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Would Climate Change Jeopardize Food Security in the MENA Region?

هل يشكل تغير المناخ خطرا على الأمن الغذائي في منطقة الشرق الأوسط وشمال أفريقيا؟

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Abstract: Climate change exacerbates the existing challenges to food security in the Middle East and North Africa region. Challenges include water scarcity, increasing population, economic slowdown, global crisis as COVID-19, and Russo-Ukrainian war. The present paper aims to contribute to the existing literature tackling climate effects on food security in the region. The paper investigates the impact of climate on food access and food utilization, using panel data for 12 MENA countries during the period from 2000 to 2020. The findings show that GHG emissions and changes in surface temperature negatively affects food access in the region by increasing the number of undernourished. However, food utilization, measured by the prevalence of stunting among children under five years older, is not affected by the used climate indicators. Moreover, the main drivers of food security in the MENA region include inflation, urbanization and access to sanitation. The findings are policy relevant. Policies and intervention programs should differ according to the targeted dimensions of food security. Adaptation and mitigation strategies are required to ensure food security and environmental sustainability.

JEL classification : C33, O13, Q18.

Keywords : Climate change; food security; food access, food utilization; MENA region

الملخص: ان التغير المناخي قد يؤدي الى تفاقم تحديات الأمن الغذائي في منطقة الشرق الأوسط وشمال أفريقيا. تشتمل التحديات على ندرة المياه، الزيادة السكانية، البطء في النمو الاقتصادي، وأزمات عالمية مثل كوفيد 19 والحرب الروسية - الأوكرانية. هنالك وفرة في الأدبيات التي تناقش أثر تغير المناخ على إتاحة الغذاء من خلال التأثير على الإنتاج الزراعي. تهدف الورقة الحالية للمساهمة في الأدبيات الموجودة لدراسة العلاقة بين التغير المناخي والأمن الغذائي في منطقة الشرق الأوسط وشمال أفريقيا من خلال التحقيق في قدرة الوصول إلى الغذاء واستخدام الغذاء. تم استخدام البيانات المقطعية الزمنية لاثني عشر دولة من دول الشرق الأوسط وشمال أفريقيا خلال الفترة من 2000 إلى 2020. وقامت الورقة بتقدير أثر العوامل المناخية المختلفة (تغير درجات الحرارة، الأمطار، وانبعاثات غازات الاحتباس الحراري) على قدرة الوصل إلى الغذاء واستخدام الغذاء. أظهرت النتائج بإن انبعاثات غازات الاحتباس الحراري وتغيرات درجات حرارة السطح تخفض من قدرة الوصل إلى الغذاء في المنطقة عن طريق الزيادة في أعداد من يعانون سوء التغذية. وبالرغم من ذلك وفيما يخص استخدام الغذاء والذي يقاس عن طريق انتشار التقزم بين الأطفال دون سن الخامسة، لا يتأثر استخدام الغذاء بالعوامل المناخية المستخدمة في النموذج. علاوة على ذلك، يضم المحرك الرئيسي للأمن الغذائي في منطقة الشرق الأوسط وشمال أفريقيا التضخم، والتحضر، والوصول إلى خدمات الصرف الصحي وعدم المساواة في الدخول. وفقا لنتائج الدراسة ينبغي أن تختلف السياسات وبرامج التدخل وفقًا للأبعاد المستهدفة للأمن الغذائي. وهناك حاجة إلى استراتيجيات التكيف والتخفيف لضمان الأمن الغذائي والاستدامة البيئية للمنطقة.

الكلمات الدالة: التغير المناخي، الأمن الغذائي، الوصول للغذاء، استخدامات الغذاء، منطقة الشرق الأوسط وشمال أفريقيا.

Introduction:

Climate change, measured by increasing temperature, variability of precipitation, greenhouse gases (GHG) emission, water scarcity, flood and droughts, is a global and complex phenomenon that affects all aspects of human life. The Middle East and North Africa (MENA) region is one of the most vulnerable areas to climate change risks, even though they represented about 5% of the world's total emissions of GHS in 2019 (Lienard, 2022). The region is considered as one of the most water-stressed regions in the world, putting pressure on agriculture production. Agriculture is a key sector for both social and economic development and plays a vital role in ensuring food security in MENA countries. As the largest water-consuming sector in the region, the sector is vulnerable to climate change effects. Rising temperatures and declining rainfall result in a decline in crop productivity and yields, increasing dependence on food imports.

Estimates predict that climate change will decrease precipitation in the MENA region, leading to a reduction of internal renewable water (rivers and aquifers) by 4% by 2050 (Frederic and Ninar, 2022). Additionally, rising sea levels is expected to change the land use in the land scarce region, reducing the available land for agriculture production. It is expected that the global sea level will rise from 30 to 122 cm by the end of this century, leading to losses in agriculture areas and more migration stress from coastal to urban areas. Moreover, temperature is predicted to rise by 4 °C by 2050. If GHG emissions keep increasing at the same current rate, the projected temperature in the future will surpass the human adaptability threshold in the MENA region. The rising temperatures and decreasing water resources will continue to accelerate the desertification rate and shrink arable lands. Desertification has negative effects on ecosystem dynamics, human health, air quality, and land productivity.

Within this context, the literature investigating climate change and food security in the MENA region is abundant but focuses on food availability (Alboghdady and El-Hendawy; 2016; Tekce and Deniz, 2016). Though, climate change does not only affect food availability. Climate change is also expected to adversely affect other dimensions of food security in the region, through different channels. Droughts, floods, heat waves and water scarcity reduce global food production, resulting in rising food prices and limiting access to food. Additionally, individuals working in agriculture sector or other sectors vulnerable to climate change, are expected to lose their income and fall into poverty (Tull 2020; Peter Lankes et al, 2022).

With a limited fiscal space and inefficient social safety nets, the limited purchasing power of households threatens their food security as reflected in the quality and quantity of consumed food. Food utilization dimension is affected as well through the decrease of the nutritional quality and the spread of diseases in the air and water due to elevated CO_2. Moreover, the food stability dimension will be directly affected by the negative impacts of climate change on the other three food security dimensions.

The present paper aims to contribute to the existing empirical literature by investigating other dimensions of food security, mainly food access and food utilization in the MENA region.To the knowledge of the authors, there is limited empirical research tackling these two dimensions in the region. More precisely, the paper is an attempt to answer the following questions: (1) what is the impact of climate change on food access in the MENA region? and (2) what is the impact of climate change on food utilization in the MENA region? Using a panel data for 12 MENA countries during the period from 2000 to 2020, the paper estimates the effects of different climate indicators (change in temperature, precipitation and GHG emission) on food access and food utilization.

