

## Article

# Challenges to Food Security in the Middle East and North Africa in the Context of the Russia–Ukraine Conflict

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**Abstract:** In this article, the impact of the Russia–Ukraine conflict on food security in the Middle East and North Africa (MENA) region is analyzed. With Ukraine being recognized as one of the major global grain producers and exporters, the conflict is seen as posing a significant challenge to MENA countries, which are heavily dependent on grain imports from Ukraine. The importance of global linkages in food supply chains and their influence on regional food security is highlighted in this context. Utilizing secondary data from 2002 to 2021 obtained from the United Nations Food and Agriculture Organization (FAO), the study focuses on demography and food security, analyzing how these factors intertwine with grain export dynamics. The escalating hostilities have disrupted transportation routes, damaged infrastructure, and hindered logistics, resulting in substantial export volume reductions. Geopolitical tensions have exacerbated these effects, diminishing confidence among MENA grain importers. The study highlights how these disruptions have influenced global supply chains, prices, and agricultural product availability, with a specific focus on the MENA region's challenges in food security, compounded by conflicts, climate change, and import dependence. A detailed demographic analysis reveals the impact of population changes on food demand and distribution, offering insights into how population growth and urbanization, alongside shifts in malnutrition and obesity rates, affect food security. The study concludes that the MENA region's increasing reliance on food imports, coupled with climatic and political variabilities, underscores its growing vulnerability to global supply chain disruptions and the need for robust strategies to address these challenges.

**Keywords:** food security; MENA region; Russian–Ukrainian conflict; grain import and export; international trade



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## 1. Introduction

The MENA region (Middle East and North Africa), encompassing the Middle East and North Africa, is an important geopolitical area comprising a diverse array of countries and territories. It should be emphasized that there is no single universal definition of this region, but for the purposes of this article, we rely on the definition provided by the World Bank. According to this definition, the MENA region consists of 20 countries, including Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Yemen, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, the United Arab Emirates, and Palestine. This region has long been dependent on food imports, especially grains, to meet the growing needs of its population [1]. Due to limited agricultural production capabilities caused by harsh climatic conditions [2], these countries must rely on external sources to ensure food security for their citizens. In this context, Ukraine, as one of the world's leading grain exporters, plays a role in securing food supplies for the MENA region [3]. However, the ongoing Russian–Ukrainian conflict, which has been escalating since 2014 [4], has created a situation of uncertainty regarding grain imports from Ukraine. This war,

occurring in one of the largest grain producers and exporters globally, has the potential to disrupt supply chains and destabilize food markets worldwide [5]. Undoubtedly, the consequences of this may be most acutely felt by countries that are most dependent on food imports, such as those in the MENA region.

Food security, defined by the United Nations Food and Agriculture Organization (FAO) as a situation where 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 [6], is a fundamental priority for all countries. From the perspective of the Ministry of Agriculture and Rural Development, food security is a strategy of states aimed at ensuring society's access to safe, nutritious, and diverse food, as well as providing it in adequate quantities. It also ensures that food is available at an affordable price and delivered through an uninterrupted supply network. Food security is guaranteed when there are no shortages of high-quality food in a country, and it is accessible to everyone [7]. According to Wiśniewska and Wyrwa, the definition of food security refers to a situation where all citizens of the world have the opportunity to consume safe, valuable, and nutritious food that meets their fundamental dietary requirements, while also respecting basic human rights to existence and equitable development [8]. In the MENA region, where food security is already threatened by factors such as climate change and armed conflicts, additional disruptions in food supplies can lead to severe crises [9].

The aim of this article is to explore the challenges to food security in the Middle East and North Africa (MENA) region arising from the Russia–Ukraine conflict, with a specific focus on the disruption of grain exports from Ukraine.

## 2. Literature Review

This literature review explores the broader impacts of geopolitical conflicts on global food security, with a specific focus on the impacts of the Russian–Ukrainian war and the challenges faced by the Middle East and North Africa (MENA) region. The review synthesizes existing research and analyzes to provide a comprehensive understanding of how these conflicts have influenced global food market dynamics and food security in the MENA region.

### *2.1. Consequences of the Russian Military Aggression in Ukraine for the Global Dynamics of the Food Market*

Analyzing the geopolitical effects of the Russian–Ukrainian conflict of 2022, it is important to consider not only the direct wartime consequences but also the long-term impact on global commodity markets, particularly food and energy markets. The full-scale invasion of Ukraine by Russia, which began on 24 February 2022, resulted in numerous civilian casualties, destruction of key infrastructure, and widespread displacements ([10]. In response, many Western countries, including the United States, Europe, Canada, and Australia, gradually expanded sanctions, targeting individuals, financial institutions, corporations, and large state enterprises, as well as exports [11]. While the humanitarian effects of this conflict are undoubtedly catastrophic, understanding the impact of this war on global trade, production, and consumption dynamics, especially in commodity markets, is important. The military aggression dealt a severe blow to global commodity markets, particularly in the food and energy sectors, contributing to significant disruptions that seem to maintain prices at historically high levels [12].

