Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Assessing the Impact of Climate Change on Food Security Indicators: An Empirical Study in Algeria (2000-2023)

Bourouba Katia[1], Fouzi Tahar Abderzag[2], Hamza Abderrezek[3], Emad Suliman Sharif Mohamed [4]
[1]*Department of finance Laboratory of Partnership and investment in small and medium enterprises*
Faculty of Economics, Commercial and Management Sciences, University of SETIF (1), Algeria
Katia.bourouba@univ-setif.dz. ORCID: : 0009-0005-5416-5075
[2]*Department of Business Administration, College of Business, University of Bisha, Box 551, Bisha 61922, Saudi Arabia, Email: Job email: fabdelrzag@ub.edu.sa,ORCID : 0000-0003-3352-5447*
[3]*University Mohamed- University of El Bachir El Ibrahimi -Bordj Bou Arreridj-ALGERIA*
Email: hamzaabderrezek@gmail.com
[4]*Emad Suliman Sharif Mohamed, Administrative Sciences dept., Applied College, University of Bisha, P.O. Box 551, Bisha, 61922, Saudi Arabia. Email:Email: essharif@ub.edu.sa*

ARTICLE INFO

Received: 18 Dec 2024

Revised: 10 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

The governments of Algeria and Saudi Arabia, like all decision-makers in the MENA region, place central importance on the issue of food security, considering it a matter of national security for these countries. This issue is influenced by internal and external factors, including geopolitical, economic, climatic, and other elements that can complicate the achievement of food security. This econometric study focuses on assessing the impact of factors influencing food security, represented by total cereals production in Algeria, on greenhouse gas emissions—specifically carbon dioxide—precipitation, and cultivated land area for 2000-2023. Using the ARDL model, the study concluded a positive relationship between grain production and the variables of precipitation and cultivated land area in both the short and long term, while production is negatively affected by carbon dioxide emissions in the short term.

Keywords: Food Security; Cereal Production; Greenhouse Gas Emissions; ARDL Model; MENA Region.

1. Introduction

Food security is a critical component of a nation's or region's economic stability. It is shaped by the ability of the country or area to meet the agricultural product needs of its population in sufficient quantities to support a sustainable and healthy standard of living (Zhichkin, Nosov, et al., 2021). Production and supply represent the input dimension of the narrow food security concept (Julia, Stéphane, 2018). In MENA region, food security relies not only on agricultural factors but also on a range of macroeconomic elements, including trade openness and international food prices. These factors can directly or indirectly influence the country's food security status, regardless of its reliance on agriculture or the oil sector (Assil, Amine, 2021). In this study, which will consist of two main chapters, we dedicated the first chapter to presenting some indicators of food security and climate change in two countries from the MENA region, within the framework of a theoretical foundation for the topic and its contexts. The second chapter includes an applied econometric study on Algeria, examining the impact of factors such as agricultural land area, precipitation, and CO2 emissions.

1. theoretical background

1.1. Literature review

Concerns about food security became prominent a few years after World War Two (1939–1945), with some scholars citing Malthus' research (1798) as the starting point for studies on population's food security (Morteza, Pantea, et al., 2022). Climate change poses a significant threat to global food security. Evaluating research efforts on food security in light of climate change is crucial for policymakers and funding sponsors to inform future decisions. (Waleed, 2020) seeked to provide an overview of research activity related to food security in this context. The study identified water

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

security, health, crop production, and food availability as key research areas related to food security within the context of climate change. It emphasized the need to explore new technologies and innovative solutions for climate change adaptation and mitigation to prevent food insecurity, particularly in resource-limited regions of the world. However, by relying on the Scopus database for this bibliometric study, many studies from Africa, Asia, Latin America, and Eastern Europe have been ignored, even though these regions are the most affected by the issues of food security and climate change, where these topics have been discussed in detail.

In another study conducted by (Amy, Pete, et al., 2021) the researchers concluded that the SSPs scenarios had a significant impact on future food insecurity, mainly due to projected population changes. Countries with declining population growth showed higher levels of food security, whereas those with rapid population growth experienced the most severe impacts on food security. While climate change scenarios did affect future crop yields, population growth emerged as the primary factor driving changes in the prevalence of undernourishment. Nonetheless, the FEEDME model used in the study includes potential oversimplification of complex food environments and challenges in capturing dynamic, real-time changes. Additionally, the model may struggle with generalizability across varied geographical and cultural contexts, necessitating adaptations to local realities for accurate application.

(Courtney, 2020) also argues that Human-driven increases in fossil fuel emissions have been a major factor behind the rise in atmospheric carbon dioxide (CO_2) and other greenhouse gases, leading to warmer temperatures, changes in precipitation patterns, and a higher frequency of extreme weather events worldwide. In agricultural regions, these climate shifts can hinder plant productivity, posing challenges to the global capacity to maintain sufficient food production for a growing and increasingly affluent population with evolving access to affordable and nutritious food. However, the study didn't benefit from a more detailed exploration of the mitigating effects of other abiotic stressors, such as increased temperatures, which are mentioned as potential alleviators of nutrient decline. By elaborating on how these factors interact, the complexity of climate change's impact on agriculture could be more thoroughly conveyed. (Tomoko, Gen, et al., 2021) combined crop modeling and climate scenarios to estimate the effects of extreme climate events on future food insecurity. Compared to median-level climate change, The researchers found that an additional 20–36% of the population under high emission scenarios and 11–33% under low emission scenarios could face hunger by 2050 in the event of a once-in-100-year extreme climate event. However, while the methodology is well-articulated, the study could benefit from a deeper discussion of the socio-economic factors that interact with climate impacts, such as policy responses and adaptive capacity in different regions. The exclusion of climate mitigation effects is noted but warrants further exploration, as these measures are crucial for comprehensive food security strategies. Additionally, the focus on the mid-century period, while pragmatic, might overlook the immediate and short-term risks posed by climate extremes, which could offer valuable insights for more urgent policy interventions. Expanding on the practical applications of the findings, particularly how they could inform adaptive strategies in vulnerable regions, would enhance the relevance and impact of the analysis.

As for the research aspect in Africa and the general trend toward addressing food security issues and how it is affected by climate change, (Phemelo, Helen, et al., 2023) noted a lack of studies addressing this impact. The study recommended that research prioritize developing innovative solutions to address the impacts of climate change on food security, poverty, and inequality in Africa, while exploring new technologies, policies, and practices. It highlighted the need for policies that support and promote the adoption of locally relevant agricultural practices and technological advancements that enhance both efficiency and sustainable resource use. Yet, the study's reliance on bibliometric analysis may limit the depth of understanding of the nuanced impacts of these factors. The noted lack of longitudinal studies suggests a need for more in-depth, temporal analyses to capture the evolving dynamics of climate change and inequality. Additionally, while the study highlights the gendered impacts of climate change, it could benefit from a more detailed exploration of the specific barriers women face in agricultural productivity and access to resources. The recommendation for socio-economic inclusion policies is pertinent, but the passage could be strengthened by providing concrete examples of successful policy interventions or strategies that have mitigated these challenges in similar contexts. This would offer practical insights for policymakers aiming to enhance food security and reduce inequality in Africa.