The paper is organized as follow; section 1 reviews the literature tackling climate change and food security in the MENA region. Section 2 presents the economic and food security status in the selected 12 MENA countries. Sections 3 presents the methodology used and section 4 discusses the estimated results. Finally, section 5 concludes.

1.Literature Review:

According to World Food Summit (WFS) in 1996, "food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life". This widely accepted definition reflects the multi-dimensions of food security. More precisely, food security consists of the following four dimensions (1) Availability: the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports; (2) Access: access by individuals to adequate resources for acquiring appropriate foods for a nutritious diet; (3) Utilization: the utilization of food through an adequate diet, clean water, sanitation, and healthcare to reach a state of nutritional well-being where all physiological needs are met; and (4) Stability: to be food secure, a population, household, or individual must have access to adequate food at all times.

Food security is a key goal for development and interlinked with the other development goals. There are many theories to explain drivers of food security, including: (1) Neo-Malthusian Perspectives; (2) Techno-ecology theory; (3) Urbanization and (4) Dependence and world system theories. The Neo-Malthusian theory focuses on the negative effects of population pressure on planet's resources and the ability to nourish people. According to this theory, there is a need of a sustainable society to maintain food security. Sustainability ensures the needs of the current generation without affecting the needs of future generation. While for the Techno-ecology theory, it confirms that human creativity and technology acts as non-scarce resources that can increase yields and reduce environmental damages at the same time. Therefore, the future challenges can be overcome through human ingenuity and technology like adoption of new effective agricultural practices to produce sufficient food to the increasing population (ProEssays, 2021).

The Urbanization theory highlights the disparity between urban and rural areas in which urban areas get more attention and better services, infrastructure and food, leaving the rural areas undeveloped. As a result, the higher rate of urbanization might put more pressure on food security, affecting its different dimensions. Finally, the Dependence and World System theories confirm that food security is a complex and global phenomenon with the existence of many international factors that affect hunger, and there is a relationship between individuals, countries and the global food order (ProEssays, 2021). The analysis in this paper is based on these theories, by investigating the global climate change, economic and political factors affecting food security.

The adverse effects of climate change on food security can be explained through different channels. First, climate change negatively affects food availability through its effects on agro-ecosystems and agricultural production. Climate change have negative impacts on sources of income and purchasing power of individuals, mainly for those working in the agriculture sector. This would result in an increase in number of undernourished, a decrease in the average per capita food intake and nutritional quality. Other channels include the negative drawbacks of climate change on water and air quality and spreading various diseases.

The impact of climate change on food security in the MENA region has been pointed out in many previous studies, mainly focusing on food availability dimension. Alboghdady and El-Hendawy (2016) investigated the negative impact of climate change on agriculture production in the MENA region by using fixed effect regression analysis and marginal impact analysis of a panel data during the period of 1961 to 2009[1].

The results show that a 1% increase in temperature during winter and spring led to a 1.12% and 0.14% decrease in agricultural production, respectively. Results also indicated that increased precipitation during winter and fall seasons (due to climate change) had a negative impact on agricultural soil and its productivity. The overall findings conclude that climate change has significant non-linear impacts in the MENA region, particularly on agricultural production. Similarly, Tekce and Deniz (2016) highlights the negative impact of climate change on the environment and the economies of the MENA countries. Using a panel data of 11 MENA countries from 1980 to 2013, the results show that both the temperature and precipitation have non-significant impacts on agricultural trade variables. Oil consumption has positive significant impact on agricultural trade variables, on other hand; oil consumption per capita has negative impact on trade volume. The trade agreement dummy has negative and significant effect on agricultural trade volume as a ratio of GDP and agricultural import as a ratio of GDP. Finally, growth rate has a positive impact on agricultural exports as value and as ratio of GDP.

The Food-Energy-Water (FEW) Security faces several challenges in the MENA region. Hameed et al. (2019) examined the FEW systems in sixteen countries of the region.[2] The indicators taken into consideration to assess the FEW systems are climate change, water security, economic growth, population growth, urbanization, poverty, food security, and political stability. The results show that most of countries are facing FEW resources insecurity due to poor planning and/or management strategies. Moreover, the study found

[1] The study includes twenty Middle East and North Africa countries: Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, Turkey, United Arab Emirates and Yemen.

[2] The study includes sixteen Middle East and North Africa countries: Iraq, Iran, Syria, Lebanon, Israel, Palestine, Egypt, Turkey, and the Arabian Peninsula (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia (KSA), United Arab Emirates (UAE), and Yemen).

that both climatic and socio-economic factors have a negative impact on FEW resources in the region, particularly on the water sector. The overall findings of this study conclude that in terms of water-energy security, energy production is mainly affected by drought, water deficiency, and economic growth in the MENA region. And that in terms of water-food security in those countries; it is highly affected by water scarcity, drought, urbanization, population growth, and political unrest. Recently, Jemmali et al. (2021) analyzed the dynamic relationships between climate change, agricultural sustainability, and food-water poverty for a panel of 21 MENA countries[1]. Panel fixed effect and random effect models are estimated for the period from 1990 to 2016. They found that the depth of food deficit is negatively associated with agricultural value added, cereal yields and GDP per capita. CO_2 emission is associated with an increase in food deficit, similarly, an increase in precipitation would increase food deficit. There is a negative and significant relationship between temperature and prevalence of undernourishment.

The literature tackling food access and food utilization might not as rich as the literature tackling the availability dimension (Lobell and Burke, 2010; Tirado et al. 2010; Datta, 2023; El Bilali, H. 2023; Ibrahim, 2023; Ibrahim, 2024 and Guo, 2023). Despite the use of different models for each study, these studies have shown a close relationship between climate change and the difficulty of obtaining food or even the safety of that food when it is possible to reach and obtain.

Food access is affected by climate change through the channels of food price and source of income. The decline in global food production and the interruption of global food value chains resulted from environmental phenomena might result in an increase in food price and decline in sources of income. The decreasing purchasing power of individuals limited their economic access to food. For the impact of climate change on food utilization, Lobell and Burke (2010) described two main pathways by which climate change affects food utilization. Diet, the first pathway, entails impact on the nutrient content of the food people grow and eat. Health, the second pathway, entails food and water safety and diseases and infections that impact the body's ability to absorb nutrients as well as nutrient requirements. Similarly, Tirado et al. (2010) and Porter et al. (2014) pointed to the negative impact of climate change on food utilization through a reduction in the production and consumption of some food items. This is because of the decrease in the nutritional quality and safety of those items, particularly cereals. Additionally, Zheutlin et al.

(2014) investigated the climate change impact on human health particularly children. The author concludes that there is a strong relationship between climate change and increasing child malnutrition, obesity, and diabetes due to increasing level of greenhouse gases including the carbon dioxide.