One of the areas particularly affected by the conflict is food production. Farmers in the conflict-affected areas of Ukraine have lost livestock, food supplies, and other assets, disrupting food supply to markets in these and other surrounding regions and neighboring countries [13]. FAO estimates for the 2022/2023 season indicate significant disruptions in the production of winter grains, related to shortages of production inputs, affecting agricultural activities both in Ukraine and Russia [14]. In Ukraine, the area of winter crop sowings has fallen by about 20% [15]. Winter wheat harvests are expected to start in early July 2024, but fuel availability and wartime conditions may limit harvesting and storage

capabilities. It is estimated that about 25% of the areas sown with winter crops will likely remain unharvested [16]. On the other hand, major disruptions in field crops are not expected in the Russian Federation. However, uncertainty exists regarding the export of agricultural products, despite the exclusion of food and fertilizers from international sanctions [15]. Economic sanctions, however, may disrupt the import of agricultural production inputs such as pesticides and seeds, essential for Russian agricultural production [11]. All these losses in production may lead to reduced farmer incomes, negatively impacting their future food production decisions [15]. Therefore, turmoil in the agricultural market has potentially far-reaching consequences. In 2023, the conflict cost Ukrainian farmers and agricultural corporations USD 28.3 billion in terms of lost income, damage to machinery and agricultural equipment, warehouses, livestock, and crops, as well as increased transportation costs [17]. Reduced yields and quality of agricultural products not only threaten the Russian and Ukrainian agricultural sector but also global food supplies, putting global food security into question [15].

The war in Ukraine has a significant impact on logistics, affecting elements of transport infrastructure—land transport, ports, and warehouses [18]. According to studies by Collier, infrastructure destruction is one of the most severe and long-lasting effects of wars [19]. It not only directly disrupts logistical processes but also requires significant investments for reconstruction, which can take years, even decades. Additionally, increased insurance premiums for vessels in the Black Sea raise the cost of maritime transport. This phenomenon is well-documented in the literature by Bichou and Gray, who emphasize that insurance costs are a significant factor in logistics costs, especially in situations of heightened conflict-related risk [20,21]. Consequently, these factors contribute to rising food import and export costs [18]. This is also consistent with findings by Anderson and Martin, who observed that disruptions in logistics tend to increase trade costs, which in turn affects food prices [22]. As noted by Schiffing and Valantis Kanellos, although container shipping in the Black Sea represents a relatively niche market globally, one of the largest container terminals is in Odessa [23]. If it is cut off by Russian forces, the effects on Ukrainian imports and exports can be significant, with potentially drastic humanitarian consequences.

Undoubtedly, the Russian–Ukrainian conflict affects energy supply chains, both directly and indirectly. This situation has broad implications for the global economy, and the agricultural sector is particularly sensitive to it [24]. Agriculture is a highly energy-dependent sector, especially in developed regions, where mechanization and the application of modern technology have enabled significant increases in efficiency and productivity [25]. The rise in oil prices, being one of the direct consequences of the conflict, affects not only the operational costs of agriculture but also the costs of production inputs, such as fertilizers and pesticides, which are highly dependent on oil prices [26]. On the other hand, rising oil prices may encourage farmers to seek alternative, more sustainable energy sources, which can bring long-term benefits to the agricultural sector but also require significant initial investments [27]. In the longer term, rising energy prices may lead to increased pressure to improve energy efficiency in agriculture, which can result in lower production costs and increase the sector's resilience to future energy price shocks [28]. Nevertheless, the short-term impact of rising energy prices on agriculture is decidedly negative as it leads to increased production costs and, consequently, higher food prices for consumers. This can also lead to reduced use of production inputs, lowering yields and harvests, contributing to increased pressure on global food prices and threatening global food security [24].

The war not only causes direct destruction but also creates a hazard associated with currency fluctuations. Many developing economies, which are mainly based on agriculture, tie their finances to the US dollar to cover their financial obligations [29]. Hence, a sustained strengthening of the dollar compared to other currencies poses a threat to these countries, particularly affecting their agricultural and food sectors. Additionally, possible limitations in economic growth in various regions of the world can affect global demand for agricultural and food products, carrying negative consequences for global food security [30].

Such significant international events as the current tensions in the Ukraine region undoubtedly generate an atmosphere of investment uncertainty. This state can negatively impact the agricultural sector at various levels, from local to global [14,31]. In the longer-term perspective, such a situation may inhibit innovation, development, and modernization in agriculture, which can negatively impact global food production. Uncertainty is one of the key factors hindering investment. According to Bloom, a 1% increase in uncertainty can lead to a 4.5% decrease in investment [32]. Therefore, uncertainty generated by conflicts can lead to reduced investments in agriculture, which, in turn, may limit the possibilities for development and modernization of this sector. Moreover, uncertainty can have serious consequences for food production. As noted by Anderson, uncertainty may discourage farmers from adopting new technologies and practices, which can hamper the efficiency and productivity of agriculture [22].

Significant responses to crises also include changes in agricultural policies, which can take many forms, affecting agriculture in various ways. In many cases, countries may decide to increase subsidies for farmers, thereby reducing financial burdens and supporting production [27]. These changes can provide temporary relief for farmers but may also result in long-lasting changes in market structures and production models [22]. Additionally, governments may introduce changes in trade policy, such as changing tariffs or quotas, which can also have a significant impact on the agricultural sector. Such actions can affect the availability of imported agricultural products and can influence the pricing of local production [22]. Another important approach may be investing in agricultural research, which typically aims to increase productivity and sustainable development in agriculture. New technologies and practices can bring long-term benefits, both in terms of production and environmental protection [33]. In any case, these policy changes can have long-lasting effects on global food production. They influence the decisions of producers, consumers, and traders, which, in turn, affect global food markets [27,34]. Therefore, it is important that these policies are developed and implemented with a full understanding of their potential consequences. In response to Russia's invasion of Ukraine, the European Parliament adopted a comprehensive resolution in March 2022, supporting many initiatives contained in the European Commission's package and calling for the urgent development of an EU action plan to ensure food security both inside and outside the EU [35]. European Union leaders supported actions aimed at protecting food security and strengthening the resilience of food systems at the national level. Financial resources allocated for this purpose were to be implemented in the short and medium term to secure access to safe and adequate food and to strengthen food systems, making them more resilient to various types of crises and threats. Most actions could be implemented using the Common Agricultural Policy (CAP). EU members emphasized the importance of maintaining food supply security and took some immediate actions to maintain food security and build a resilient food system [35].