In conclusion, (Hualin, Yuyang, et al., 2021) argue that in scientific research, the identification of a problem is typically followed by an in-depth investigation of its underlying driving forces. Food security is a complex issue

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

influenced by a variety of factors. Previous studies have suggested that these factors include climate change, population growth, wars and conflicts, urbanization, and food waste, among others. However, scholars differ in their views on the relative impact of each factor on food security. The mention of emerging research trends, such as the integration of water and land resource security, is insightful but could be expanded to include examples of innovative studies or projects that exemplify these trends. Additionally, while future research directions are outlined, a more detailed discussion on the practical implications of these trends for policy and practice would enhance the analysis. This could include potential strategies for ensuring sustainable food supply chains or addressing the challenges of food access in vulnerable regions.

1.2. The key concepts of food security

Definitions of food security have evolved over time since the first introduction of the term to the policy context in the early 1970s (Jennifer et al., 2022). Even as recently as two decades ago, around 200 different definitions of food security appeared in published literature (Marisol, Judy, et al., 1992). The continuing evolution of food security as an operational concept in public policy has reflected the wider recognition of the complexities of the technical and policy issues involved. The most recent careful redefinition of food security is that negotiated in the process of international consultation leading to the World Food Summit (WFS) in November 1996. The contrasting definitions of food security adopted in 1974 and 1996, along with those in official FAO and World Bank documents of the mid-1980s, are set out below with each substantive change in definition underlined. A comparison of these definitions highlights the considerable reconstruction of official thinking on food security that has occurred over 25 years. These statements also provide signposts to the policy analyses, which have re-shaped our understanding of food security as a problem of international and national responsibility (FAO, 2003). Since the studies on food security are often context specific, depending on which of the many technical perspectives and policy issues, this multidimensional and multifaceted operational construct had no coherent definition then (Wen, Elliot M, 2018). Therefore, we will attempt below to combine the various definitions found in modern literature by researchers or those issued by relevant international official bodies.

1.2.1 Defining food security

The largest group of articles focuses on food security and "food safety," whereas the subject category of "poverty" has seen a significant decline (Norbert, Julieth, et al., 2022). One reason for this may be that the subject category "poverty" was not a primary focus of research before the global economic crisis (József, Péter, et al., 2018).

Based on the 1996 World Food Summit, food security is defined 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 (World Bank Group, 2023). Besides, according to the United Nations Sustainable Development Goals (SDGs), one of the key priorities is to "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture." This goal includes several targets, such as eliminating hunger and malnutrition, improving the productivity and income of small-scale farmers, preserving genetic diversity, and fostering sustainable and resilient agricultural systems and practices (Hen-I et al., 2022).

Food security exists when all people, at all times, have access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2003). Access to non-food inputs such as clean water, sanitation, and health care has recently been included in the broader definition of food security (Awudu, Christian, 2012).

This definition is further refined in The State of Food Insecurity 2001: “Food security is 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” (FAO, 2002).

As suggested by the definitions reviewed above, vulnerability can manifest as both a chronic and transitory phenomenon. The following are useful working definitions.

“Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Household food

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

security is the application of this concept to the family level, with individuals within households as the focus of concern (FAO, 2003).

Food insecurity exists when people do not have adequate physical, social or economic access to food as defined above" (FAO, 2003).

1.2.2 Food security and Food Sovereignty

The concepts of food security and food sovereignty, both significant within the discourse on sustainable food systems, have seen increased interest over recent decades (Luis et al., 2024). The concept of food sovereignty was introduced by small-scale producers through the transnational social movement La Vía Campesina (LVC) and was globally launched at the 1996 United Nations World Food Summit. It emphasizes the rights of people, rather than corporations and market institutions - whom LVC believes dominate the global food system - to have control over how food is produced and what kinds of food are cultivated (Devon, Marcela, et al., 2021).

By the mid-2000s, the food sovereignty movement had expanded to include hundreds of organizations across more than 200 countries. The Nyéléni Declaration provided the most widely recognized definition of food sovereignty as shown in (figure 1) (Wittman, 2023).

Figure 1. *Pillars of food sovereignty*

Source: (Wittman, 2023)

The concept of food sovereignty has quickly shifted from the margins to the forefront of international discussions on food, environment, development, and well-being (Michel P, Priscilla, 2024).

Food sovereignty is a resurgence of Indigenous ways of knowing and being. It is a movement that not only addresses physical access to food but restores emotional and spiritual connections to land, water, plants, and animals (Valarie Blue Bird et al., 2023). Three levels of food sovereignty are often misunderstood: individual, household, and national. While food safety concerns the health quality of the food consumed and food security addresses its availability and reliability, food sovereignty focuses on the right of individuals, households, or nations to determine their own food-related decisions. It differs from food self-sufficiency, as a household may not grow all its own food (i.e., be self-sufficient) but still has the autonomy to choose what foods to eat and under what conditions (sovereignty). The core

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

principle can be summarized as: "No individual, household, or country has the right to dictate the food policies of another." (Per Pinstrup, Derrill D, 2011).

1.2.3 The four pillars of food security

According to the concepts provided by the Food and Agriculture Organization the term “food security” encompasses four basic pillars (FAO, 2003): (i) food availability: the existence of enough quantities of food of adequate quality, supplied through domestic production or imports (including food aid); (ii) food access: people’s access to adequate resources to acquire appropriate food and a nutritious diet; (iii) utilization: biological use of food through adequate nutrition, drinking water, sanitation, and medical care, to achieve a state of nutritional well-being in which all physiological needs are satisfied, a concept that highlights the importance of non-food inputs in food security; and (iv) food stability: a population, a household, or a person must always have access to adequate food in order to have food security (Juan, Carla, 2021)

The United Nations Sustainable Development Goals (UN SDGs) and the European Green Deal are considered essential to mitigate the anthropogenic climate change (CC) crisis. They are synergetic since they endorse maintainable agrifood systems and the preservation of the environment (Theodoros, Slim, 2024). Current agro-food systems significantly impact the environment and the climate, including soil and water resources. Frequent natural disasters resulting from climate change, pandemics, and conflicts weaken food systems and exacerbate food insecurity worldwide (Akila, Ranjith, 2022). Many elements of food systems are inherently unstable, making it essential for analysts of food security and sustainability to focus on the dimension of stability. This attention should encompass a range of factors that contribute to fluctuations in food availability, including unpredictable variations in weather, natural and man-made disasters that impact agricultural productivity, the uncertain occurrence of pests, and the unpredictable outcomes of human-driven farming practices (Jock R, 2018).

1.2.4 Food security represented by the total cereals production indicator

Recently, food production has been challenged by food safety and insecurity crises stemming from various natural disasters and diseases. These issues are further exacerbated by irresponsible human activities, often driven by globalization and urbanization, which contribute to natural disasters. For instance, deforestation leads to soil erosion, increasing the risk of floods that contaminate water and agricultural land with chemicals, heavy metals, and other pollutants (Anis Munirah, Norfarizan-Hanoon, 2022).

