, RCP.6, and RCP.8.5) of atmospheric greenhouse gas (GHG) concentrations for three future periods, the HadGEM2-ES global circulation model developed by the Met Office Hadley Centre was chosen (Haitham & Al-Mukhtar, 2022). The atmospheric and land surface components of the CMIP5-AR5 Earth System model HadGEM2-ES and HadGEM2-AO were used to download the forecast climate data from the World Bank website for the future period periods(https://climateknowledgeportal.worldbank.org/download-data) . Because the climate of Iraq is arid or semi-arid and the effect of climate change on it, researchers and scholars of water resources and their impact on water and food security need to provide climate change data (such as temperature, precipitation and evaporation), so HadGEM2-ES and HadGEM2-AO is one of the best sites to download climate data because of its ease of use and download, in addition to its availability in The World Data Bank website is free for researchers.

3. Water Security

Water security “is defined here as the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments and economies” (Grey & Sadoff ,2007; Hailu , et.al.,2020; Polaine , et.al.,2022; Albrecht & Gerlak ,2022). Due to the uneven distribution of water resources in terms of time and geography, water security is an important component of regional development (Huang et al.,2020). Global Water Partnership introduced water security by relying on agricultural production, the environment, risk management, and need clarification (GWP, 2012). Only two of the numerous challenges that humanity is currently dealing with and will continue to deal with for decades are water security and climate change. Even yet, the globe will have to deal with a lot of other pressing issues during the rest of the twenty-first century (Tortajada & Biswas ,2022). Biswas and Tortajada (2016) clarified that population increase is one of the main factors affecting water security.

Water resource security encountered several difficulties in recent years. In other words, the threat to the area's water supplies is growing. More focus on the social and environmental systems' sustainable development. The significance of water security and the issues it raises to focus water security and provide indicators for Measure (Aligholi & Hayati , 2022) .

Many researchers have identified different approach of water security, these parameters differ from one researcher to another according to the methodology used in building the framework of water security within the watershed boundaries.

Babel & Shinde, 2018, classified the approaches of water security as follows water availability, water productivity, water-related disasters, Watershed health, and Water governance. These dimensions were divided into environmental and hydrological indicators that take into account sustainability in the concept of water security, especially for the large scale watershed.

Marcal , et.al.,2022 explained the risks of the unexpected of water security in countries and their impacts on the Economy, environment, and health of living populations. Risks of losing water security Identified conflict over water as a threat to international security and peace, Identified flood risks as a challenge for people in the floodplain

The water and agricultural systems are under a populations challenge as a result of climate change. Predicted temperature increases might hasten the degeneration of agricultural lands and the worsening of water shortages (Rousset, 2007). Decision-makers throughout the Indo-Pacific face a variety of overlapping socio-economic, ecological, and political concerns. While freshwater supplies are becoming progressively strained by environmental deterioration and unsustainable consumption habits, rising populations, and economies are pushing up water demand (Okiand & Kanae , 2006; Glasser , et.al.,2022). This matches with United Nation 2017, when rising greenhouse gas (GHG) concentrations, there is a major rise in the dangers of climate change associated with freshwater. According to the most recent modeling research, 7% of the world's population is predicted to see a reduction in renewable water supplies of at least 20% for every degree of global warming. Many researchers concluded the specific dimensions of water security:

1-Water availability is classified according to many criteria, including Water scarcity and Annual per capita water resources availability (Babel & Shinde, 2018). Water is of vital and critical importance to ecosystems and human societies. The effects of human activities on land and water are now large and extensive; Marcal , et.al.,2021).

2-Water productivity is classified according to many criteria, including industrial, agricultural, aquaculture, and livestock revenue per drop (Babel & Shinde 2018). water productivity, highlighting its actual increased importance for sustained economic growth and poverty alleviation Marcal , et.al.,2021).

3- Water-related disasters can be classified into drought factors and flood factors (Babel & Shinde, 2018; Support Water Security Strategies for sustainable development against Climate Change , equal and Safe Water Use and Better Quality of Human Life (Rousset, 2007).

4- Water body health can be classified into Surface water quality factor, Groundwater quality average, class water Quality Rivers, and Biochemical oxygen demand (Babel & Shinde 2018).