The onset of the Russian–Ukrainian war triggered a strong wave of migration of Ukrainian citizens to Western Europe. The prolonged conflict and the possibility of integration in EU countries have led some Ukrainian refugees to not want to return to Ukraine, creating a labor shortage, potentially hindering post-war economic recovery [36,37]. The impact of the conflict on migration can have a significant impact on food production at various levels. At the local level, the conflict may force people to leave their farms, which can contribute to the cessation of agricultural production resulting in food shortages and rising prices [38]. Conflict-induced migrations can also affect labor market dynamics in the agricultural sector on a global scale. Migrants leaving conflict areas often seek employment opportunities in the agricultural sector in other countries. Many of them may join the ranks of agricultural workers, which, in turn, can contribute to increased food production [25]. Nevertheless, migrants encounter a range of challenges, such as legal barriers to work, inadequate living conditions, and limited access to services [39]. Therefore, migration policies and labor laws can play a key role in managing these challenges. Effective strategies can help integrate migrants into host communities and increase their contribution to food production [40].

Armed conflicts have a fundamental impact on the natural environment, and their consequences are far-reaching and include both direct damage from war activities and long-term changes in agricultural practices [41]. The impact of warfare on the environment can manifest itself in various ways: direct and indirect, short and long term. These include the following:

- Destruction of landscapes, ecosystems, habitats, and species populations;
- Risk of technological disasters;
- Destruction, pollution, and exclusion from use of agricultural land, resulting in a threat to the food security of many people;
- Threats to human life and health resulting from ecosystem degradation and technological disasters;
- Limited access to natural resources, soil, water, and air pollution, and the risk of epidemics [42].

War violates the basic principles of ecological justice and deepens injustice in all its forms and manifestations. Since the occupation of Crimea and military actions in parts of Donetsk and Luhansk, Ukraine has been grappling with all of the above problems. Prolonged conflicts also lead to the intensification of the exploitation of natural resources. The need to increase food production can lead to excessive water use and soil degradation [33], which, in turn, negatively affects the country's ability to produce food in the future [43].

In summary, Russian aggression in Ukraine has a multidimensional impact on the global food market dynamics. Both the direct effects of the conflict and long-term changes in agriculture and the environment are changing the structure and functioning of the global food market, with potential consequences for the health and wellbeing of people worldwide.

## *2.2. Food Security in the Middle East and North Africa (MENA) Region: An Analysis of Contemporary Challenges*

The Middle East and North Africa (MENA) region, encompassing 20 countries and home to over 400 million people, presents a diverse picture in terms of food security conditions, influenced by its economic, social, and political heterogeneity. Although agriculture plays a pivotal role in many of the MENA economies, it faces challenges such as limited water resources, climate change, and political conflicts [24]. The region's reliance on food imports makes it vulnerable to global market price fluctuations and supply issues [44].

The MENA region is particularly susceptible to the effects of climate change, especially the increasing frequency and intensity of droughts. The IPCC's 2022 report highlights that the MENA region is among the world's most vulnerable areas to the impacts of climate change, experiencing ever higher temperatures, rising sea levels, droughts, floods, intense water scarcity, and polluted air.

This change significantly impacts food production, with an increased risk of droughts. The FAO's 2018 report "The State of Food Security and Nutrition in the World 2018" emphasizes the severe consequences of droughts on crop yields and animal health [35]. Over 80% of the countries in the MENA region depend on imported food, making them particularly vulnerable to climate change, which directly threatens food access and stability through reduced agricultural productivity and increased price volatility. In response to these challenges, it is crucial to develop long-term drought management and climate change adaptation strategies. The FAO recommends improving water resource management, promoting sustainable agricultural practices, and developing drought-resistant crops and efficient irrigation technologies [45].

The MENA region is also characterized by limited water resources, posing a fundamental challenge to agriculture. According to the World Bank [46], MENA has the lowest per capita water availability globally. The region's limited water resources directly affect agriculture, which is a primary livelihood source for a significant part of the MENA population. As reported by the FAO [13], agriculture consumes up to 85% of the region's available



water resources, and its scarcity leads to reduced crop yields, negatively impacting the region's food security. A lack of stable food production can lead to price increases and market instability, threatening food access for the region's poorest inhabitants. Additionally, the World Bank highlights that water resource management in the MENA region is inadequate for current challenges [47]. Inefficient water use in agriculture, lack of investment in water-saving technologies, and unregulated exploitation of underground water resources lead to water resource degradation and increased pressure on already limited resources.

The Middle East and North Africa (MENA) region, marked by conflicts and political instability, faces significant challenges to food security. As noted by Brinkman and Hendrix, conflict is always a severe threat to food security, primarily impacting the most vulnerable populations [48]. Conflicts in the MENA region often disrupt food supply chains through direct destruction of infrastructure and by hindering the transportation of goods [47]. Consequently, food becomes less accessible to many, especially those in conflict zones. Simultaneously, political instability can lead to the neglect of the agricultural sector, limiting access to essential services like agricultural advice, credit, or insurance [28]. Long-term neglect of this sector can lead to decreased food production and increased dependence on imports.

Three significant conflicts in this context are as follows:

- The Syrian conflict, beginning in 2011, which led to massive population displacement and infrastructure destruction, significantly hindering food production and distribution. By 2020, over 9.3 million people in Syria were suffering from food insecurity [47].
- The conflict in Yemen, which has led to the world's most significant food crisis, with nearly 17 million people suffering from food insecurity as of 2017 [6].
- The prolonged Israeli–Palestinian conflict, which has impacted Palestinian food security in various ways, including restrictions on access to agricultural lands and difficulties in importing and exporting goods [49].

