

Review paper

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NEXUS BETWEEN CLIMATE CHANGE AND FOOD SECURITY IN TUNISIA

Nader Amir FARES, Hamid EL BILALI*

International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM-Bari),
Valenzano (Bari), Italy

*Corresponding author: elbilali@iamb.it

ABSTRACT

Tunisia, a North African country located in the Mediterranean region, faces significant challenges to its food security in the context of a changing climate. This study aims to provide an in-depth analysis of the literature dealing with the nexus between climate change and food security in Tunisia. In particular, the review investigates the impact of climate change on the four dimensions of food security – namely availability, access, utilization, and stability – and explores potential mitigation and coping strategies. The review suggests a lack of research on this critical topic. Climate change has impacted negatively Tunisia's water resources, leading to increased water scarcity and a decline in agricultural productivity. This situation has direct implications for food availability in the country. Furthermore, the increasing frequency of extremely severe weather events (e.g., droughts, floods) contributes to the volatility of food prices. This affects the accessibility of food for vulnerable populations, particularly those residing in rural areas. Moreover, access to food is becoming harder for consumers, which has also led to some changes in diets (cf. food use/utilization). By the end, the Tunisian food system is more vulnerable and threatened by climate change, which affects its long-term stability and sustainability. Additional research is necessary to gain a better understanding of the intricate interplay between climate change and food security in Tunisia, as well as how this challenge can be compounded by other external crises and stresses, such as the COVID-19 pandemic and the war in Ukraine. Such research could help advance knowledge on food security in Tunisia and North Africa more broadly.

Keywords: *climate change, food system, agriculture, food security, North Africa.*

INTRODUCTION

Food security and nutrition security are closely related. Food security is a concept that refers to the availability, accessibility, and affordability of food, whereas nutrition security is a concept that refers to the capacity to get adequate and nutritious food that fits the dietary needs of consumers (FAO, 2021). The Sustainable Development Goals (SDGs), the second SDG in particular, seek to eradicate hunger, provide food security and nutrition, and support sustainable

agriculture. Food security and nutrition are important components of sustainable development (UN, 2015).

Unfortunately, food insecurity and malnutrition remain major challenges in many developing nations, including the Middle East and North Africa (MENA). Tunisia, in particular, confronts food security and nutrition concerns (FAO, 2021; World Bank, 2020). One of the global challenges is climate change and it has significant implications for food security and nutrition. The agriculture sector is one of the sectors most affected by climate change although its significant contribution to greenhouse gas (GHG) emissions (IPCC, 2019). For countries such as Tunisia, where agriculture is a vital sector from a socio-economic point of view, climate change poses a significant challenge on different scales (FAO, 2020).

Tunisia is a country with a population of approximately 12 million people (INS Tunisia, 2023). The sector of agriculture is a vital contributor to the country's economy, employing around 16% of the population (World Bank, 2021). Tunisia is characterized essentially by the production of olive, citrus, and dates (INS Tunisia, 2023). However, climate change has already had significant impacts on the country's agriculture and rural development, which has made the agri-food sector vulnerable (FAO, 2020). Indeed, the changing climate in Tunisia is a cause for concern, with trends showing increasing temperatures during the summer season reaching sometimes more than 42 degrees, and decreasing rainfall during winter (IPCC, 2019). In addition, Tunisia also faces significant issues related to food insecurity and malnutrition. According to FAO et al. (2021), around 7.3% of the Tunisian population experiences undernourishment, while 13.5% of children under five suffer from stunting (FAO, 2021).

In this context, the present paper aims to analyze the state of research on the nexus between climate change and food security in Tunisia. Specifically, the paper investigates whether and how the scholarly literature addresses the impacts of climate change on the four dimensions of food security (*viz.* availability, access, utilization and stability) and explores the synergies and trade-offs between climate change mitigation and food security.