As a result, climate change has a negative impact on the food stability dimension, through its impact on all the other dimensions (Hashem, 2020). Mahmah and Amar (2021) investigated the role of the agriculture sector in ensuring food security in the MENA region using a panel data model for each food dimension (availability, accessibility, utilization, and stability) over the period (1990–2017). Using a GMM method, they found that food security in the MENA region depends on both agricultural and various macroeconomic factors like trade openness, international food prices, and the oil sector, which may affect a country's food security position. More recently, Ibrahim (2023) analyses the impacts of climate change on food security dimensions in Egypt during the period 2022 –2070 by using the ARIMA Model. The paper found that there is a negative and significant impact of climate change on all dimensions of food security. In terms of food access, food prices are expected to rise from 13.5% to 18.9% by 2070, declining the purchasing power of individuals and limiting access to food. It is expected that there will be an increase in the percentage of children under 5 years of age who are overweight from 17.8% to 21.2% and an increase in the prevalence of obesity in the adult population (18 years and older) from 40.0% to 53.1% by 2070.

To conclude, climate change reflected in high temperature, greenhouse gas emissions, rising sea levels and other climate change-related phenomena, is expected to negatively affect all food security dimensions, exacerbating already existing challenges. Climate-related shocks might jeopardize the welfare of vulnerable population groups as poor households, women and elderly. The adverse drawbacks on their sources of income would limit their purchasing power limiting their access to food in terms of quantity and quality. These negative effects are amplified in contexts of rising inflation and global crisis. This was observed during the COVID-19 crisis and the Russian invasion to Ukraine. Vulnerable households resort to coping strategies affecting their food security, as a reduction in number of meals consumed or consumption of less nutritious cheap food items (World Food Programme, 2020; UNDP, 2021).

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[1] The study follows the definition of the MENA region adopted by the World Bank which includes Israel, Iran, Malta and the Arab world, minus Mauritania.

Though, to our knowledge, most of the literature tackling food security and climate change in the MENA region focuses on the availability dimension through focusing on agriculture. Consequently, the aim of the present paper is to fill this gap by analyzing the impact of climate change indicators as temperature, precipitation and GHG emission on food access and food utilization in 12 MENA countries during the period 2000-2020.

2.Food Security in the MENA region

The analysis in the present paper includes 12 countries of the MENA region. The selection of the countries is mainly driven by data availability. These countries are Algeria, Egypt, Iran, Iraq, Jordan, Lebanon, Kuwait, Morocco, Oman, Saudi Arabia, Tunisia, and United Arab of Emirates (UAE).

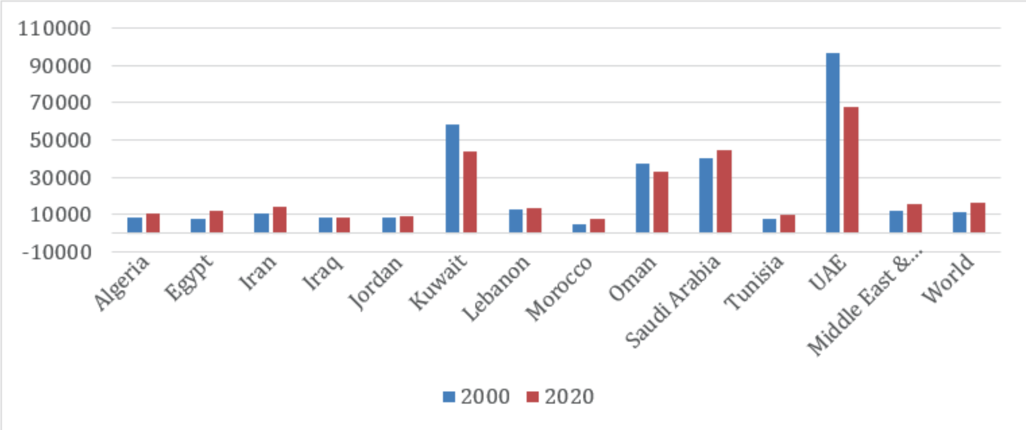
The studied countries are heterogeneous in terms of economic context and food security. The GDP per capita in the MENA region increased between 2000 and 2020 by 26 % to reach 15581 PPP (constant 2017 international $). This increase in GDP per capita hides heterogeneity between the different selected countries. In 2020, GDP per capita varies between 7546 PPP (constant 2017 international $) in Morocco and 67668 PPP (constant 2017 international $) in UAE (Figure 1). Similarly, population growth and urban population vary between the different countries. In 2020, some countries as Algeria, Egypt, Iraq and Jordan have population growth higher than the World average of 1.01. While other countries face negative population growth as Lebanon and Oman (Figure 2). Population growth is one of the main challenges facing food security in high populated countries in the region. The local production is not sufficient to feed the increasing demand resulting in increasing dependence on food imports.

Population growth and urbanization are two challenges for food security. Food stability is threatened by rapid population growth, one of the main drivers of climate change phenomenon due to human economic activities (Yassin, 2016). And the rapid rate of urbanization puts pressure on available land for agriculture production. Urbanization causes changes in dietary habits and increases demand on processed food resulting into high rate of obesity and overweight. In almost all the studied countries, urban population represents more than 50% of total population (Figure 2).

Food security status varies between the different countries and over the years. According to the latest available data, in 2020, the prevalence of moderate or severe food insecurity in the population varies between 7.5% of total population in UAE and 43% of total population Jordan, which is higher than the world's prevalence of 28%.

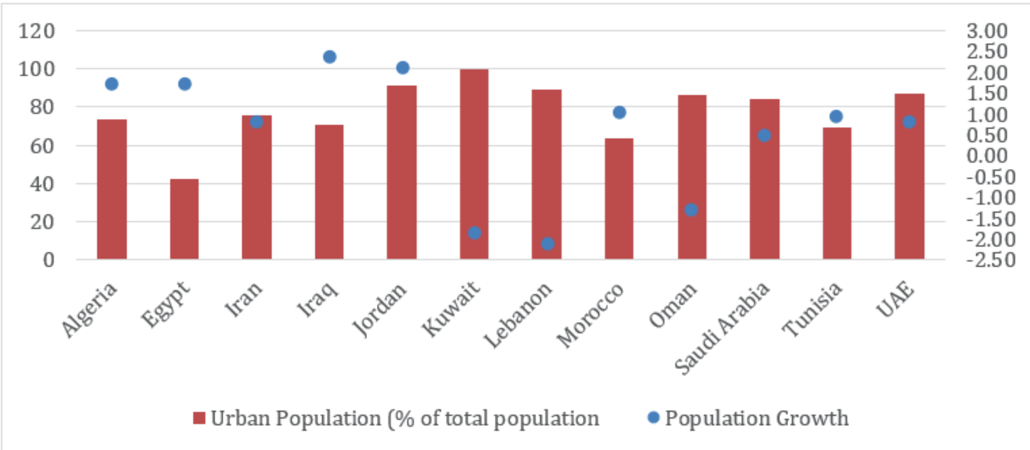
Between 2015 and 2020, the prevalence of moderate or severe food insecurity decreased in Kuwait, Algeria, Egypt and Iran while it increased in Jordan, Morocco and Tunisia (Figure 3).