As mentioned earlier, the FAO's definition of food security is based on four pillars, most of which relate to indicators that the FAO also monitors and publishes annually within its country-specific reports. The indicators most affected by climate change and greenhouse gas emissions are local cereals production, arable land area, and the variability of food supplies. In this research paper, we will evaluate the impact of greenhouse gas emissions represented by co2 emissions on local cereals production along with the introduction of other variables that we will define at the beginning of the econometric study. Therefore, within this first chapter (the theoretical framework), we will limit our analysis to the two most significant and comprehensive indicators, which we consider to be the most representative of food security and climate change (GHG and total cereals production).

1.2.4.1 Algeria’s Cereals, total production

Based on FAO statistics, Table 1 presents the data related to Cereals, total production.

Table 1. Algeria’s Cereals, total production evolution 2000-2023 (FAO, 2024)

Year	Cereals production (kg/h)	Year	Cereals production (kg/h)
2000	934,656.39	2012	5,137,455
2001	2,659,594.68	2013	4,912,551
2002	1,953,325.24	2014	3,435,535
2003	4,266,387.06	2015	3,761,229.6

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

2004	4,033,241.92	2016	3,445,227.37
2005	3,527,824.19	2017	3,478,175.14
2006	4,018,104.98	2018	6,066,238.69
2007	3,602,256.3	2019	5,633,592.07
2008	1,536,002.32	2020	4,393,330.47
2009	5,253,472.23	2021	2,784,008.92
2010	4,211,354.54	2022	4,718,203.91
2011	4,247,535.01	2023	950,000

Source : (FAO, 2024)

Algeria's cereals production from 2000 to 2023 has been marked by significant fluctuations, with production peaking notably in 2018 at approximately 6.07 million kg/h, alongside strong outputs in 2009 and 2012. However, this growth has been interspersed with sharp declines, particularly in 2008 and 2021, culminating in a dramatic drop to just 950,000 kg/h in 2023, the lowest recorded in the dataset. The overall trend reflects high sensitivity to external factors affecting agricultural output, highlighting challenges in achieving consistent production levels and underscoring the need for strategies to stabilize and improve cereals production in Algeria.

1.2.4.2 Saudi Arabia's Cereals, total production

Based on FAO statistics, Table 2 presents the data related to Cereals, total production.

Table 2. Saudi Arabia's Cereals, total production evolution 2000-2023 (FAO, 2024)

Year	Cereals production (kg/h)	Year	Cereals production (kg/h)
2000	2,167,394	2012	1,084,597
2001	2,591,615	2013	881,553
2002	2,852,747	2014	1,568,940
2003	2,948,817	2015	1,616,813
2004	3,189,319	2016	1,507,153
2005	3,006,637	2017	1,493,955
2006	3,042,777	2018	1,378,885
2007	2,960,073	2019	1,293,633
2008	2,431,704	2020	1,250,955
2009	1,585,994	2021	877,638
2010	1,565,155	2022	1,068,744
2011	1,414,016	2023	1,230,000

Source : (FAO, 2024)

Saudi Arabia's cereals production from 2000 to 2023 displayed significant fluctuations, with an initial rise peaking at approximately 3.19 million kg/h in 2004, followed by a sharp decline to about 881,553 kg/h by 2013. A moderate recovery occurred from 2014 to 2015, with production reaching around 1.62 million kg/h, but this was followed by another decline, hitting a low of 877,638 100 g/h in 2021. While there has been a slight recovery in recent years, reaching 1.23 million kg/h in 2023, the overall trend indicates volatility, highlighting the challenges of maintaining consistent cereals production in Saudi Arabia.

2. Climate change and food security

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

The mechanisms through which food security can be affected by climate change are many and often complex (Shouro, Elizabeth, 2022). The negative impacts of climate change on global food security are among the greatest threats of this century, and addressing these challenges is crucial to meeting the future food demands of a rapidly growing population (Muhammad, Muhammad, et al., 2022). The primary changes to the Earth's atmosphere can result from natural processes or human activities. Notably, anthropogenic activities such as pollution, urbanization, industrialization, agricultural practices, land use changes, and deforestation contribute to increased atmospheric concentrations of water vapor, carbon dioxide (CO_2), and other greenhouse gases (GHGs), which accelerate the pace of climate change (Akila, Ranjith, 2022).

Future climate change is expected to intensify the scale and probability of negative consequences for food security and nutrition (FSN). The timing and severity of these impacts, as well as our capacity to respond, will depend on the level of greenhouse gas (GHG) emissions and the socioeconomic pathways (SSPs) followed (Alisher, Rachel, 2023). Climate change can impact food systems in multiple ways, from directly affecting crop production—such as changes in rainfall causing droughts or floods, or temperature shifts altering the length of the growing season—to influencing markets, food prices, and supply chain infrastructure (Gregory, Ingram, Brklacich, 2005).

In this research paper, we will address the impact of greenhouse gas emissions as the most significant factor affecting food security in Algeria and Saudi Arabia by evaluating their negative effect on certain food security indicators, including Cereals total production, arable land area, and the variability of food supply per capita.

2.1 greenhouse gas emissions in Saudi Arabia

Over the past three decades, Saudi Arabia has experienced a sharp increase in greenhouse gas (GHG) emissions (Reema Gh, 2021). Saudi Arabia's presidency of the Group of Twenty (G20) in 2020 provided an international platform for the country to enhance its profile in climate policy through the promotion of the "circular carbon economy" (CCE). The CCE concept builds on the principles of the circular economy but focuses on energy and carbon dioxide (CO_2) or greenhouse gas (GHG) emissions, rather than material flows (Thamir, Jan Frederik, et al., 2022).

Table 3 shows the evolution of greenhouse gas emissions in Saudi Arabia during the period 2000-2022.

Table 3. GHG emissions in Saudi Arabia 2000-2022

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GHG emissions Mt CO_2eq/yr	350.221	362.375	380.249	407.289	429.664	457.063	480.736	502.466	538.817	558.382	603.145	634.093
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
GHG emissions Mt CO	669.549	678.185	720.933	752.734	757.292	752.535	736.553	738.504	733.063	751.180	786.955	805.158

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

2eq /yr												

Source : (Crippa, Guizzardi, et al., 2024)

The trend in GHG emissions in Saudi Arabia from 2000 to 2023 shows a general upward pattern, this represents an overall increase of 130% over the period. While there are some periods of stabilization or decline, particularly between 2016 and 2020, the overall trajectory suggests significant challenges in reducing emissions due to several factors, the most important of which are:

- Economic growth: Saudi Arabia's economic expansion, particularly in the energy and industrial sectors, has been a major driver of emissions (Uzair, Qingbin, et al., 2023).
- Energy consumption: The country's reliance on fossil fuels for energy generation has been a significant contributor to emissions growth (Nicholas, Natalia, et al., 2020).

External shocks: Events like the global financial crisis (2008–2009) and the COVID-19 pandemic (2020) likely influenced the brief dips in emissions (Mary, Festus, et al., 2021).