These conflicts and political instability significantly impact the MENA region's food security. Population growth and urbanization are key factors affecting food security in the MENA region. According to the United Nations (UN), the region's population is expected to increase by nearly 50% by 2050 [50]. This phenomenon places additional pressure on food availability and distribution, considering the existing inequality in food access in many countries of the region. Another significant factor is rapid urbanization. The MENA region is among the world's fastest urbanizing areas. The World Bank reports that over 60% of the region's population lived in urban areas in 2020, with this percentage expected to rise to 80% by 2050 [51]. Urbanization can have complex effects on food security, impacting both food production and distribution [52].

Population growth and urbanization significantly affect the availability of natural resources, including water and soil, crucial for food production. In a region already struggling with limited water resources, these trends could further intensify pressure on these resources [53]. However, urbanization can also present new opportunities for improving food security. Access to larger markets and innovative technologies can increase the efficiency of food production and distribution [54]. Therefore, it is vital for policymakers in the MENA region to integrate these trends into their food security strategies, considering both the challenges and opportunities they present.

Food security is a fundamental dimension for the development and stability of societies [55]. However, the MENA region faces two extreme nutritional problems—undernutrition and obesity. Undernutrition, especially among children, is prevalent in many rural and impoverished communities, while obesity is increasingly common in cities among the middle and upper classes. In terms of food security, these two issues present challenges for public health and food policy [56]. According to a report by the Food and Agriculture Organization (FAO), about 52 million people in the MENA region suffer from chronic undernutrition [49]. Undernutrition, particularly among children, leads to lasting health and development damage, hindering education and earning potential in adult life. On the other hand, the World Bank (WB) estimates that about 58% of adults

in the region are overweight or obese [57]. The causes of these problems are complex and multidimensional. Although the MENA region produces enough food to meet basic nutritional needs, distribution and access to healthy food are uneven. These problems are linked to low agricultural productivity, variable climatic conditions, conflicts and political instability, and changes in lifestyle and diet [44]. Both issues have serious implications for public health and economic development. Undernutrition leads to increased mortality and morbidity, while obesity is linked to chronic diseases such as diabetes, heart disease, and cancer. Addressing these issues requires an integrated approach that includes improving food production and distribution, promoting healthy diets and lifestyles, and building community resilience to food and climate shocks [58]. Although undernutrition and obesity are two extremes of poor nutrition, both are linked to inadequate access to a healthy and balanced diet. In the context of food security, solving these problems is key to improving health and wellbeing.

The MENA region remains largely dependent on food imports due to limited agricultural production capabilities resulting from extreme climatic conditions, such as drought and salinity [44,59]. This dependency on food imports makes these countries particularly vulnerable to price shocks on global markets, which can lead to sudden increases in food prices and deteriorating food security. Global price shocks can directly affect the availability and affordability of food [60]. As history shows, sudden price increases in global markets, such as those during the financial crisis in 2008 and 2011, can lead to increased food prices in local markets, making food unaffordable for the poorest segments of society [61]. Reducing dependency on food imports by increasing food self-sufficiency may be one solution. However, given the limited water and soil resources in the region, there is a need for investment in innovations and technologies that can increase agricultural efficiency and resilience to climate change [13]. Proper management and diversification of food imports, as well as developing regional and international cooperation, can also help mitigate the effects of price and logistical shocks.

The Global Food Security Index (GFSI), developed by the Economist Intelligence Unit, assesses food security in 113 countries based on 59 indicators measured across four categories: affordability, availability, quality and safety, and sustainable development and adaptation. Affordability assesses consumers' ability to purchase food, their vulnerability to price shocks, and the presence of social programs and safety nets that help protect consumers from unexpected price changes. Availability focuses on food availability at the country and individual level, considering access to resources for food production, such as land and water, and infrastructure (such as storage and transportation) that affects the ability to deliver food to markets. Quality and safety include issues such as diet diversification, availability of animal protein, food safety and hygiene standards, and access to clean water. Sustainable development and adaptation, a new category introduced to the index in 2017, assesses factors related to sustainable agriculture and adaptation to climate change. Each of these categories is measured based on multiple indicators, which are scored on a scale from 0 to 100, where a higher score indicates a better situation. The indicators are then aggregated to form an overall score for each country. It is important to understand that the GFSI is a relative measure that compares countries with each other, not absolute measures of food security. This means that countries with higher scores are not necessarily "safe" in terms of food security but are simply safer compared to other countries.

Below is the ranking of MENA countries according to the Global Food Security Index in 2022. Table 1 contains data on the 15 MENA countries included in the analysis due to the availability of available information during the studied period.

**Table 1.** Ranking of MENA countries according to the Global Food Security Index in 2022.

Rank (15 Countries)	Overall Score	Affordability	Availability	Quality and Safety	Sustainability and Adaptation
1. United Arab Emirates	75.2	86.7	73.8	81.3	55.2
2. Israel	74.8	88.6	67.2	87.4	52.2
3. Qatar	72.4	88.6	72.9	71.7	51.0
4. Oman	71.2	88.6	64.3	73.2	53.6
5. Bahrain	70.3	91.3	60.1	76.3	47.3
6. Saudi Arabia	69.9	83.2	67.2	71.6	53.7
7. Jordan	66.2	85.3	59.8	55.4	58.9
8. Turkey	65.3	58.4	65.3	78.5	61.2
9. Kuwait	65.2	80.0	62.9	67.8	45.5
10. Morocco	63.0	74.6	42.9	73.1	60.0
11. Tunisia	60.3	74.5	54.1	58.8	49.7
12. Algeria	58.9	66.8	57.3	54.7	54.2
13. Egypt	56.0	65.2	54.2	45.9	55.8
14. Yemen	40.1	46.4	26.9	48.7	37.8
15. Syria	36.3	32.0	26.6	50.8	38.4

Source: The Economist Intelligence Unit 2022, <http://foodsecurityindex.eiu.com/> (accessed on 23 November 2023).