4. Food Security

4.1. Food Security in General

Much has changed since 1974, when the FAO began reporting on the global prevalence of hunger. The world's population has continually increased, with most people now living in cities. Technology has advanced at a breakneck speed, while the economy has become more linked and international. All of this has resulted in significant changes in the way food is produced, delivered, and eaten across the world. However, these changes have resulted in concerning trends in malnutrition. Although child stunting has declined dramatically over the last 20 years, overweight and obesity, as well as diet-related non communicable illnesses, remain on the rise (FAO, 2019).

This vastly different world calls for new ways of thinking about hunger and food insecurity and their consequences for nutrition. The imperative is to make sure no one suffers from hunger. But we must also recognize that there are many people who, while not "hungry" in the sense that they suffer physical discomfort caused by severe lack of dietary energy, may still be food insecure. They have access to food to meet their energy requirements, yet are uncertain that it will last, and may be forced to reduce the quality and/or quantity of the food they eat in order to get by. This moderate level of severity of food insecurity can contribute to various forms of malnutrition and has serious consequences for health and well-being (FAO, 2002).Now can be define the food security from (FAO, 2002):

‘‘A situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” Clearly, not all crop production is dedicated to food security. Industrial fiber crops and biofuels) and beverage crops make no direct contribution to kilocalorie consumption by human beings although some industrial crop residues are used as livestock fodder (FAO, 2008). But overall, water management in crop production tends to be concentrated on food crops where the timing and reliability of supply is critical. Water management (irrigation, drainage, and water conservation) achieves stability of crop production by maintaining soil conditions close to optimum for crop growth. Irrigation allows the cultivation of crops when , fluctuating is erratic or insufficient, insures high-value, high-risk horticulture from failure, and has played a major role in achieving national and regional food security in Asia, as well as improving individual livelihoods (Hussain, 2005).

More than any other industry, agriculture is extremely sensitive to the effects of climate change. Food is produced in rain-fed systems throughout the majority of the poor world, including many Indo-Pacific farmers, without consistent access to irrigation. These systems are extremely susceptible to variations in temperature, precipitation patterns, and harsh weather (Glasser , et.al.,2022).The extent and area of irrigation have grown massively in the twentieth century but have depleted surface and groundwater flows, often with severe consequences for aquatic ecosystems and those dependent on them (Emerton and Bos, 2004; FAO, 2004a). It is increasingly recognized, although rarely common practice, that greater net socio-economic benefit can be obtained from maintaining the integrity of managed ecosystems (FAO, 2004a; Gibson, 2012; Peng & Berry 2018; FAO, 2008) give the dimensions of Food Security which are listed below, Figure1:

1. Food Availability

The availability of sufficient quantities of food of appropriate quality supplied through domestic production or imports (including food aid).

2. Food Access

Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).

3. Utilization

Utilization of food through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security.

4. Stability

To be food secure, a population, household, or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

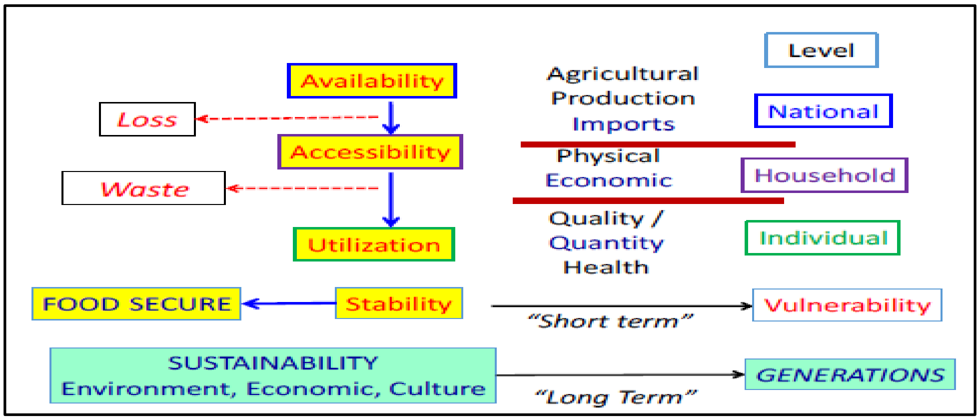

Figure (3): Approaches of Food Security (Berry, et.al., 2015).