2.2 greenhouse gas emissions in Algeria

The agricultural sector is vital for Algeria's economic growth, contributing over 12% to the country's GDP in 2017 and providing direct and indirect employment for approximately 13 million people. However, the impacts of climate change on both the agricultural sector and food security present a significant threat to sustainable development (Mohammed, Mohamed, et al., 2022). Algeria has formulated an initial strategy to combat climate change and has implemented various projects for adaptation and mitigation. This national strategy primarily focuses on four key areas: institutional strengthening, adaptation to climate change, mitigation of greenhouse gas (GHG) emissions, and capacity building for human resources (Sahnounea, Belhamel, et al., 2013).

Table 4 shows the evolution of greenhouse gas emissions in Algeria during the period 2000-2022.

Table 4. *GHG emissions in Algeria 2000-2022*

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GHG emissions Mt CO2eq /yr	158.333	147.716	147.274	161.098	159.256	164.488	172.839	172.627	180.770	176.962	184.920	191.633
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
GHG emissions Mt CO2eq /yr	207.949	212.941	225.886	236.183	234.105	239.171	247.903	254.404	241.131	253.945	263.216	256.792

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Source : (Crippa, Guizzardi, et al., 2024)

Between 2000 and 2023, Algeria's greenhouse gas (GHG) emissions demonstrated an overall increasing trend. The emissions rose from 158.33 Mt CO2eq in 2000 to a peak of 263.22 Mt CO2eq in 2022, with a slight decrease to 256.79 Mt CO2eq in 2023. This represents a significant 62% increase over the 23-year period.

3. Empirical Study

4. *3.1 Introduction to the study variables*

To empirically examine the long-run co-integration and dynamic interactions among the selected variables, we utilize the autoregressive distributed lag **(ARDL)** approach to cointegration, developed by (Perasan, et al., 2001). This method is chosen for three key reasons:

- First, the bounds test procedure is straightforward. Unlike other multivariate cointegration techniques, such as those proposed by Johansen and Juselius (1990), it allows for the estimation of the cointegration relationship using ordinary least squares (OLS) once the model's lag order is determined (Angeliki, 2019).
- Second, the bounds testing procedure does not require pre-testing the variables in the model for unit roots, making it more flexible than approaches like Johansen's. It can be applied regardless of whether the underlying regressors are purely I(0), I(1), or fractionally/mutually cointegrated (Diabate, 2019).

Third, the test is more efficient with small or finite sample sizes, which is relevant for this study. However, it is important to note that the procedure will fail in the presence of I(2) series (Zafar, 2020).

In this empirical study, we use the Autoregressive Distributed Lag (ARDL) model to analyze the determinants of food security in Algeria, represented by the total cereals production over the period 2000-2023. We then converted the data into quarterly
observations using the Litterman method, resulting in the following study variables:

- Total Cereals Production: The dependent variable measured in (kg/h) representing an overall indicator of food security, denoted by the symbol $\boldsymbol{CER\_PRO}$.
- **Arable land**: An independent variable that explains total grain production, measured in **(1000 h)** and denoted by the symbol $\boldsymbol{CUL\_AREA}$.
- **Annual precipitation**: An independent variable that explains total grain production, measured in **(mm)** and denoted by the symbol $\boldsymbol{PREC}$.
- **CO_2 Emissions**: An independent variable that explains total grain production, measured in **(Mton CO_2)** and denoted by the symbol $\boldsymbol{CO2}$.

(The time series of the last three variables are presented in **Appendix 1)**

The model takes the following form:

$$CER\_PRO_t = f(CUL\_AREA_t \ . \ PREC_t \ . \ CO2_t)$$

In this study, we apply the Napierian logarithm to the variables because the log-linear form is commonly used due to its ease of computation and its ability to address heteroscedasticity issues. Additionally, the elasticities provide valuable economic interpretations.

3.2 Analysis of the Stationarity of Study Variables

The table 5 shows the results of the Dickey-Fuller test for the study variables:

Table 5. *Dickey-Fuller Test Results for Study Variables*

Rank	First difference	Level	series

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

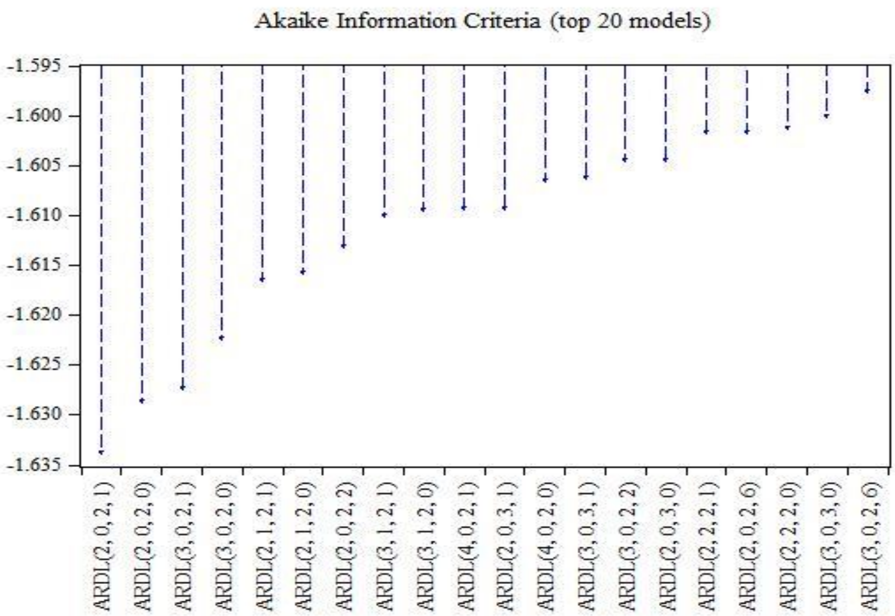
Research Article

	Trend & Intercept	Intercept	None	Trend & Intercept	Intercept	None		
I(1)	7.4827-	7.3618-	7.4174-	2.3146-	2.6721-	0.4813-		
I(1)	3.9395-	3.6903-	3.7422-	1.9191-	1.9114-	0.0254-	$LNCUL\_AREA_t$	
I(1)	3.7043-	3.1107-	3.0388-	0.9183-	0.1275	1.3448-	$LNPREC_t$	
I(1)	4.7674-	4.6836-	4.6998-	0.9558-	1.6879-	0.7861	$LCO2_t$	
	-4.0620	-3.5038	-2.5906	-4.0620	-3.5038	-2.5906	1%	Tabulated critical values
	-3.4599	-2.8935	-1.9444	-3.4599	-2.8935	-1.9444	%5	
	-3.1561	-2.5839	-1.6144	-3.1561	-2.5839	-1.6144	%10	

Source: Prepared by researchers based on EViews 10 outputs.

From table 5, we find that the results of the Dickey-Fuller test for the variables in their logarithmic form indicate that the study variables contain a unit root at their original level, as they become stationary after taking their first difference.

Figure 2. *Top 20 ARDL Models by AIC*



Source: EViews 10 output.

Figure 2 illustrates the top 20 models with the lowest AIC values, with ARDL (2,0,2,1) being the best among them.