The analysis of the Global Food Security Index (GFSI) for the Middle East and North Africa (MENA) region allows for the identification of several significant findings. There is a clear disparity in food security among the MENA countries. The United Arab Emirates (UAE) and Israel rank at the top with scores above 74, while Syria and Yemen are at the bottom with scores below 40. This indicates that geopolitical, economic, and social factors can influence food security in the region.

Despite high scores in the affordability category (above 88) for countries like the UAE, Israel, Qatar, Oman, and Bahrain, their overall score in food security is lowered by other factors such as availability, quality and safety, and sustainable development and adaptation.

Countries lower on the list, including Yemen and Syria, have significantly lower scores in the availability category, reflecting their difficulties in ensuring constant, reliable access to food.

Countries like Israel have high scores in the quality and safety category (87.4), whereas Egypt has a much lower score (45.9). This indicates different standards and practices regarding food quality and safety throughout the region.

Almost all countries, regardless of their ranking, score lower in the category of sustainable development and adaptation. This suggests that the MENA region as a whole may face challenges in adapting to issues such as climate change, water scarcity, and other environmental problems that could impact food production and security in the long run.

In summary, although some MENA countries are relatively secure in terms of food security, there are clear inequalities and issues that require urgent attention and action at various policy levels.

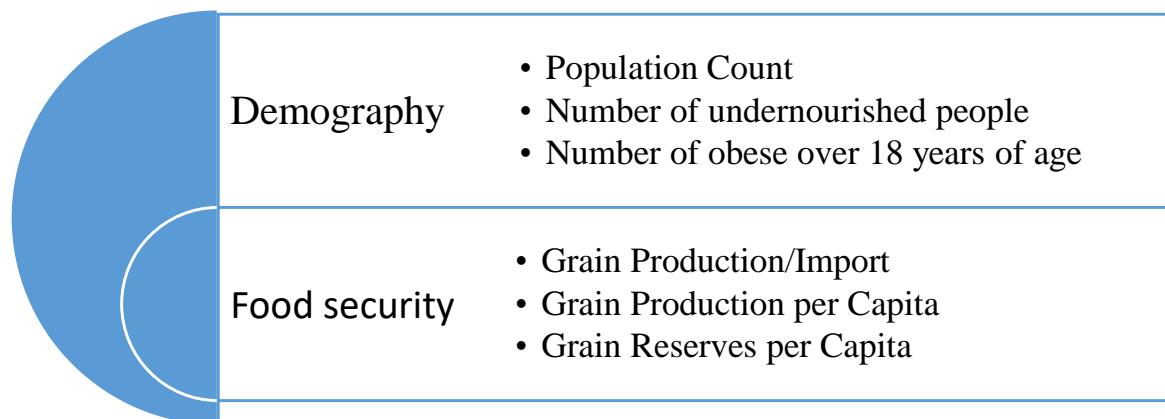
According to a report by Human Rights Watch (HRW) published in March 2022, it is important for governments to ensure that the Ukrainian conflict does not exacerbate the already-existing food crisis in the Middle East and North Africa, protecting every person's right to access food that is both affordable and healthy [10]. The obstacles arising from the Russian–Ukrainian conflict contribute to increasing food prices and exacerbate the issue of poverty. As stated by Lama Fakih, director of Human Rights Watch for the Middle East and North Africa, “global food distribution networks require global unity in times of crisis.



Without cooperation to ensure food security and affordability, the conflict in Ukraine could contribute to deepening the global food crisis, especially in the Middle East and North Africa” [62].

### 3. Materials and Methods

The analysis covering the years 2002–2021 was conducted based on secondary data obtained from the databases of the United Nations Food and Agriculture Organization (FAO). This analysis is crucial for understanding the long-term trends in grain production and export, demographic changes, and food security. The chosen timeframe, covering the years 2002–2021, aligns with significant events in the Russian–Ukrainian conflict and its aftermath, providing a comprehensive view of the war’s impact on agricultural trade and food security. The time series used in the study focused on two significant aspects: demography and food security (Scheme 1). These data provided an in-depth insight into the evolution of demographic trends and changes in food security, which is crucial in the context of global changes in agriculture and food trade.



**Scheme 1.** Key indicators in the analysis of demography and food security.

Demographic analysis involves examining population count, undernourishment, and obesity rates. The purpose is to understand how population dynamics in the MENA region affect food demand and how these have been influenced by the conflict. This is essential for gauging the war’s impact on food security and nutritional status in the region.

Food security analysis includes the evaluation of grain production/import, grain production per capita, and grain reserves per capita. This method aims to assess how the war has affected grain availability in the MENA region, both in terms of total production and on a per-capita basis. It helps in understanding the region’s ability to sustain food security amidst supply chain disruptions caused by the conflict.

Each of these methods directly contributes to a comprehensive understanding of the war’s impact on grain exports, demographic shifts, and food security in the MENA region.

The study includes:

- Assessment of the intensity of changes in the phenomenon through the application of measures:

$$- \text{increments} : \Delta y_{t/t-c} = y_t - y_{t-c} \quad (1)$$

$$- \text{indices} : i_{y_{t/t-c}} = \frac{y_t}{y_{t-c}}, \quad (2)$$

where  $y_t$  is the observed variable realizations in time  $t$  ( $t = 1, 2, \dots, n$ ) and  $c$  ( $c \in N$ ) is a constant;

- Determining the direction and speed of changes by fitting models of developmental trends.

In the context of this research, the application of increments and indices, complemented by fitting models of developmental trends, is selected due to their analytical utility in addressing the study's specific objectives. Increments allow for the quantification of immediate fluctuations in key variables, such as grain production and exports, while indices provide a relative comparison of these changes against a baseline period, elucidating long-term variations. Fitting developmental trend models is instrumental in identifying the trajectory and speed of these changes, thus offering a holistic view of the conflict's impact on agricultural dynamics and food security in the MENA region. This methodological framework is chosen not solely for its prominence but for its alignment with the nuanced analytical requirements of the study.