METHODS

The paper draws upon a comprehensive search of both scholarly literature and grey literature, as well as various databases from the National institute of statistics and the Ministry of Agriculture in Tunisia. The search was conducted in June 2023 using Web of Science (Table 1) and included all documents indexed by that date, without any time range or publication date restrictions. The initial search was carried out using the search string: (*Tunisia OR "North* Africa" OR "South* Mediterranean"*) AND (*"food security" OR "food insecurity" OR nutrition*) AND (*"climate change" OR "climate variability" OR "global warming"*). The search string used in the initial search was designed to narrow down the search topic in a systematic way, ensuring that relevant articles were identified. The search was not limited by geography; however, the focus of the scholarly literature was on North Africa, South Mediterranean, and Tunisia. The search returned 243 documents and

88 resulted eligible after the screening of titles, abstracts and, when needed, full texts (Table 1). In addition to the Web of Science search, many articles were sourced from various organizations such as the Food and Agriculture Organization of the United Nations (FAO) and the World Bank. The use of both scholarly literature and grey literature allowed for a more comprehensive review of the topic, enabling the inclusion of a wide range of perspectives and data sources. Despite the challenges associated with finding and evaluating grey literature, it can provide valuable information for researchers, policymakers, and practitioners, particularly in rapidly evolving fields or where research is not typically published in peer-reviewed journals.

Table 1. Systematic review steps and process: documents identification and selection.

Selection steps	Number of selected documents	Number of excluded documents and ineligibility reasons
Initial search and documents Identification	243	-
Screening of records based on titles	345	59 documents excluded because they do not focus on Tunisia or do not address climate change or food security
Screening of documents based on abstracts	175	62 documents excluded: <ul style="list-style-type: none"> • 25 documents because they do not address climate change • 30 documents because they do not address food security • 7 documents because they are not relevant to Tunisia
Scrutiny of full-texts	113	25 documents excluded because they did not meet the eligibility criteria
Inclusion of eligible documents in the systematic review	88	-

RESULTS AND DISCUSSION

Several studies have analyzed food and nutrition security in Tunisia. A study by Belhaj and Maalej (2017) analyzed the scientific production on food and nutrition security in Tunisia between 1991 and 2015. It identified 75 publications in the field, with the majority of articles published in journals in the agricultural and biological sciences subject areas. The most active institutions in the field were the National Institute of Agronomy of Tunisia (INAT) and the Ministry of Agriculture (MARHP), while the most prolific authors were affiliated with these institutions (Belhaj and Maalej, 2017). Another study by Ben Khaled and Ben Mansour (2019) analyzed the scholarly literature on food security in Tunisia between 2000 and 2018. It identified 57 publications in the field, with the majority of articles published in journals in the agricultural sciences subject area. The most active

institutions in the field were the National Institute of Agronomy of Tunisia and the University of Carthage, whereas the most prolific authors were affiliated with these institutions (Ben Khaled and Ben Mansour, 2019). A more recent study by Lahmar et al. (2020) analyzed the literature on food security in North Africa, including Tunisia, between 2009 and 2019. The study identified 486 publications in the field, with the majority of articles published in journals in the agricultural and biological sciences subject areas. The most active Tunisian institutions in the field were also INAT and the University of Carthage (Lahmar et al., 2020). These studies highlight the important role of agricultural research institutions in the field of food and nutrition security in Tunisia. However, it is important to note that research in this field is multidisciplinary and involves contributions from a range of disciplines including nutrition, public health, and economics, among others.

In terms of journals, Belhaj and Maalej (2017) and Ben Khaled and Ben Mansour (2019) identified several journals that were the most frequent publishers of articles in the field of food and nutrition security in Tunisia. These journals include the Tunisian Journal of Agricultural Sciences, the Journal of Food Security, the International Journal of Agriculture and Biology, and the Journal of Applied Environmental and Biological Sciences.

Overall, these studies provide useful insights into the state of research on food and nutrition security in Tunisia. However, further research is needed to identify the gaps and limitations in the current research and to develop strategies to address these gaps.

Climate change and food availability

Climate change is influencing different factors that are related directly to food availability such as crop production or indirectly such as irrigation, pests and diseases and soil fertility.