3.4 Bounds Test

From table 6, we find that the calculated F-statistic value, which is equal to 4.52, is greater than the upper limit value at a 5% significance level, which is 3.83, and thus the alternative hypothesis is accepted, i.e. there is a long-term

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

equilibrium relationship between total cereals production and its explanatory variables in Algeria during the study period. Thus, there is a simultaneous integration relationship.

Table 6. *Bounds Test Results*

F-Bouds Test	*Null Hypothesis : No levels relationship*			
Test Statistic	*Value*	*Signif*	*I(0)*	*I(1)*
		Asymptotic : n=1000		
F-statistic	*4.523391*	*10%*	*2.37*	*3.2*
k	*3*	*5%*	*2.79*	*3.67*
		2.5%	*3.15*	*4.08*
		1%	*3.65*	*4.66*
Actual Sample Size	*87*	*Finite Sample : n=80*		
		10%	*2.474*	*3.312*
		5%	*2.92*	*3.838*
		1%	*3.908*	*5.044*

Source: EViews 10 output.

3.5 Estimation of the model parameters for the long and short term and the error correction parameter

After confirming the existence of a long-term equilibrium relationship between the total cereals production and its explanatory variables in Algeria, we will estimate the parameters of the ARDL model for the long and short terms and the error correction vector parameter. This estimate includes the time series lags included in the model along with the error correction term (ECM). The estimation results were as follows:

Table 7. *Long-Term Parameter Estimates for ARDL Model*

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	*Coefficient*	*Std.Error*	*t-Statistic*	*Prob*
LNCUL_AREA	*18.45801*	*8.629345*	*2.138982*	*0.0356*
LNPREC	*1.485353*	*0.306387*	*4.847959*	*0.0000*
LNCO2	*0.897153*	*0.170723*	*5.255008*	*0.0000*
C	*-160.4090*	*78.13271*	*-2.053033*	*0.0434*
*EC=LNCER_PRO-(18.4580*LNCUL_AREA+1.4854*LNPREC + 0.8972*LNCO2-160.4090)*				

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

Source: EViews 10 output.

The ECM equation can be derived as follows:

$$EC = LCER\_PRO_t - (-160.40 + 18.45 \cdot LNCUL\_AREA_t + 1.48 \cdot LNPREC_t + 0.89 \cdot LNCO2_t)$$

Table 8: *Results of estimating the error correction model for the ARDL model*

ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std.Error	t-Statistic	Prob
D(LNCER_PRO(-1))	0.289775	0.080959	3.579299	0.0006
D(LNPREC)	1.733520	0.348404	4.975600	0.0000
D(LNPREC(-1))	-0.892007	0.380530	-2.344120	0.0216
D(LNCO2)	-1.308165	0.894578	-1.462326	0.1477
CointEq(-1)*	-0.328727	0.067415	-4.876146	0.0000

Source: EViews 10 output.

The ECM estimating results indicate a strong alignment between the short-term and long-term parameter estimates in terms of their significance and sign.

3.6 Diagnosis of the estimated model

3.6.1 Economically

3.6.1.1 Evaluation of Short-Term and Long-Term Parameter Estimates

Based on the ARDL model results shown in Tables 7 and 8, we conclude the following:

- Coefficient for Arable land $\boldsymbol{LNCUL\_AREA_t}$: Indicates a positive and significant effect on total cereals production in both the long and short terms. The partial elasticity of cereals production with respect to Arable land is 18.45 in the long term, meaning that a 1% increase in Arable land leads to an 18.45% increase in cereals production. In the short term, this elasticity is 0.289, meaning a 1% increase in Arable land leads to a 0.289% increase in the same year.
- Coefficient for Annual precipitation $\boldsymbol{LNPREC_t}$: Shows a positive and significant effect on total cereals production in both the long and short terms. In the long term, the partial elasticity of cereals production with respect to Annual precipitation is 1.48, meaning a 1% increase in rainfall leads to a 1.48% increase in cerels production. In the short term, this elasticity is 1.73, indicating a 1% increase in rainfall amount leads to a 1.73% increase in the same year.
- Coefficient for CO2 Emissions $\boldsymbol{LNCO2_t}$: Shows a positive and significant effect on total cereals production in the long term, with an elasticity of 0.89. This means a 1% increase in CO2 emissions leads to a 0.89% increase in cereals production. However, in the short term, there is a negative and insignificant effect with an elasticity of -1.30, indicating that a 1% increase in CO2 emissions leads to a 1.30% decrease in cereals production in the same year.

3.6.1.2 Evaluation of the Unrestricted Error Correction Model (ARDL-ECM)

The estimated ECM parameters closely align with the long-term estimates in terms of signs and statistical significance. The error correction coefficient (Coint Eq (-1)) reflects the adjustment speed from the short to the long term. It is expected to be negative and significant, supporting the existence of a long-term equilibrium relationship.

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

The coefficient value is -0.3287, meaning that each deviation in the short term is corrected by 0.3287% per quarter, so a full adjustment (100%) takes approximately 3.04 quarters.

3.6.2 Statistically

Based on the statistical criteria, we find that the estimated ARDL model (2.0.2.1) is statistically acceptable

in general, as most of its estimated parameters have statistical significance according to the Student test at a significance level of α = 5%, while the value of the corrected coefficient of determination, which is $\bar{R}^2 = 0.8302$, indicates the high explanatory power of this model, i.e. the independent variables explain 83.02% of the changes in total cereals production in Algeria during the study period, and the Fisher statistic, which is 47.67, indicates the overall significance of the estimated model.

Table 9. *Statistical Indicators and Criteria for the Estimated ARDL Model*

R-squared	0.830226	Mean dependent var	15.14286
Adjusted R-squared	0.812814	S.D. dependent var	0.229202
S.E. of regression	0.099164	Akaike info criterion	-1.686382
Sum squared resid	0.767016	Schwarz criterion	-1.431288
Log likelihood	82.35762	Hannan-Quinn criter	-1.583664
F-statistic	47.67941	Durbin-Watson stat	1.945924
Prob(F-statistic)	0.000000		

Source: EViews 10 output.

3.6.3 econometrically

After estimating the parameters of the ARDL model for both the long and short terms and diagnosing it economically and statistically, we conduct the following model diagnostic checking tests:

Table 10. *Results of Model Diagnostic Checking Tests*

BGLM	ARCH	Jarque Bera	Reset
F – statistic = 0.1745 Prob. F(2.76) = 0.8402	F – statistic = 2.538 Prob. F(1.84) = 0.1154	J. B = 0.4103 Probability = 0.1845	F – statistic = 0.6194 Prob. F(1.18) = 0.4337

Source: Prepared by researchers based on EViews 10 outputs.

Accordingly, the results of the model diagnostic checking tests are as follows:

- The BGLM statistic indicates the absence of autocorrelation in the errors.
- The ARCH test result indicates no heteroscedasticity problem, as the p-value is 0.11, which is greater than the 5% significance level, confirming the absence of heteroscedasticity.
- The Jarque-Bera (JB) statistic indicates that the residuals follow a normal distribution, with a p-value of 0.41, which is greater than the 5% significance level.
- The RESET test statistic suggests the correctness of the functional form of the estimated model, as the p-value is 0.43, which is greater than the 5% significance level, thus supporting the hypothesis that the model is correctly specified.