Furthermore, to determine the degree of changes in both the structure of production and export of grains (barley, maize, sorghum, wheat, rice, and others (sorghum, millet, rye, oats)) in the years studied, the measure used was as follows [63]:

$$v_{t/t+1} = \frac{1}{2} \sum_{j=1}^m |\alpha_{(t+1)j} - \alpha_{tj}| \quad (3)$$

where  $\alpha_{tj}$ ,  $\alpha_{(t+1)j}$  represent the share of the  $j$ -th component of the structure in the years studied and  $t$  &  $t + 1$ , with the following conditions met:  $0 \leq a_{tj} \leq 1$ ,  $\sum_{j=1}^m a_{tj} = 1$ ,  $t = 1, 2, \dots, n$ .

This method is considered in the study to quantify and analyze the structural changes in grain production and exports over the specified years. It specifically focuses on the proportion of different grains (like barley, maize, sorghum, wheat, rice, millet, rye, oats) in the total production and export mix. By evaluating the share of each grain type in consecutive years, the method provides detailed insights into shifts in agricultural focus and export priorities. This is crucial for understanding the dynamics of agricultural production and trade patterns, particularly in response to external factors such as market demands, climatic conditions, or geopolitical events. The approach allows for a nuanced analysis of how the agricultural sector adapts and evolves over time.

The Pearson linear correlation method was employed to assess the relationship between the Cereals Price Index and cereal imports from Ukraine to the MENA region. The significance of this method lies in its capacity to quantify the strength and direction of the linear association between these variables, thereby offering invaluable insights into market dynamics and their potential implications for food security.

In terms of theoretical foundations, the study involved an extensive review of the literature, aimed at identifying and understanding key concepts, theories, and existing research on the impact of global changes in the agricultural sector on the MENA region. This systematic literature analysis included both primary and secondary sources, including scientific publications, reports of international organizations, and statistical data, which helped to build a theoretical basis for the study. In particular, the analysis focused on the economic and agricultural situation in the MENA region countries. Applying such an approach allowed for a holistic and multidimensional understanding of the specifics and challenges related to food security and agricultural trade in these countries.

#### 4. Results

This section of the research presents the empirical findings derived from our analysis, focusing specifically on the direct impacts and implications of the study's core topics.

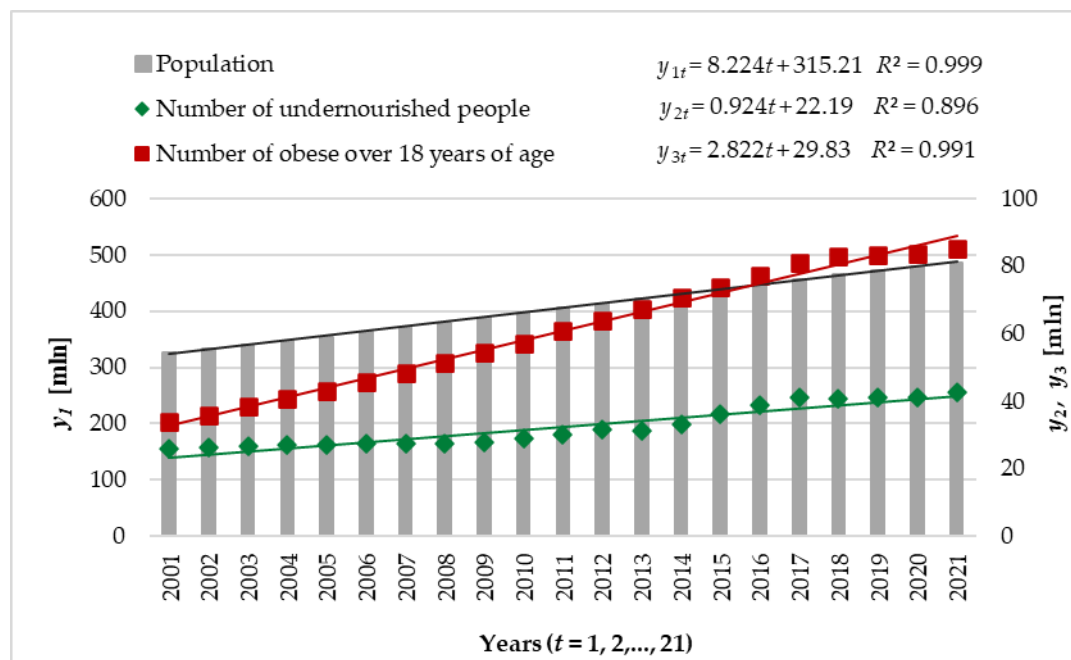
The results delve into the demographic dynamics within the MENA region, including trends in population growth, urbanization, and shifts in health indicators like malnutrition and obesity. These factors are critically analyzed for their influence on food demand and distribution patterns in the region. Additionally, this section explores the intricacies of cereal production and import within the MENA context, highlighting how these have evolved in response to climatic and political changes. The findings aim to provide a

comprehensive understanding of the region-specific challenges and trends that directly affect food security and agricultural practices.

#### 4.1. Demographic Analysis

The demographic analysis of the Middle East and North Africa (MENA) region is crucial for understanding the challenges related to food security. The dynamics of the population, including changes in population size, the prevalence of malnutrition, and obesity trends, directly impact the demand for food, its distribution, and food policy in the region. Below are detailed findings from studies conducted between 2001 and 2021, shedding light on significant demographic changes and their impact on food security in MENA.