Climate change is expected to have significant impacts on agricultural production in Tunisia, particularly in terms of crop production, animal production, and fisheries. Studies have reported that this phenomenon is likely to reduce agricultural yields, particularly in rainfed systems, due to increased temperatures, changing precipitation patterns, and increased frequency of extreme events (Kouki et al., 2018). For instance, Kouki et al. (2018) found that climate change is projected to reduce the yields of major crops, including wheat, barley, and olive, in Tunisia. Similarly, Ouessar et al (2021) reported that climate change is expected to negatively impact animal production, including dairy and meat production, due to heat stress and changes in forage quality. According to FAO (2019), the total agricultural production in Tunisia has already decreased by 12% between 2000 and 2017 due to climate change impacts, namely drought and water scarcity.

Climate change also poses significant challenges to soil health, water resources, and pest management in Tunisia and these parameters can influence the production and, consequently, food availability. In fact, soil degradation is one of the most pressing issues facing the country, with an estimated 70% of the land affected by erosion, salinization, and nutrient depletion. High temperatures exacerbate soil

degradation by increasing erosion rates and reducing soil moisture, which can lead to reduced crop yields and food availability (FAO, 2019).

Water scarcity is another challenge that is exacerbated by climate change. Tunisia is already a water-stressed country, and climate change is expected to worsen this problem. Changes in precipitation patterns and increased temperatures can lead to reduced water availability, particularly for rain-fed agriculture. Moreover, climate change can exacerbate existing water quality issues, such as contamination from agricultural runoff and saltwater intrusion into aquifers. The presence of water is crucial to ensure efficient production (MARHP, 2016).

Pests and diseases are also impacted by climate change, with changes in temperature and precipitation patterns altering the geographic distribution and prevalence of these threats. In Tunisia, pests such as the olive fruit fly and the date palm weevil are already significant issues that can impact crop yields. Climate change is expected to exacerbate these threats, making it more challenging to control them. Addressing pest and disease management is crucial to ensure the long-term sustainability of agriculture and food production in Tunisia (Jeder et al., 2020).

Additionally, climate change has been identified as a determinant and cause of food insecurity in Tunisia, leading to increased food losses and waste. For example, heat stress, drought, and floods caused by climate change have led to significant food losses in Tunisia, particularly in the fruit and vegetable sector. Knaepen (2021) estimated that on average, 20-30% of crops are lost due to climate change-related extreme events. Similarly, changes in food availability and quality induced by climate change have led to increased food waste in Tunisia. Ouessar et al. (2021) reported that food waste in Tunisia has reached up to 30% of total food production, with fruits and vegetables being the most wasted products.

Climate change and food access

Climate change can affect food access in Tunisia through its impacts on economic accessibility and physical accessibility. Higher food prices driven by climate change can lead to reduced affordability, particularly for vulnerable populations. According to Souissi et al (2022), the average price of wheat, a staple food in Tunisia, has increased by more than 200% over the past decade due to climate change impacts, such as drought and heatwaves. This increase in food prices can exacerbate food insecurity for households with limited purchasing power or those experiencing poverty (Souissi et al, 2022).

Moreover, climate change can exacerbate physical accessibility challenges due to the increased frequency of natural disasters and climate-induced migration. For instance, El Mokhtar et al (2022) found that climate-induced migration in Tunisia has led to increased competition for resources, including food, water, and land, particularly in urban areas. This increased competition can limit access to food for vulnerable populations, especially those who have been displaced by climate-induced migration (El Mokhtar et al, 2022).

Food access can be limited also because of the degradation of the quality, in particular the microbiological quality. In fact, in addition to the impacts on economic accessibility natural physical accessibility, climate change can also impact food safety in Tunisia (Souissi et al., 2022).

Climate change and food utilization

Food utilization refers to the way in which food is prepared, stored, and consumed by individuals and communities. In fact, the unavailability of certain foods as a result of climate change can affect diets and consumption patterns. For example, Ouessar et al. (2021) reported that climate change has led to a decrease in the availability of many products, such as milk, meat, and eggs, in Tunisia, which may lead sometimes to a shortage of these foods. This decrease in availability can result in reduced consumption of these foods, which are important sources of high-quality proteins, vitamins, and minerals (Ouessar et al., 2021).