Figure 1: GDP per capita, PPP (constant 2017 international $) from 1990 to 2020



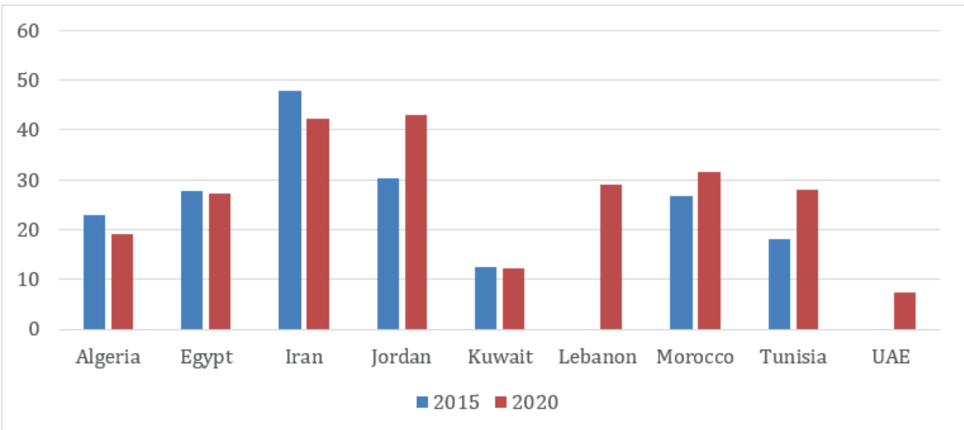
Source: Constructed by the authors from WDI (2023)

Figure 2: Population Growth (%) and Urban Population (as % of total population) in 2020



Source: Constructed by the authors from WDI (2023)

Figure 3: Prevalence of moderate or severe food insecurity in the population (%)



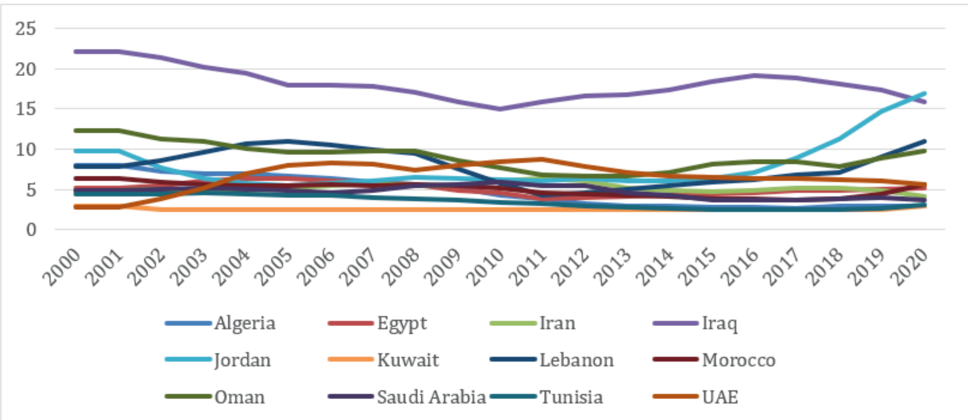
Source: Calculated by the authors from WDI (2023)

For Food utilization, the prevalence of undernourishment had varied over the years, with heterogenous time trends between countries. Over the 20 years from 2000 to 2020, Iraq faces the highest prevalence of undernourishment, with an average of 18% of the total population. This high rate is expected given the conflict context in the country. On the opposite, countries as Kuwait and Tunisia have the lowest prevalence of undernourishment with less than 5% over the 20 years (Figure 4).

Household food insecurity is associated with inadequate intake of micronutrients among children and women (Ghose et al, 2016). The prevalence of anemia among children and women (pregnant and non-pregnant) is one of the common measures of the utilization dimension of food security. Many of the studied countries succeeded in reducing the prevalence of anemia among children between 2000 and 2019. However, the prevalence of anemia among children of age 5 years old remain 20% or higher for the selected countries (Figure 5). This means that more efforts need to be done regarding food utilization to ensure food security.

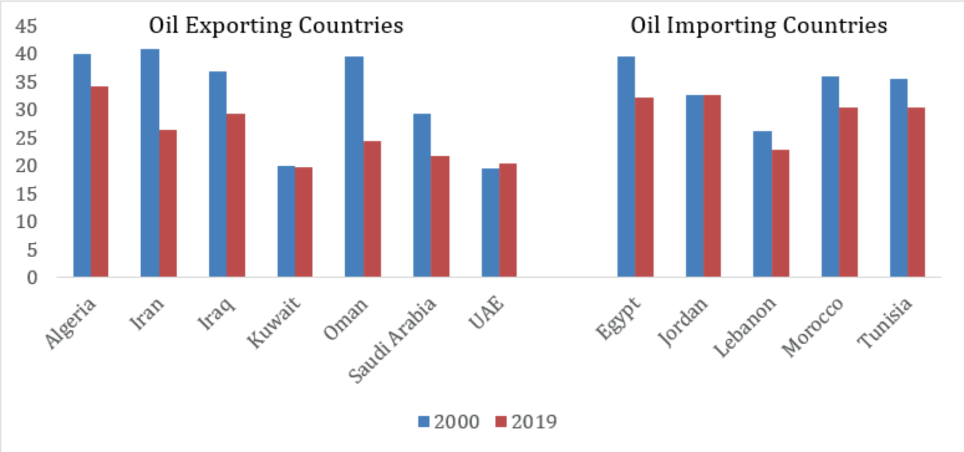
Stunting among children under five years old is a key challenge facing food security in the region over the years. This measure of food security is highly correlated with chronic poverty, another barrier to the region's development. All selected countries, except Kuwait and Saudi Arabi succeeded in decreasing stunting rate between 2000 and 2020. However, the rate remains high than 5% in all countries in 2020, with the highest prevalence in Egypt (21% among children under five years old) (Figure 6).