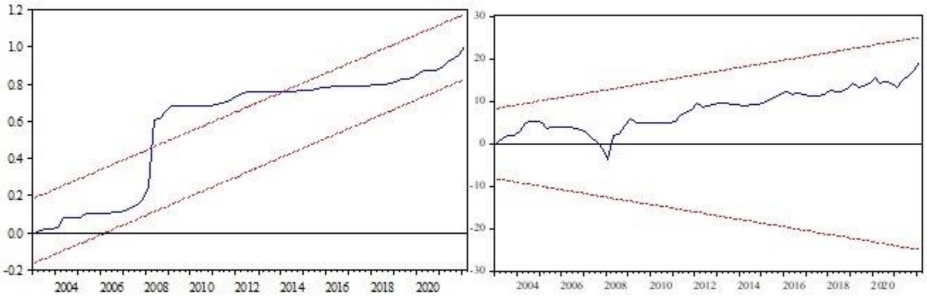
Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

- **Structural Stability Tests for Model Parameters:**

To verify that the estimated model is free from structural changes over time, we use the following two tests:

- The Cumulative Sum of Recursive Residuals (CUSUM) test;
- The Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) test;

Figure 3. *Results of the Structural Stability Tests for Model Parameters*



Source: EViews 10 output.

The previous graph shows that the CUSUM and CUSUMSQ statistics for this model fall within the critical bounds at the 5% significance level, indicating stability and consistency in the model estimates between the long-term and short-term results. This suggests that the estimated parameters of the Unrestricted Error Correction Model (UESM) are structurally stable throughout the study period.

5. CONCLUSION

The theoretical section of our study highlighted the rising trends in greenhouse gas emissions in both Algeria and Saudi Arabia. While these emissions may not yet match the levels seen in industrialized countries with nuclear plants and chemical factories, their upward trend is an alarm bell. Algeria, through its 2030 development program, and Saudi Arabia, through Vision 2030, are both committed to achieving high levels of food security by increasing local grain production. This focus is supported by the data presented in the first part of the study. Therefore, it is essential for the governments of both countries to mitigate the factors that negatively impact food security, particularly the indicators analyzed in the econometric part of the research.

The positive relationship between cultivated land area, rainfall, and total grain production requires policymakers to improve agricultural land management and prevent urban encroachment on these lands. Additionally, expanding forested areas can help curb desertification. Regarding rainfall, a crucial indicator of climate change, it is necessary to reduce carbon dioxide emissions, which harm the environment, especially as both countries are poised for industrial expansion.

Key Recommendations for Policy Makers in the MENA Region

1. Integrating Climate Risk into Food Systems

Addressing climate risks in the MENA region's food systems is essential for tackling vulnerabilities exacerbated by the region's unique challenges, such as water scarcity, dependence on food imports, and political instability. By embedding climate risk management, policymakers can mitigate global market fluctuations, supply chain disruptions, and economic and financial risks. This approach not only reduces the impact of widespread food insecurity but also strengthens regional food security and promotes stability in socio-economic and political systems.

2. Building Climate-Resilient Food Systems in the MENA Region

Climate-resilient food systems in MENA should include the following priority actions:

- Climate-proof logistics and supply chains: Enhance infrastructure to safeguard food distribution against climate-induced disruptions.

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

- Reducing post-harvest losses: Invest in technologies and practices to preserve food quality in hot and arid climates.
- Mitigating food price volatility: Develop policies and mechanisms to stabilize food prices, particularly for import-dependent countries.
- Improving access to basic services: Strengthen access to healthcare, clean water, and sanitation, which are critical in mitigating health risks tied to climate change.
- Enhancing social protection measures: Tailor safety nets and social protection programs to address the needs of vulnerable populations, particularly those affected by climate-related shocks.

These efforts should be supported by inclusive and sustainable economic growth, with a focus on creating jobs and economic opportunities for marginalized groups, particularly youth and women, who are disproportionately affected by unemployment and poverty in the region.

3. Adapting Agriculture to Regional Challenges

Agriculture in the MENA region, which is highly dependent on scarce water resources, must adapt to the realities of climate change. Key measures include:

- Investing in water-efficient agricultural practices and technologies, such as precision irrigation and drought-resistant crop varieties.
- Focusing on areas of comparative advantage, such as high-value crops suited to arid conditions, to maximize agricultural productivity.
- Supporting poor rural food producers to adapt to changing risks by providing access to financial tools, training, and resources. For those unable to sustain agriculture as a livelihood, policies should facilitate their transition to alternative employment opportunities.
- Targeting drought management and poverty reduction efforts at the most vulnerable populations in remote and marginal environments, which are particularly prone to climate shocks.

By implementing these measures, MENA policymakers can build resilient food systems that not only address immediate climate risks but also contribute to long-term regional stability, food security, and sustainable development.

Appendix 1

Arable land in Algeria in (1000 h) and denoted by the symbol CUL_AREA

year	Arable land	year	Arable land
2000	7,662	2012	7,506
2001	7,583	2013	7,496
2002	7,547	2014	7,496
2003	7,503	2015	7,462
2004	7,493	2016	7,404
2005	7,511	2017	7,470
2006	7,470	2018	7,500
2007	7,469	2019	7,530
2008	7,489	2020	7,530
2009	7,493	2021	7,530
2010	7,502	2022	7,530
2011	7,502	2023	7,530

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Source: (FAO, 2024)

Annual precipitation in Algeria in (mm) and denoted

by the symbol ***PREC***

year	Prec	year	Prec
2000	60.79	2012	86.41
2001	68.06	2013	89.82
2002	71.21	2014	77.52
2003	10.2	2015	80.02
2004	97.67	2016	69.56
2005	73.31	2017	78.31
2006	93.24	2018	95.10
2007	90.24	2019	78.64
2008	83.53	2020	60.66
2009	93.89	2021	61.96
2010	95.86	2022	57.61
2011	97.61	2023	95.23

Source: (World Bank, 2024)

CO2 Emissions in Algeria (Mton CO2) and denoted

by the symbol ***CO2***

Year	CO2 fossil	Year	CO2 fossil
2000	87.93	2012	140.25
2001	85.82	2013	145.7
2002	89.68	2014	155.01
2003	96.5	2015	164.86
2004	96.62	2016	160.99
2005	101.39	2017	166.55
2006	105.5	2018	174.83
2007	108.91	2019	181.64
2008	113.7	2020	171.89
2009	116.08	2021	179.74
2010	118.61	2022	186.64
2011	124.79	2023	180.35

Source: (Crippa, Guizzardi, et al., 2024)

Acknowledgement:

The authors are thankful to the Deanship of Graduate Studies and Scientific Research at University of Bisha for supporting this work through the Fast-Track Research Support Program.