In addition, the Food Security Conceptual Framework (FIVIMS) add two dimension model provides the definition for other key concepts such as food insecurity and vulnerability (World Food Program, 2004):

- Food Insecurity: A situation that exists when people lack secure access to sufficient amounts of safe and nutritious food required for normal growth and development and an active and healthy life. It may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level. Food insecurity, poor conditions of health and sanitation and inappropriate care and feeding practices are the major causes of poor nutritional status. Food insecurity may be chronic, seasonal or transitory.
- Vulnerability: The presence of factors that place people at risk of becoming food insecure or, adaption including those factors that affect their ability to cope.

4.2. Food Security in Iraq

There are a good agricultural practices available in Iraq such as north rain-fed area in north of Iraq, and using irrigation from the Tigris and Euphrates rivers in the central and south. Agriculture consider a traditional way of life in Iraq peoples and it is one of the biggest employment sectors, with relatively high numbers of women and youth employed. Food security depends on agriculture (UNESCO, 2019).

The importance of agriculture is not restricted to feeding the population. Agriculture area, like the food it produces, is a cornerstone to several major aspects of life: culture, health, livelihoods, and prosperity. In Iraq, agriculture is the second largest contributor to Gross domestic product (GDP) oil production and employs approximately 20% of the population. Although the sector's contribution to the economy declined from about 9% in 2002 to 3.6% in 2009, it is still a major source of livelihood for the poor and is the largest source of rural employment.

The agriculture sector was growing rapidly, nearly doubling in value between 2009 and 2013, before falling by 30% after 2014. The agricultural sector in Iraq has faltered due to conflict, poor access to water, deteriorating soil quality, challenging legislative environment; and low public and private investment in new technologies for equipment, irrigation, farming, and fishing.

Many studies explained is depended on the studies which explained the low productivity per unit area with a large waste of water due to use ancient and traditional irrigation methods where the irrigation efficiency ranges is between 60-70% , losses transport to 33% and field losses 30 - 40%. In addition to, a large part of the Iraqi territory was affected by a problem salinization and waterlogging, especially in the two regions central and southern regions due to poor operation, maintenance and lack of integrated drainage networks (ESCWA, 2019).

ESCWA, 2019 showed the lands that need the irrigation networks which depend on the availability of water, however there are extensive plans to use water before upstream countries in view of the unfair use of water from before the riparian states of the common river basins Tigris and Euphrates .

The agricultural sector faces many problems and challenges which increase the effect with successive droughts, rainfall fluctuating, environmental changes, growing demand and agricultural products. All these reason is reflected in the demand for water, with limited supply as a result of population growth resulting in insufficient self-sufficiency. The contribution of the agricultural sector to the GDP decreased. So that, the state towards to importing from abroad to fill the deficit and this costs the economy Iraqi sums are large.

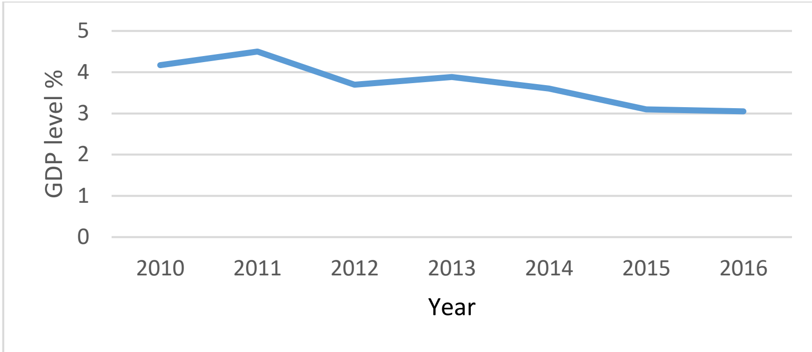

Figure (4): the contribution of the agricultural sector to the GDP (2010-2016)

Al-Wazzan and Al-Hamada (2017) clarify in their research important points, which are related to each other by interrelations, reflecting the level of Food Security in Iraq between the two variables of supply and demand, and thus represented:

1. The agricultural potential in Iraq, which reflects the agricultural reality and the ability to meet food demand.
2. Development of population numbers.
3. Income level.
4. Strategic grain production rates.

AL-Wazzan and Al – Hamada 2017 explained in their study depended on data and statistics vided by the international agencies of nutrition as well as a special questionnaire prepared, applying the international measures of nutritional security shows that inhabitants of Diyala and Babylon districts were suffering more than the other people of Iraq, while the people Sulaymaniyah, Dohuk, Arbil, MUSIAL and Baghdad were the less affected by the nutritional problem.