Figure 4: Prevalence of undernourishment (% of total Population) from 2000-2020



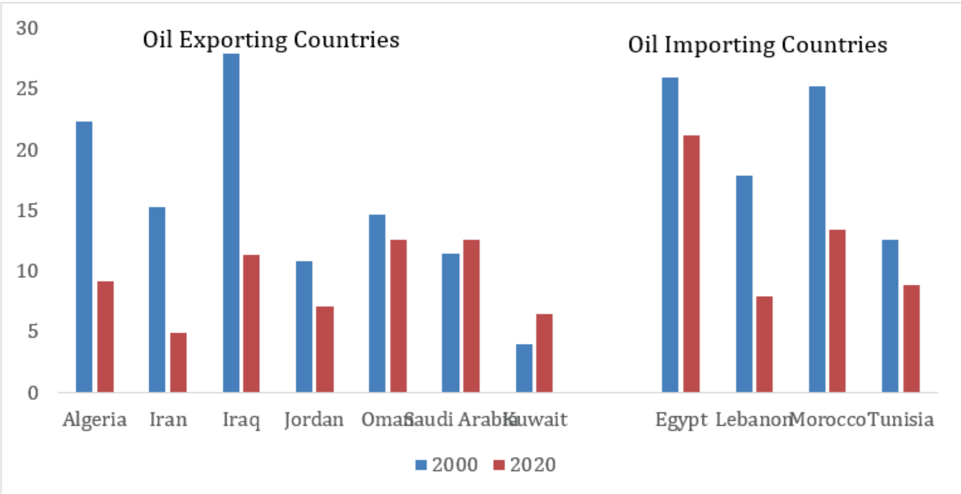
Source: Constructed by the authors from the WDI (2023)

Figure 5: Prevalence of Anemia among children (2000-2019)



Source: Constructed by the authors from the WDI (2023)

Figure 6: Prevalence of stunting among children under five years old



Source: Constructed by the authors from the WDI (2023)

3.Data and Methodology

The data used in the paper is collected from different sources including the Food and Agriculture Organization of the United Nations (FAO), the World Development Indicators (WDI), the Climate Change Knowledge Portal (CCKP) and the IMF for the 12 selected countries over the period from 2000 to 2020. The summary statistics of the used variables are present in table 1.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Number of undernourished (Million)	252	1.80	1.75	0.09	7.00
Prevalence of stunting among children under 5 years old	231	13.25	6.28	4.00	27.90
Agriculture, forestry, and fishing, value added (% of GDP)	252	5.85	4.24	0.16	15.54
Services Value Added (% of GDP)	242	49.70	11.38	10.86	87.42
Urban population (% of total population)	252	74.18	14.77	42.70	100.00
Trade Openness	252	85.15	31.83	30.20	221.90
inflation	234	5.86	9.32	-10.07	84.86
Precipitation	252	181.02	177.43	10.88	939.73
Mean Temperature Change	231	1.25	0.50	0.05	2.71
GHG emission	252	208946.60	221432.50	18884.75	891701.00

The paper examines the effect of climate indicators on two food security dimensions, food access and food utilization, while controlling for other socio-economic determinants of food security. More precisely, the following model will be estimated:

$$FS_{it} = \alpha + X_{it}\beta + \varepsilon_{it} \ (1)$$

FSit is the food security indicator measured for country i at time t. Two food security indicators will be used: prevalence of undernourishment for food access (Access Model) and prevalence of stunting among children under five years old for food utilization (Utilization Model). The climate change indicators, the explanatory variables of interest, include GHG emission, annual surface temperature change, and change in precipitation. These selected variables might affect food access and utilization through different channels. One of these channels as discussed above is the effect of GHG emission and temperature on food production. Another channel includes the effect of these indicators on the productivity and the income levels of individuals working in sectors affected by climate change. Given the potential multicollinearity between the different climate indicators, two versions of each model will be estimated. One version is estimated using GHG emission and another version is estimated using annual surface temperature change and change in precipitation.

The choice of the control variables is based on the different theories - Dependence and World System theories and the Urbanization theory - and the literature discussed above (Jemmali et al, 2021 and Mahmah and Amar, 2021). Following the Dependence and World System theories, the model includes countries characteristics as economic growth, inflation and access to sanitation. To control for economic growth, the model incudes the shares of agriculture and of services value added as percentage of GDP to reflect the structure of economic growth. This allows avoiding multicollinearity between economic growth and other macro-economic indicators. Similarly, the model includes trade openness, given that food security is affected by the global food order (Dependence and World System theories). Trade openness is a key factor, mainly for food importer countries as countries in the region. Finally, the urbanization level is included in the model as recommended by the Urbanization theory.

Given the nature of the panel data, the number of observations (N) and of time series (T) in the panel, we estimate fixed-effect, random-effect and pooled OLS models for each food security dimension. In the fixed-effects approach, time is constant, and unobservable factors are either captured by dummy variables or eliminated through time-demeaning. The time-invariant (unobservable) disturbances are part of the disturbances in the random-effects model, so their correlation with the regressors is zero. If this assumption is met, the random-effects estimator will have a more significant efficiency advantage than the fixed-effects estimator. Hausman's (1978) specification test is used to investigate the appropriateness of either fixed- or random-effects approaches. Finally, for robustness check, pooled OLS model is estimated using the same variables in addition to year dummies.

The reference year is 2008, the year of food crisis. Additionally, we include a dummy variable equals 1 if the country is a GCC country, 0 otherwise.

4.Results and Discussion

The results of the estimated fixed effects and random effects models of the two dimensions of food security are presented in Tables 2 and 3. Using the Hausman test[1], the results show that when the GHG emission is used as an indicator of climate change, the random effects regression is suitable for both the access and utilization models. While when the annual surface temperature change and precipitation change are used, it is the fixed effect model that is more suitable.

The results show that climate change has a significant adverse effect on food access. Increasing temperature and GHG emission increase the number of undernourished in the MENA countries. These adverse effects correspond to what was found in the literature (Lloyd et al, 2011; Jemmali et al, 2021) and can be explained through food availability and poverty channels. Increasing temperature and GHG emission might result in a declining agricultural productivity and food production, mainly in a context of water scarcity as in the region. The negative effect of climate change on agriculture production result in a decline in food availability and an increase in food prices. Additionally, increasing temperature has negative effect on agriculture productivity resulting in lower income for those depending on agriculture sector as the main source of income. As poverty and food security are highly correlated, those vulnerable individuals will have limited economic access to food.

However, climate change has no significant effects on food utilization, measured by the prevalence of stunting among children under five years old. This result is valid for all climate change indicators used in the two models. This result can be explained by the fact that stunting is highly correlated with chronic poverty. Drivers of stunting includes households' characteristics at the micro level more than climate hazard at the country level. According to the UNICEF's conceptual framework, children's dietary intake as stunting is affected by household's characteristics as household's food security and income level, care and feeding practices, unhealthy households and surrounding environment. The literature on stunting shows that gender, age and education of the head, access to sanitation and health services are significant drivers of stunting (Joulaei et al, 2021; Elayouty et al, 2022). Other drivers include country's economic growth, inflation, healthcare and nutrition programmes (Makdissi, 2024).