The results of the demographic analysis for the Middle East and North Africa (MENA) region (Chart 1) reveal a significant population increase from 175.5 million in 2001 to 333.6 million in 2022—an increase of 158.1 million people (48.3%). The trend line for population time series from 2001 to 2021 shows a systematic annual increase of approximately 8.224 million people, with a high determination coefficient  $R^2 = 0.999$ , indicating the stability of the observed growth pattern.



**Chart 1.** Demographic trends in the MENA region from 2001 to 2021: population ( $y_1$ ); number of undernourished people ( $y_2$ ); number of obese people over the age of 18 ( $y_3$ ) with fitted trend lines.

The food security of the region, measured by the number of undernourished people, also shows significant trends. Over twenty years, the number of undernourished people increased by 65.4%, with an annual increase averaging 0.924 million people. While in 2001, the percentage of undernourished people was 7.85% of the total MENA population, in 2021, this percentage increased by 0.9%, illustrating the challenge of providing adequate food for the growing number of inhabitants.

Equally alarming is the increase in obesity in the region, with more adults facing this issue. In 2021, the number of obese people over the age of 18 reached 85.2 million, an increase of 150.6% compared to 2001. The annual growth rate in this demographic group averaged 2.822 million people, signaling the need for public intervention in the area of nutritional health and obesity prevention. The trend line for obesity shows a consistent increase with the equation  $y_3(t) = 2.822t + 29.83$  and a determination coefficient  $R^2 = 0.991$ , indicating the high predictability of this pattern.

During the analyzed period from 2003 to 2021, variable dynamics were observed in the MENA region in three key areas: population, undernourishment, and obesity (Table 2). The rise and fall in population numbers indicate significant demographic changes in the region. Simultaneously, there were significant fluctuations in the number of undernourished people, pointing to variability in access to food resources and the nutritional status of the population. The dynamics in the number of obese individuals over the age of 18 also reflect important changes in the health trends and lifestyles of the region's inhabitants. Overall, these variable trends indicate the complexity and multidimensionality of the challenges associated with food security and public health in the MENA region.

**Table 2.** Metrics of dynamics in the population and the number of undernourished people and obese people over the age of 18 in MENA during the years 2001–2021.

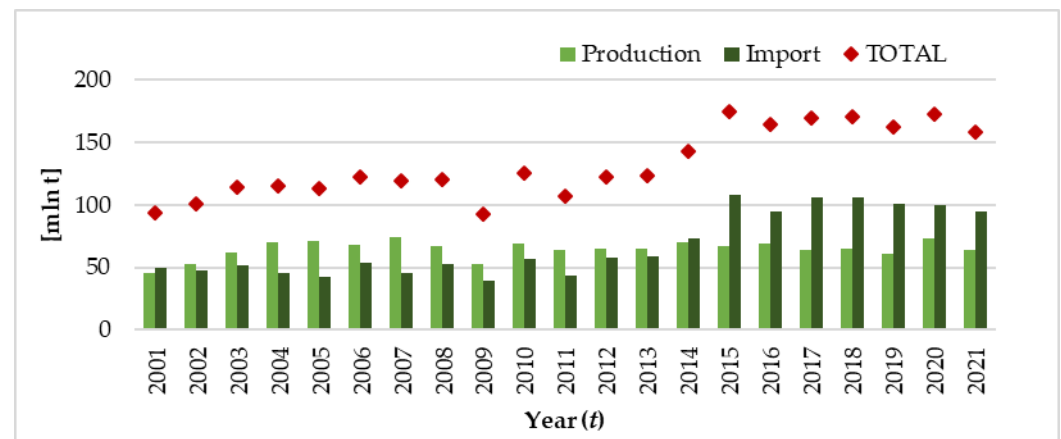
Specification	Year (t)									
	2003	2005	2007	2009	2011	2013	2015	2017	2019	2021
Population (mln)										
$\Delta y_{t/t-2}$	12.5	14.2	16.9	17.9	16.7	16.7	17.7	16.4	16.2	12.9
$i_{y_{t/t-2}}$	1.04	1.04	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.03
Number of undernourished people (mln)										
$\Delta y_{t/t-2}$	1.10	0.40	0.30	0.20	2.40	1.20	4.70	5.10	−0.20	1.60
$i_{y_{t/t-2}}$	1.04	1.01	1.01	1.01	1.09	1.04	1.15	1.14	1.00	1.04
Number of obese over 18 years of age (mln)										
$\Delta y_{t/t-2}$	4.40	4.40	5.50	6.10	6.60	6.20	6.70	6.90	2.40	2.00
$i_{y_{t/t-2}}$	1.13	1.11	1.13	1.13	1.12	1.10	1.10	1.09	1.03	1.02

Source: Own elaboration based on data from the United Nations Food and Agriculture Organization (FAO), <https://www.fao.org/faostat/en/#home> (accessed on 20 August 2023).

The demographic analysis for the MENA region from 2001 to 2021 sheds light on critical aspects of food security. The 48.3% population increase during the analyzed period poses challenges for the region in ensuring sufficient food supply. At the same time, the observed 65.4% increase in the number of undernourished people indicates escalating problems with food accessibility and quality. Additionally, the 150.6% increase in obesity among adults since 2001 highlights the need to focus on nutritional and health aspects within food policies. The results emphasize the complexity of the challenges related to food security in the MENA region, requiring an integrated approach that encompasses both access to and quality of food, as well as its impact on public health.

#### 4.2. Analysis of Cereal Production and Import in the MENA Region

Chart 2 displays the annual production and food import in MENA countries from 2001 to 2021. Quantitative data analysis reveals that since 2014, food imports have exceeded domestic production, indicating an increasing reliance on external supplies for food security. The total availability of cereals, which is the sum of production and imports, represented by red diamonds, shows a continuation of the upward trend, despite a declining trend in domestic production. This indicates an increasing volume of imported food in response to insufficient internal production capacities. In 2021, food imports reached the highest level in the analyzed period, which may reflect both an increase in food demand and potential challenges for domestic food production, such as climate change, scarcity of natural resources, or infrastructural limitations.