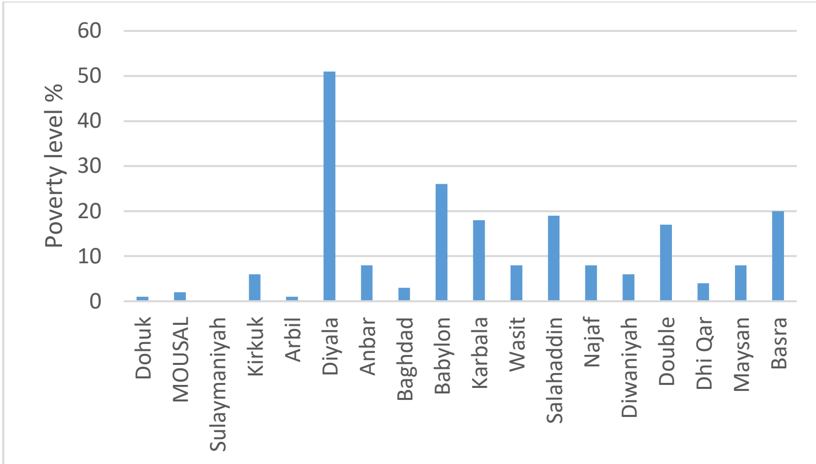

Figure (5): Poverty level for each Governorate (AL-Wazzan & Al – Hamada 2017).

The climate of Iraq is sub-continental, influenced by the climate of the White Sea Average widens the daily and the annual thermal range, which is reflected in an increase in the rate of evaporation.

5-Impact of climate change on food and water security concepts

Natural fluctuations in the global climate serve as a backdrop to human-caused climate change (WFP, 2018),

- Climate Change effects on water resources globally, it is anticipated that future climate change would have more detrimental effects on freshwater systems. According to projections, by the mid-2050s, more land will be susceptible to rising water stress as a result of climate change than will be under rising water stress. It is anticipated that increasing yearly runoff in some regions would boost the total water supply. The detrimental consequences of increasing precipitation variability and seasonal runoff changes on water availability, water quality, and flood risks are projected to outweigh this gain in many locations, though(UNDP,2010; Morrison et al.,2010;UN 2019).
- As a result of protracted dry spells and a severe drought, there will be an increase in the water needed for agriculture, especially irrigation. According to some studies, the amount of irrigated land would expand by more than 40% by 2080(Morrison et al., 2010).
- The expected effects of climate change on key crop yields are now well documented. Positive effects are less frequent than negative ones worldwide. Wheat and maize yields have already been significantly impacted by climate change in several places, as well as internationally,

according to observations of the impacts of climatic trends on crop output (FAO 2015).On the other hand, Future temperature increases might lead to significantly lower agricultural yields in some locations, while changes in precipitation could have an impact on crop output in crucial areas (WFP 2018).

5. Conclusions

Water shortages are now a major impediment to social and economic progress and a threat to survival in more regions of the world. The repercussions of water scarcity and their influence on human security, which is closely tied to water and food security, were urgently in need of investigation. The most significant of these characteristics are highlighted in this article through local and international research and reports, which also discuss the fundamental ideas and dimensions of water and food security. The article included an explanation of the risk of losing food security and water security, as well as showing the dimensions for each element .Especially food security in Iraq because the agricultural sector faces many problems and challenges which increase the effect with successive droughts, rainfall fluctuating, environmental changes, growing demand and agricultural products. All these reason is reflected in the demand for water, with limited supply as a result of population growth resulting in insufficient self-sufficiency.

The impact of climate change on food and water security concepts was studied in studies and articles as a long-term water, which is shown by rising yearly temperatures and increased precipitation variability amounts. Additionally, under challenging weather circumstances, the region's water supply and quality are reduced due to population growth and the industrial environment. There is already a lot of proof of how significantly agricultural products will be affected by climate change. Among the main conclusions about the impact of climate is its impact on water resources in Iraq, drought in the lands and lack of crop production. To confront the effects of climate change on water and food security, strategies must be mentioned in the management of water resources, especially in improving irrigation efficiency, and proposing agricultural patterns suitable for climate change and meeting human needs.

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