As discussed in the literature, food security dimensions are affected by other macro-economic factors[1] (Jemmali et al, 2021 and Mahmah and Amar; 2021). The structure of the economic growth matters for food security. The higher the shares of agriculture and services value added in GDP the lower the number of undernourished and the prevalence of stunting. This can be expected given the importance of these two sectors in providing economic

opportunities for vulnerable groups in the region. However, this negative effect is significant only when the temperature and the precipitation are controlled for.

Urban population has different effects according to the dimension used. When the GHG emission is controlled for, urbanization has no significant effect on undernourishment. However, when both temperature and precipitation are included in the model, the number of undernourished increases with urbanization. This might be explained by the increasing demand on processed food, change in dietary habits, in addition to encroaching fertile land used for agriculture (Tull, 2020). For both versions of the utilization model, increasing urban population decreases the prevalence of stunting. According to Tull (2020), urbanization can be considered as an opportunity for agri-food industry providing more economic opportunities, decreasing poverty, and improving living standards of individuals and food utilization. Similarly, trade openness has different impacts on both dimensions. The number of undernourished significantly decreases with trade openness. This effect might be explained by the increase in food availability through imports.Though, the prevalence of stunting increases with trade openness. A result that requires more investigation.

As expected, higher inflation increases the number of undernourished and prevalence of stunting. However, this relation is significant only in the access model. Increasing access to sanitation improve food security by decreasing the number of undernourished and stunting in the region.

The results of the pooled OLS confirm the results of panel data models for climate variables (See Annex 2). Increasing GHG emission and surface temperature would result in higher number of undernourished, with no significant effect on the prevalence of stunting.

[1] Hausman Test results are available in appendix 3

[1] We tested for multicollinearity between the explanatory variables using pairwise correlation, VIF indicator and the significance of the variables. The results show that the level of multicollinearity given the nature of the variables do not affect our results as reflected in the significance of the different variables and the overall significance of the model.

Similar results were found for all the macro variables included except for urbanization in the access model. When pooled OLS model is estimated and the years and countries effects are controlled for, higher urban population decreases the number of undernourished, while the effect was positive in the panel data model. This contradictory results between the two models require more research.

Finally, number of undernourished is lower in the GCC countries, compared to the other countries. Both the number of undernourished and the prevalence of stunting were significantly higher in the years following 2015 compared to 2008. This might be the effect of economic slowdown, and the different crisis as COVID-19 crisis the Russo- Ukranian war during these years.

Table 2: Estimated Results of Access Model

	Number of undernourished (in logarithmic form)			
	GHG Emission (in log)		Change in Temperature and Precipitation	
	FE	RE	FE	RE
Agriculture Value Added as share of GDP (%)	-0.0395** (0.0154)	-0.0209 (0.0130)	-0.0559*** (0.0212)	0.00972 (0.0307)
Services Value Added as share of GDP (%)	-0.0124*** (0.00333)	-0.0137*** (0.00322)	-0.0136*** (0.00404)	-0.0427*** (0.00527)
Urban population (% of total population)	0.0241** (0.0100)	0.00852 (0.00712)	0.0321*** (0.00743)	0.0210** (0.00986)
Trade openness	-0.00702*** (0.000997)	-0.00717*** (0.000990)	-0.00768*** (0.00122)	-0.00820*** (0.00276)
inflation	0.00449** (0.00188)	0.00494*** (0.00187)	0.00586** (0.00230)	0.0145** (0.00678)
People using at least basic sanitation services (% of population)	-0.00941** (0.00476)	-0.0108** (0.00465)	-0.0101* (0.00564)	-0.0333*** (0.0125)
Change in temperature			0.0842* (0.0470)	0.591*** (0.127)
Change in precipitation			0.000170 (0.000478)	0.00124 (0.00149)
GHG emission (in log)	0.152 (0.172)	0.403*** (0.119)		
Constant	-1.048 (1.357)	-2.838*** (1.032)	-0.0321 (0.538)	3.341*** (1.240)

Observations	**224**	**224**	**163**	**163**
R-squared overall	**0.03**	**0.47**	**0.008**	**0.47**
Number of panelid	**12**	**12**	**9**	**9**
F test/ Wald Test	**9.07**	**138.47**	**9.07**	**138.47**
P value	**0**	**0**	**0**	**0**
Hausman test	**(1)**		**(2)**	

Standard errors in parentheses
***** p<0.01, ** p<0.05, * p<0.1**
Hausman Test results are in appendix 3

Table 3: Estimated Results of the utilization model

	Number of undernourished (in logarithmic form)			
	GHG Emission (in log)		**Change in Temperature and Precipitation**	
	FE	**RE**	**FE**	**RE**
Agriculture Value Added as share of GDP (%)	**-0.0838 (0.117)**	**-0.0671 (0.0961)**	**-0.361** (0.152)**	**-0.717*** (0.107)**
Services Value Added as share of GDP (%)	**0.00524 (0.0274)**	**-0.00163 (0.0260)**	**0.00653 (0.0289)**	**-0.104*** (0.0184)**
Urban population (% of total population)	**-0.197** (0.0769)**	**-0.221*** (0.0509)**	**-0.152*** (0.0532)**	**-0.152*** (0.0344)**
Trade openness	**0.0199** (0.00805)**	**0.0196** (0.00793)**	**0.0238*** (0.00875)**	**-0.0133 (0.00964)**
inflation	**0.00223 (0.0145)**	**0.00298 (0.0143)**	**0.0134 (0.0165)**	**0.0713*** (0.0237)**
People using at least basic sanitation services (% of population)	**-0.384*** (0.0365)**	**-0.382*** (0.0353)**	**-0.423*** (0.0404)**	**-0.467*** (0.0436)**
Change in temperature			**0.355 (0.337)**	**0.147 (0.444)**
Change in precipitation			**0.00277 (0.00342)**	**0.00602 (0.00522)**
GHG emission (in log)	**-0.834 (1.318)**	**-0.376 (0.841)**		
Constant	**70.80*** (10.44)**	**67.27*** (7.462)**	**61.77*** (3.849)**	**76.50*** (4.332)**

Observations	211	211	163	163
R-squared overall	11	11	9	9
Number of panelid	0.42	0.47	0.65	0.77
F test/ Wald Test	66.78	480.28	43.11	524.49
P value	0	0	0	0
Hausman test	(3)		(4)	
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 Hausman Test results are in appendix 3				

5.Concluding Remarks

MENA region is one of the most vulnerable regions to climate change phenomena. Food security challenges in the region include water and land scarcity, increasing population, poverty, and dependence on food imports. These challenges are exacerbated by climate related shocks. Within this context, the paper contributes to the existing literature tackling food security and climate change in the region by investigating the impact of climate change on two dimensions of food security; food access and food utilization. Panel fixed effects, random effects and pooled OLS models are estimated using a panel data of 12 MENA countries from 2000 to 2020. Climate change is measured by GHG emission, annual surface temperature change and precipitation change.