Moreover, climate change can affect food safety. A study by Knaepen (2021) reported that climate change can lead to increased food losses and waste in Tunisia, which can have negative impacts on food safety and quality. This is because food may be contaminated or spoiled, which can increase the risk of foodborne illnesses (Knaepen, 2021). Moreover, higher temperatures and changes in precipitation patterns can increase the prevalence of foodborne pathogens, such as *Salmonella* and *Escherichia coli*, which can cause foodborne illnesses and reduce the safety of food products (FAO, 2018). Additionally, changes in temperature and humidity can lead to increased aflatoxin contamination in crops, particularly in peanuts and corn, which can lead to liver cancer and other health problems (Souissi et al., 2022). In addition, climate change can affect food processing and storage practices. For instance, Kouki et al. (2018) reported that climate change can lead to changes in post-harvest practices, such as drying and storing food, which can affect the safety and quality of food. Sudden modifications in temperature and humidity caused by external factors can increase the risk of fungal and bacterial growth, which can spoil food and increase the risk of foodborne illnesses (Kouki et al., 2018).

Climate change, long-term food security and food system stability

The stability of the food system is strictly related to its vulnerability to challenges and how far it can deal with food insecurity. Climate change has significant implications for long-term food security and the stability of food systems. In fact, its repercussions on agriculture, in particular, can undermine food system stability by increasing the vulnerability of agricultural production systems to many climatic shocks and stresses (IPCC, 2019). Climate change is projected to have severe impacts on crop yields, livestock productivity, and fisheries, which can have cascading effects on food availability and affordability (FAO, 2021).

In Tunisia, climate change poses a significant threat to food security and the stability of the food system. The country has already experienced the impacts of climate change, including rising temperatures, decreasing rainfall, and more frequent extreme weather events such as droughts and floods (World Bank, 2020).

The agriculture sector, which employs around 16% of the population and contributes significantly to the country's economy, is particularly vulnerable to these changes (World Bank, 2021).

To address these challenges, building resilience to climate change is essential to ensure the long-term stability of Tunisia's food system and food security. This can be achieved through a range of measures, including improving the resilience of agricultural production systems, diversifying crops and livestock, and investing in climate-smart agriculture practices (FAO, 2020). For example, the Tunisian government has initiated several programs and policies to enhance the resilience of the agriculture sector to climate change. The National Adaptation Plan for the Agriculture Sector (NAP-Ag) aims to integrate agriculture into the national plan and strengthen the adaptive capacity of the food sector to climate change by promoting sustainable agriculture practices, improving water management, and enhancing early warning systems for climate-related risks (UNEP, 2019). The government has also launched the Sustainable Intensification of Agriculture (SIA) program, which aims to increase agricultural productivity while reducing greenhouse gas (GHG) emissions and enhancing climate resilience (FAO, 2018). However, the country is still suffering from the severe consequences of this phenomenon.

Climate change mitigation and food security: synergies and trade-offs

The quest for food security in Tunisia can both contribute to and be affected by climate change mitigation efforts. For example, agricultural intensification and expansion can increase GHG emissions, thus exacerbating climate change. According to FAO (2018), the agricultural sector is responsible for about 14% of Tunisia's total GHG emissions, with enteric fermentation, synthetic fertilizers, and manure management being the main sources of emissions. Souissi et al. (2022) estimated that the agri-food sector accounts for about 30% of total GHG emissions in Tunisia. Moreover, climate change mitigation measures can have implications for food security.

Identifying and implementing policies and interventions that promote sustainable and climate-resilient agriculture, such as climate-smart agriculture (CSA), is crucial to address the actual challenges. CSA can enhance the food value chain by increasing agricultural productivity and incomes, reducing food security issues, and building resilience to climate change while reducing GHG emissions and enhancing carbon sequestration (Jeder et al., 2020). Jeder et al. (2021) reported that CSA practices, such as integrated pest management, agroforestry, crop rotation, and efficient use of water and nutrients, can help reduce GHG emissions and improve soil health while increasing crop yields and enhancing food security in Tunisia.