Journal of Information Systems Engineering and Management
2025, 10(49s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

REFERENCES

[1] Agboola, M. O., Bekun, F. V., & Balsalobre-Lorente, D. (2021). Implications of Social Isolation in Combating COVID-19 Outbreak in Kingdom of Saudi Arabia: Its Consequences on the Carbon Emissions Reduction. *Sustainability*, Vol (*13)* 16, 9476. https://doi.org/10.3390/su13169476

[2] Akbari, M., Foroudi, P., Shahmoradi, M., Padash, H., Parizi, Z. S., Khosravani, A., Ataei, P., & Cuomo, M. T. (2022). The Evolution of Food Security: Where Are We Now, Where Should We Go Next? *Sustainability*, Vol *14*(6), 3634. https://doi.org/10.3390/su14063634

[3] Anis Munirah, M., & Norfarizan-Hanoon, N. (2022). Interrelated of food safety, food security and sustainable food production. Food Research, Vol (6) (1), pp 304-310. doi:10.26656/fr.2017.6(1).696

[4] Assil, E. M., Amine, A. (2021). Food Security in the MENA Region: Does Agriculture Performance Matter? In: B. M, & B. Barjees, Emerging Challenges to Food Production and Security in Asia, Middle East, and Africa (pp. 101–125). Cham: Springer. doi.org/10.1007/978-3-030-72987-5_4

[5] Awudu, A., & Christian, K. (2012). Food Security Policy in Developing Countries. In: L. Jayson L, R. Jutta, & S. and Jason F, The Oxford Handbook of the Economics of Food Consumption and Policy (pp. 345-369). Oxford: Oxford University Press. doi.org/10.1093/oxfordhb/9780199569441.013.0014

[6] Berchin, I.I., Silva de Amorim, W., de Andrade Guerra, J.B.S.O. (2020). Food Security. In: Leal Filho, W., Marisa Azul, A., Brandli, L., Gökçin Özuyar, P., Wall, T. (eds) Sustainable Cities and Communities. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-95717-3_18

[7] Bozsik N, Cubillos T. JP, Stalbek B, Vasa L, Magda R (2022) Food security management in developing countries: Influence of economic factors on their food availability and access. PLoS ONE, Vol 17(7): e0271696. https://doi.org/10.1371/ journal.pone.0271696

[8] Buluma, P. (1992). Household food security: a conceptual review. Household Food Security: Concepts, Indicators, New York and Rome: UNICEF and IFAD. Retrieved from www.academia.edu/1037546/Household_food_security_a_conceptual_review

[9] Cadavid, L., Arulnathan, V., & Pelletier, N. (2024). Food Security and Food Sovereignty: A Review of Commonly Used Indicators and Consideration of Environmental Sustainability Aspects. *Sustainability*, Vol (*16)* 24. https://doi.org/10.3390/su162411034

[10] Clapp, J, William G. Moseley, Burlingame, B,. Termine, P,. (2022). Viewpoint: The case for a six-dimensional food security framework, Food Policy, Vol (106) , pp 1-10. doi: 10.1016/j.foodpol.2021.102164

[11] Courtney, L. (2020). Climate change impacts on food security- focus on perennial cropping systems and nutritional value. Plant Science, Vol (293), pp. 1-7. doi.org/10.1016/j.plantsci.2020.110412

[12] Crippa, M., Guizzardi, D., et al,. (2024). EDGAR 2024 GHG emissions. Luxembourg: JRC/IEA report. dx.doi.org/10.2760/4002897

[13] Diabate, N. (2019). Government Stability, Corruption, Investment Conditions and Private Investment in Côte d'Ivoire: The Autoregressive Distributed Lag (ARDL) Approach. Modern Economy, Vol (10), pp 1812-1828. doi:10.4236/me.2019.107117

[14] FAO. (2002). The State of Food Insecurity in the World 2002. Rome: FAO. Available at: fao.org/4/y7352e/y7352e00.htm. [Accessed 02 November 2024].

[15] FAO. (2003). TRADE REFORMS AND FOOD SECURITY Conceptualizing the Linkages, Rome: FAO 2003. Available at: https://www.fao.org/4/y4671e/y4671e00.htm [Accessed 02 November 2024].

[16] FAO. (2003). TRADE REFORMS AND FOOD SECURITY: CONCEPTUALIZING THE LINKAGES. Rome: FAO. Available at: fao.org/4/y4671e/y4671e00.htm#Contents. [Accessed 02 November 2024].

[17] FAO. (2024, 10 1). The Food and Agriculture Organization (FAO). Available at: Food and Agriculture Organization of the United Nations: www.fao.org/ [Accessed 07 November 2024].

[18] Gonzalo, E., & Lara, L.-T. (2020, April 22). Working Paper 6/2020. Oil markets, energy transition, climate governance and COVID-19: the short, the medium and the long term. Madrid, Madrid, Spain: Elcano Royal Institute. dx.doi.org/10.13140/RG.2.2.17375.07844

[19] Howarth, N., Odnoletkova, N., Alshehri, T., Almadani, A., Lanza, A., & Patzek, T. (2020). Staying Cool in A Warming Climate: Temperature, Electricity and Air Conditioning in Saudi Arabia. *Climate*, *8*(1), 4. https://doi.org/10.3390/cli8010004