The results show that there is adverse effect of climate change on food access. The higher the GHG emission and the annual surface temperature change, the higher the number of undernourished in the region. These negative effects may become more severe and stronger and be destructive to the environment and humans in the near future. While climate indicators used have no significant effect on food utilization measured by the prevalence of stunting among children under five years old. This result is in line with the stunting literature. Stunting is correlated with chronic poverty and is affected by socio economic characteristics of the children and their households. Other factors affecting food access and food utilization include inflation, urbanization, access to basic sanitation and economic growth structure.

These results confirmed the complexity of food security with different dimensions affected differently by climate change and other socio-economic factors. The findings confirm that interlinkage between the different sustainable development goals. Ending hunger and ensuring food security (SDG2), mainly food access, is associated with climate action (SDG13). Climate indicators affect food access through agriculture and poverty (SDG1) channels. Increasing temperature and GHG emission decrease agriculture productivity and food availability, resulting in negative effects on food access.

The decline in agriculture productivity and climate-risks shocks jeopardize the sources of income of those depending on the agriculture sector and the vulnerable groups. Additionally, SDG2 is interlinked with economic growth (SDG8) and reducing inequalities (SDG10).

The findings of the paper are policy relevant. In a context of water scarcity, economic slowdown and the different crisis as COVID-19 and the Russo- Ukrainian war, challenges facing food security in the MENA region are exacerbated. MENA countries must take serious action by developing an adaptation strategy to mitigate the effects of climate change.

There is a necessity to invest in economic friendly agriculture and rural development of the region to increase food availability, creating economic opportunities and increase access to food while ensuring environmental sustainability. Increasing access to sanitation and basic services would ensure food security, mainly food utilization dimension. Policies and intervention programs should differ according to the targeted dimensions of food security. Finally, adaptation and mitigation strategies based on bottom-up approach, involving all the stakeholders of the food eco-system are required to ensure food security and environmental sustainability. Investing in adaptation options might reduce the impact of climate change on food security dimensions.

References

Elayouty, A. Abou-Ali, H. and Hawash, R. "Does Climate Change Affect Child Malnutrition In The Nile Basin?" ERF Working Paper No. 1613 November 2022

Alboghdady, M. and El-Hendawy, S.E. (2016), "Economic impacts of climate change and variability on agricultural production in the Middle East and North Africa region". International Journal of Climate Change Strategies and Management, Vol. 8 No. 3, pp. 463-472 https://doi.org/10.1108/IJCCSM-07-2015-0100

CCKP, 2023. Climate Change Knowledge Portal, Countries Profile. (Available at: https://climateknowledgeportal.worldbank.org/download-data).

Country economy, 2023. CO2 emission database (Available at: https://countryeconomy.com/energy-and environme-nt/co2-emissions/).

Datta, P., Behera, B., & Rahut, D. B. (2023). Climate change and water-related threats in the Indian Sundarbans: food security and management implications. International Journal of Water Resources Development, 40(3), 323–344. https://doi.org/10.1080/07900627.2023.2224459

El Bilali, H.; Ben Hassen, T. Regional Agriculture and Food Systems Amid the COVID-19 Pandemic: The Case of the Near East and North Africa Region. Foods 2024, 13, 297. https://doi.org/10.3390/foods13020297

FAO, 2015. Climate change and food security: risks and responses. ISBN: 978-92-5-108998-9. PP. 1 – 34 (Available at: https://www.fao.org/3/i51-88e/I5188E.pdf).

Frederic W.; and Ninar F., 2022. Cascading Climate Effects in the Middle East and North Africa: Adapting Through Inclusive Governance, Article, February 24, 2022 (Available at: https://carnegieendowment.org/2022/02/24/cascading-climate-effects-in-middle-east-and-north-africa-adapting-through-inclusive-governance-pub-86510).

Guo, W., Rayamajhee, V., & Bohara, A. K. (2023). Impacts of climate change on food utilization in Nepal. Review of Development Economics, 27(1), 630–659. https://doi.org/10.1111/rode.12953

Hameed, M. Moradkhani, H., Ahmadalipour, A., Moftakhari, H., Abbaszadeh, P. and Alipour, A. (2019) "A Review of the 21st Century Challenges in the Food-Energy-Water Security in the Middle East" Water Review, 11(4): 682. (Available at: https://doi.org/10.3390/w11040682).

Hashem, Eman Ahmed "The Impacts of Climate Change on Food Security – Case Study: Egypt" (June 5, 2020). Journal of Economics and Business, Vol.3 No.2 (2020), Available at SSRN: https://ssrn.com/abstract=3621203.
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap7_FINAL.pdf

IPCC, 2012. Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564 (Available at: https://www.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf).

Ibrahim, E. A. (2023). The Impact of Climate Change on Food Security Dimensions in Egypt by 2070. New Medit, 22(2). https://doi.org/10.30682/nm2302i

Ibrahim, E. A. (2024). Determinants and Performances of Food Security in the Middle East and North Africa Region Countries. New Medit 2 (2024). https://doi.org/10.30682/nm2402d

Jemmali, H., Morrar, R. and Safouane Ben Aissa, M. (2021) "The dynamic nexus between climate changes, agricultural sustainability and food-water poverty in a panel of selected MENA countries". Journal of Water and Climate Change. 12.1

Joulaei H, Keshani P, Ashourpour M, Bemani P, Amiri S, Rahimi J, Aliakbarpour M, Salehi-Abargouei A. The prevalence of stunting among children and adolescents living in the Middle East and North Africa region (MENA): A systematic review and meta-analysis. J Glob Health. 2021 Dec 25;11:04070. doi: 10.7189/jogh.11.04070. PMID: 35003712; PMCID: PMC8711751.

Lienard, C. (2022), Mitigating climate change in the MENA: shifting to a new paradigm, Brussels International Center, 1-3 https://www.bic-rhr.com/sites/default/files/inline files/BIC%20April%202022%20Policy%20Brief
Climate%20Change%20in%20the%20MENA%2C%20Clementine%20Lienard.pdf

Lloyd,S., Kovats, R. and Chalabi, Z. (2011) "Climate Change, Crop Yields, and Undernutrition: Development of a Model to Quantify the Impact of Climate Scenarios on Child Undernutrition". Env. Health Perspectives vol. 119 no. 12.