However, there are trade-offs to be considered in the pursuit of climate change mitigation and food security. For instance, policies that promote the use of biofuels for energy production can result in increased competition for land and water resources, leading to food insecurity. El Mokhtar et al. (2022) reported that the

expansion of biofuel crops in Tunisia has led to reduced availability and affordability of food crops, particularly for vulnerable populations. Therefore, it is important to develop policies and strategies that balance the goals of climate change mitigation and food security, considering the needs and perspectives of different stakeholders, including those representing the vulnerable groups.

Climate change and COVID-19: A mixed impact on food security in Tunisia

The impact of the COVID-19 pandemic on the food system in Tunisia has been significant. The pandemic has affected every aspect of the food system, from production to consumption. For instance, the closure of markets and disruptions to supply chains have led to increased food waste and reduced income for farmers, particularly small-scale farmers who rely on local markets to sell their produce (El Bilali et al., 2021). The pandemic has also affected the availability and affordability of food, with some households experiencing food insecurity due to the loss of income or reduced access to food markets (FAO, 2021).

Climate change is also projected to have negative impacts on agricultural production in Tunisia, particularly in the southern regions of the country, which could lead to reduced crop yields and reduced availability of water for irrigation (Ben Hassen et al., 2022). The COVID-19 pandemic has further exacerbated these challenges, with the closure of markets and disruptions to supply chains leading to increased food waste and reduced income for farmers (El Bilali et al., 2021).

Climate change and the COVID-19 pandemic have had a mixed impact on food security in Tunisia, with both challenges exacerbating the vulnerabilities of the country's food system. The closure of borders and disruptions to supply chains caused by the pandemic have led to reduced trade flows, higher food prices, and reduced availability of certain food items, while climate change is projected to cause reduced agricultural productivity, particularly in the southern regions. The COVID-19 pandemic has further revealed the weakness and the vulnerability of the Tunisian food system and made the situation harder for farmers in particular who, by the end, are still the weakest actors in the food value chain (FAO, 2021).

CONCLUSIONS

Tunisia is experiencing climate change, characterized by widespread warming, rainfall variability and an increase in the occurrence of climate extremes. These climate tendencies are projected to continue, which might have adverse effects on the socio-economic development of the country. There is a multifaceted relationship between climate change and food security in Tunisia. The review shows an increasing academic interest in the nexus between climate change and the four dimensions of food security. Indeed, the scholarly literature shows that climate change will affect all four dimensions of food security in Tunisia. However, there is a twofold gap in the research on the relations between climate change and food security in Tunisia; first, the research field is not sufficiently addressed even though climate change and food insecurity are among the main challenges facing the country, and second, the scholarly literature focuses on climate change impacts

on food availability, while impacts on food access, food use and stability are generally overlooked. Indeed, most of the analyzed literature deals with the effects of climate change on food production and availability, which are exacerbated by the high dependence of the country on rain-fed agriculture thus making it highly vulnerable to droughts and rainfall variability. Moreover, most of the impacts of climate change on food access, utilization and stability stem from its negative effects on food production and supply. The review also shows that, on the one hand, climate change mitigation measures can undermine food security, and, on the other hand, agriculture intensification and even some adaptation strategies aiming to enhance food security might increase GHG emissions from agriculture, forestry and other land uses.

This review has some limitations such as the limited availability/access of data; the heterogeneity of study designs and methodologies for assessing food security or climate change impacts, making it difficult to compare and synthesize their findings; the lack of standardization in the way climate change and food security are defined and measured, which makes it challenging to compare studies and draw conclusions; the limited scope of studies since most of them focus on specific Tunisian regions, usually southern or coastal ones; and publication bias since mainly studies with significant outcomes are published, leading to an overestimation of the true/real effect/impact of climate change on food security in Tunisia.

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