[20] Gregory, P., Ingram, J., Brklacich, M. (2005). Climate change and food security. Philosophical Transactions of the Royal Society B: Biological Sciences, Vol (360), pp. 2139-2148. doi.org/10.1098/rstb.2005.1745
[21] Lin, H.-I., Yu, Y.-Y., Wen, F.-I., & Liu, P.-T. (2022). Status of Food Security in East and Southeast Asia and Challenges of Climate Change. Climate, Vol (10), pp 1-35. doi:10.3390/cli10030040
[22] Xie, H., Wen, Y., Choi, Y., & Zhang, X. (2021). Global Trends on Food Security Research: A Bibliometric Analysis. *Land*, Vol *10* (2), pp 119. https://doi.org/10.3390/land10020119
[23] Popp, J. , Balogh, P., Oláh, J., Kot, S., Rákos, H., Lengyel, H. (2018). Social Network Analysis of Scientific Articles Published by Food Policy. Sustainability, Vol (10), pp. 1-20. doi.org/10.3390/su10030577
[24] García-Díez, J., Gonçalves, C., Grispoldi, L., Cenci-Goga, B., & Saraiva, C. (2021). Determining Food Stability to Achieve Food Security. *Sustainability*, Vol *13*(13), 7222. https://doi.org/10.3390/su13137222
[25] Julia, L., & Stéphane, M. (2018, November 30). Learning communities and new farmer knowledge in Canada. Geoforum, Vol (96), pp. 256-267. doi.org/10.1016/j.geoforum.2018.07.022
[26] Menegaki, A. N. (2019). The ARDL Method in the Energy-Growth Nexus Field; Best Implementation Strategies. *Economies*, Vol *7*(4), 105. https://doi.org/10.3390/economies7040105
[27] Michel P, P., & Priscilla, C. (2024). Food Sovereignty. In: A. Mark, Oxford Research Encyclopedia of Anthropology (pp. 1-47). New York: Oxford University. doi.org/10.1093/acrefore/9780190854584.013.297
[28] Mirzabaev, A., Kerr, R. B., Hasegawa, T., Pradhan, P., Wreford, A., Pahlen, M. C. T. V. D., & Gurney-Smith, H. (2023). Severe Climate Change Risks to Food Security and Nutrition. *Climate Risk Management*, Vol (*39)*, Article 100473. https://doi.org/10.1016/j.crm.2022.100473
[29] Mohammed, B., Mohamed, E., & others, &. (2022). Climate Change and Agricultural Production in Algeria. In: W. Leal Filho, & E. Manolas, Climate Change in the Mediterranean and Middle Eastern Region (p. January). 01: Climate Change Management. Springer. doi.org/10.1007/978-3-030-78566-6_12
[30] Mohammed, Touitou; Al-Amin, Abul Quasem (2018) : Climate change and water resources in Algeria: Vulnerability, impact and adaptation strategy, Economic and Environmental Studies (E&ES), ISSN 2081-8319, Opole University, Faculty of Economics, Opole, Vol. 18, Iss. 1, pp. 411-429, https://doi.org/10.25167/ees.2018.45.23
[31] Molotoks A, Smith P, Dawson TP. (2021), Impacts of land use, population, and climate change on global food security. *Food Energy Secur*.; Vol (10) :e261. https://doi.org/10.1002/fes3.261
[32] Muhammad, S. F., Muhammad, U. (2022). Uncovering the Research Gaps to Alleviate the Negative Impacts of Climate Change on Food Security: A Review. Front. Plant Sci, Vol (13), pp. 1-39. doi.org/10.3389/fpls.2022.927535
[33] Perasan, et al., (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, Vol (16), pp 289-326. doi:10.1002/jae.616
[34] Pinstrup-Andersen, Per and Watson II, Derrill D.. "Chapter 7. Food Production and Supply Policies". *Food Policy for Developing Countries: The Role of Government in Global, National, and Local Food Systems*, Ithaca, NY: Cornell University Press, 2011, pp. 174-215. https://doi.org/10.7591/9780801463433-012
[35] Reema Gh, A. (2021). Factors that impact greenhouse gas emissions in Saudi Arabia: Decomposition analysis using LMDI. Energy Policy, Vol (156), pp. 1-15. doi.org/10.1016/j.enpol.2021.112454
[36] Sahnoune, F., Belhamel, M., & others, &. (2016, December 08). Algerian energy policy and potential to reducing greenhouse gas emissions. Energy Sources, Part B: Economics, Planning, and Policy, Vol (11), pp. 1118-1127. doi.org/10.1080/15567249.2014.936537
[37] Sahnounea, F., Belhamel, M. (2013). Climate Change in Algeria: Vulnerability and Strategy of Mitigation and Adaptation. Energy Procedia, Vol (36), pp. 1286 – 1294. doi.org/10.1016/j.egypro.2013.07.145
[38] Sampson D, Cely-Santos M, Gemmill-Herren B, Babin N, Bernhart A, Bezner Kerr R, Blesh J, Bowness E, Feldman M, Gonçalves AL, James D, Kerssen T, Klassen S, Wezel A and Wittman H (2021) Food Sovereignty and Rights-Based Approaches Strengthen Food Security and Nutrition Across the Globe: A Systematic Review. Front. Sustain. Food Syst. Vol (5), doi: 10.3389/fsufs.2021.686492
[39] Shouro, D., Elizabeth, J. Z. (2022). Attributing changes in food insecurity to a changing climate. scientific reports, Vol (12), pp 1-20. doi:10.1038/s41598-022-08696-x

[40] Tamasiga, P., Onyeaka, H., Akinsemolu, A., Bakwena, M. (2023). The Inter-Relationship between Climate Change, Inequality, Poverty and Food Security in Africa: A Bibliometric Review and Content Analysis Approach. *Sustainability*, Vol *15*(7), 5628. https://doi.org/10.3390/su15075628

[41] Thamir, A. S., Jan Frederik, B., & others, &. (2022, May 22). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach. CLIMATE POLICY, Vol (23), pp. 151–167. doi.org/10.1080/14693062.2022.2070118

[42] Theodoros, V., Slim, S. (2024). Global Food Security and Sustainability Issues: The Road to 2030 from Nutrition and Sustainable Healthy Diets to Food Systems Change. Foods, Vol (13) 2, 1-29. doi:10.3390/foods13020306

[43] Tomoko, H., Gen, S. (2021). Extreme climate events increase risk of global food insecurity and adaptation needs. Nature Food, Vol (02), pp. 587–595. doi.org/10.1038/s43016-021-00335-4

[44] Uzair, A., Qingbin, G. (2023). Heterogeneous impact of industrialization, foreign direct investments, and technological innovation on carbon emissions intensity: Evidence from Kingdom of Saudi Arabia. Applied Energy, Vol (336), pp. 1-12. doi.org/10.1016/j.apenergy.2023.120804

[45] Valarie Blue Bird, J. (2023). Food Sovereignty and Health: A Conceptual Framework to Advance Research and Practice. Health Promotion Practice, Vol (24) 6, pp 1070-1074. doi:10.1177/15248399231190367

[46] Waleed, S. (2020). Bibliometric analysis of peer-reviewed literature on food security in the context of climate change from 1980 to 2019. Agriculture & Food Security, Vol (09), pp. 1-15. doi.org/10.1186/s40066-020-00266-6

[47] Wen, P., & Elliot M, B. (2018, November 28). The Concept of Food Security. Encyclopedia of Food Security and, Vol (02), pp. 1-7. dx.doi.org/10.1016/B978-0-08-100596-5.22314-7

[48] Wijerathna-Yapa, A., & Pathirana, R. (2022). Sustainable Agro-Food Systems for Addressing Climate Change and Food Security. *Agriculture*, Vol (*12)* (10), 1554. https://doi.org/10.3390/agriculture12101554

[49] Wittman, H. (2023, May 19). Food sovereignty: An inclusive model for feeding the world and cooling the planet. One Earth, Vol (06) 5, pp. 474 - 478. doi.org/10.1016/j.oneear.2023.04.011

[50] World Bank. (2024). Country: Algeria. Available at: The Climate Change Knowledge Portal (CCKP): https://climateknowledgeportal.worldbank.org/ [Accessed 19 december 2024].

[51] World Bank Group. (2023). What is Food Security?, Available at: World Bank Group - International Development, Poverty & Sustainability: https://www.worldbank.org/ext/en/home [Accessed 19 december 2024].

[52] Zafar, K. M. (2020). ARDL – Analysis of the Relationship among Exports, FDI, Current Account Deficit and Economic Growth in Pakistan. (U. o. Faculty of Economics, Éd.) Iranian Economic Review , Vol (24) 2, pp. 393 - 414 . doi:10.22059/ier.2020.76010

[53] Zhichkin, K., Nosov, V. (2021). The food security concept as the state support basis for agriculture. Agronomy Research, Vol (19) 2, pp. 629–637. doi.org/10.15159/ar.21.097