Lobell D, Burke M (2010) Climate change and food security: adapting agriculture to a warmer world. Springer, Dordrecht/New York. http://www.worldcat.org/title/climate-change-and-food-security-adapting- agriculture-to-a-warmer-world/oclc/630107791

Mahmah, A.E. and Amar, A. (2021). Food Security in the MENA Region: Does Agriculture Performance Matter? In: Behnassi, M., Barjees Baig, M., El Haiba, M., Reed, M.R. (eds) Emerging Challenges to Food Production and Security in Asia, Middle East, and Africa. Springer, Cham. https://doi.org/10.1007/978-3-030-72987-5_4

Makdissi, P. (2024) "Child stunting in Tunisia: an alarming rise". The Forum ERF Policy Portal: https://theforum.erf.org.eg/2024/10/01/child-stunting-in-tunisia-an-alarming-rise/

Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., Iqbal, M.M., Lobell, D.B. & Travasso, M.I., (2014). "Food security and food production systems". In C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects, pp.485–533. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, and New York, USA, Cambridge University Press.

ProEssays. (2021). Food Security Theories. [Online]. Available at: https://proessays.net/essays/food-security-theories [Accessed: 07 Sep. 2024].

Tekce M. and Deniz P. (2016). "The Impacts of Climate Change on Agricultural Trade in the MENA Region". Research in World Economy, 7(2): 1-4.(Available at: https://doi.org/10.5430/rwe.v7n2p1).

The Food and Agriculture Organization (FAO), 2023. FAOSTAT, Food Security Indicators (Available at: https://www.fao.org/faostat/en/)

Tirado, M.C., Clarke, R., Jaykus, L.A., McQuatters-Gallop, A. & Frank, J.M. (2010). "Climate change and food safety: a review". Food Research International, 43(7): 1745–1765. https://doi.org/10.1016/j.foodres.2010.07.003

Tull, K. (2020) "The projected impacts of climate change on food security in the Middle East and North Africa (MENA)". K4D Knowledge, evidence and learning for development. Helpdesk Report

UN-ESCWA in partnership with the Economic Research Forum (2019) "Rethinking Inequality in Arab Countries": https://www.unescwa.org/sites/default/files/pubs/executive-summary/rethinking-inequality-arab-countries-sum-en.pdf

UNDP (2021) "Potential Impact of COVID-19 On Poverty and Food Insecurity in The Arab region". RBAS Working papers series: https://www.undp.org/arab-states/publications/potential-impact-covid-19-poverty-and-food-security-arab-region

UNFCCC (1992) United Nations Framework Convention on Climate Change.United Nations Development Programme. (Available at: https://unfccc.int/resource/docs/convkp/conveng.pdf).

World Development Indicators (WDI). (https://data.worldbank.org/).

World Food Programme (2020) "WFP Global Response to COVID-19": https://www.wfp.org/publications/wfp-global-response-covid-19-september-2020

World Food Summit, 1996. Rome Declaration on World Food Security. Report, FAO, 13-17 November 1996, Italy, Rome. (Available at: https://www.fao.org/3/w3548e/w3548e00.htm).

Yassin, L. (2016). "Climate change and food security in Egypt" [Master Thesis, the AUC]. AUC Knowledge Fountain https://fount.aucegypt.edu/etds/315

Zheutlin AR, Adar SD, Park SK. (2014) Carbon dioxide emissions and change in prevalence of obesity and diabetes in the United States: An Ecological Study". Environmental International; 73:111-6. https://doi.org/10.1016/j.envint.2014.07.012.

Appendix 1: Variables used in the models.

Variable	Definition	Source
Annual Surface Temperature Change	This indicator presents the mean surface temperature change, using temperatures between 1951 and 1980 as a baseline.	IMF Climate change dashboard
Precipitation	Any liquid or frozen water that forms in the atmosphere and falls back to the Earth. It comes in many forms, like rain, sleet, and snow.	Climate Change Knowledge Portal (CCKP)
Urban Population	% of total population	World development Indicators
GHG emission	Total greenhouse gas emissions (kt of CO2 equivalent)	World Development Indicators
Prevalence of undernourishments	The percentage of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life.	Food and Agriculture Organization of the United Nations (FAO)
Share of Agriculture VA in GDP	Agriculture, forestry, and fishing, value added (% of GDP)	World Development Indicators
Trade openness	Refers to the outward or inward orientation of a given country's economy. Outward orientation refers to economies that take significant advantage of the opportunities to trade with other countries. Inward orientation refers to economies that are unable to take advantage of the opportunities to trade with other countries.	World Development Indicators

Appendix 2: Estimated results of the pooled OLS model

	Number of undernourished (in log)	Number of undernourished (in log)	Prev. of stunting among children under 5 years old	Prev. of stunting among children under 5 years old
Agriculture Value Added as share of GDP (%)	-0.0725*** (0.0204)	-0.112*** (0.0284)	-0.491*** (0.145)	-1.018*** (0.115)
Services Value Added as share of GDP (%)	-0.0294*** (0.00519)	-0.0720*** (0.00536)	-0.133*** (0.0317)	-0.177*** (0.0216)
Urban population (% of total population)	-0.0116** (0.00512)	0.0234*** (0.00834)	-0.409*** (0.0375)	-0.150*** (0.0337)
Trade openness	-0.00228 (0.00148)	-0.00976*** (0.00241)	0.0442*** (0.0117)	-0.0143 (0.00972)
inflation	0.00396 (0.00426)	0.00473 (0.00589)	-0.000332 (0.0284)	0.0485** (0.0238)
People using at least basic sanitation services (% of population)	-0.00252 (0.00685)	-0.0356*** (0.0114)	-0.0650 (0.0483)	-0.499*** (0.0459)
Change in temperature		0.588*** (0.141)		-0.837 (0.567)
Change in precipitation		0.00134 (0.00137)		0.00469 (0.00552)
GHG emission	0.595*** (0.0507)			
GCC	-1.419*** (0.140)	-1.403*** (0.170)	-0.881 (1.034)	-2.980*** (0.687)
Constant	-3.410*** (1.026)	5.892*** (1.208)	54.82*** (5.742)	84.70*** (4.875)
Observations	224	163	211	163
R-squared	0.767	0.703	0.679	0.829

Appendix 3: Hausman test Results

b = consistent under Ho and Ha; obtained from xtreg

B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho:difference in coefficients not systematic

Hausman Test	Chi2	Prob>chi2
(1)	7.45	0.3839
(2)	139	0.0000
(3)	3.6	0.8970
(4)	91.22	0.0000