**Chart 2.** Cereal production and import in the MENA region from 2001 to 2021, expressed in millions of tons.

In the context of food security, the observed data indicate a growing need for diversification of food sources and increased resilience to disruptions in supply chains.

Table 3 presents dynamic metrics for production, import, and total cereal resources in the MENA region from 2003 to 2021. These metrics, representing the average annual rate of change, are expressed as indices, where a value of 1 indicates stability, values above 1 indicate growth, and values below 1 indicate a decline in a given year compared to the previous year.

**Table 3.** Cereal production, import, and resources in the MENA region from 2001 to 2021 and dynamic metrics.

Specification	Year (t)									
	2003	2005	2007	2009	2011	2013	2015	2017	2019	2021
<b>Production</b>										
$\Delta y_{t/t-2}$	17.2	8.5	3.9	−21.8	11.0	0.9	2.0	−3.1	−2.5	3.0
$i_{y_{t/t-2}}$	1.38	1.14	1.06	0.71	1.21	1.01	1.03	0.95	0.96	1.05
<b>Import</b>										
$\Delta y_{t/t-2}$	2.57	−9.55	3.05	−5.73	3.87	15.19	49.66	−2.35	−4.99	−6.50
$i_{y_{t/t-2}}$	1.05	0.82	1.07	0.87	1.10	1.35	1.85	0.98	0.95	0.94
<b>TOTAL</b>										
$\Delta y_{t/t-2}$	19.78	−1.06	7.00	−27.56	14.87	16.09	51.64	−5.44	−7.46	−3.47
$i_{y_{t/t-2}}$	1.21	0.99	1.06	0.77	1.16	1.15	1.42	0.97	0.96	0.98

Source: Own elaboration based on data from the United Nations Food and Agriculture Organization (FAO). Accessed on 20 August 2023.

Cereal production showed diversity in dynamic metrics, with the highest value of 1.38 in 2003, suggesting a significant increase compared to the base year of 2001. The lowest index, 0.71, was recorded in 2009, indicating a decrease in production. In subsequent years, the indices fluctuated, reaching a value of 1.05 in 2021, suggesting a moderate increase in production compared to the previous year.

Cereal imports were much more volatile, with a clear increase in 2015, where the dynamic index reached 1.85, indicating a significant annual increase. However, in recent years, there has been a downward trend, with an index of 0.94 in 2021, suggesting a decrease in import levels compared to 2020.

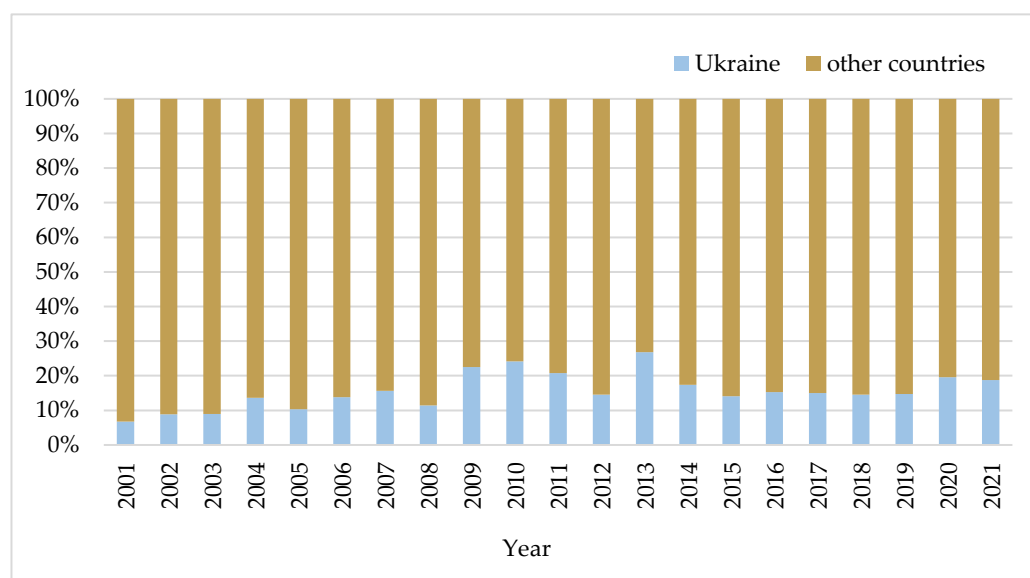
Total cereal resources, calculated as the sum of production and imports, also showed variability in dynamic metrics, with the highest increase in 2015 of 1.42. The lowest index of 0.77 was recorded in 2009, reflecting a significant decrease in cereal availability. The last



year of analysis, 2021, shows an index of 0.98, which may indicate a slight decrease in total cereal resources compared to 2020.

These metrics provide valuable information about annual changes in production, import, and availability of cereals in the MENA region, which is crucial for understanding trends and potential fluctuations in food security.

The analysis of data presented in Chart 3 indicates trends in per capita cereal availability in the MENA region from 2001 to 2021. Over the course of twenty years, we observe a variability in per capita production and import of cereals. Cereal production per capita shows minor year-to-year variations, with values starting at around 150 kg/year in 2001 and ending at a similar level in 2021. From 2014 onwards, per capita cereal imports begin to dominate over domestic production. The total availability of cereals per capita, symbolized by red diamonds in the chart below, initially was around 160 kg/year, with the highest value of about 400 kg/year in 2014, after which these values show a tendency to stabilize. These data emphasize that despite annual fluctuations, the total availability of cereals per capita in the MENA region has remained at a relatively high level over the last two decades.

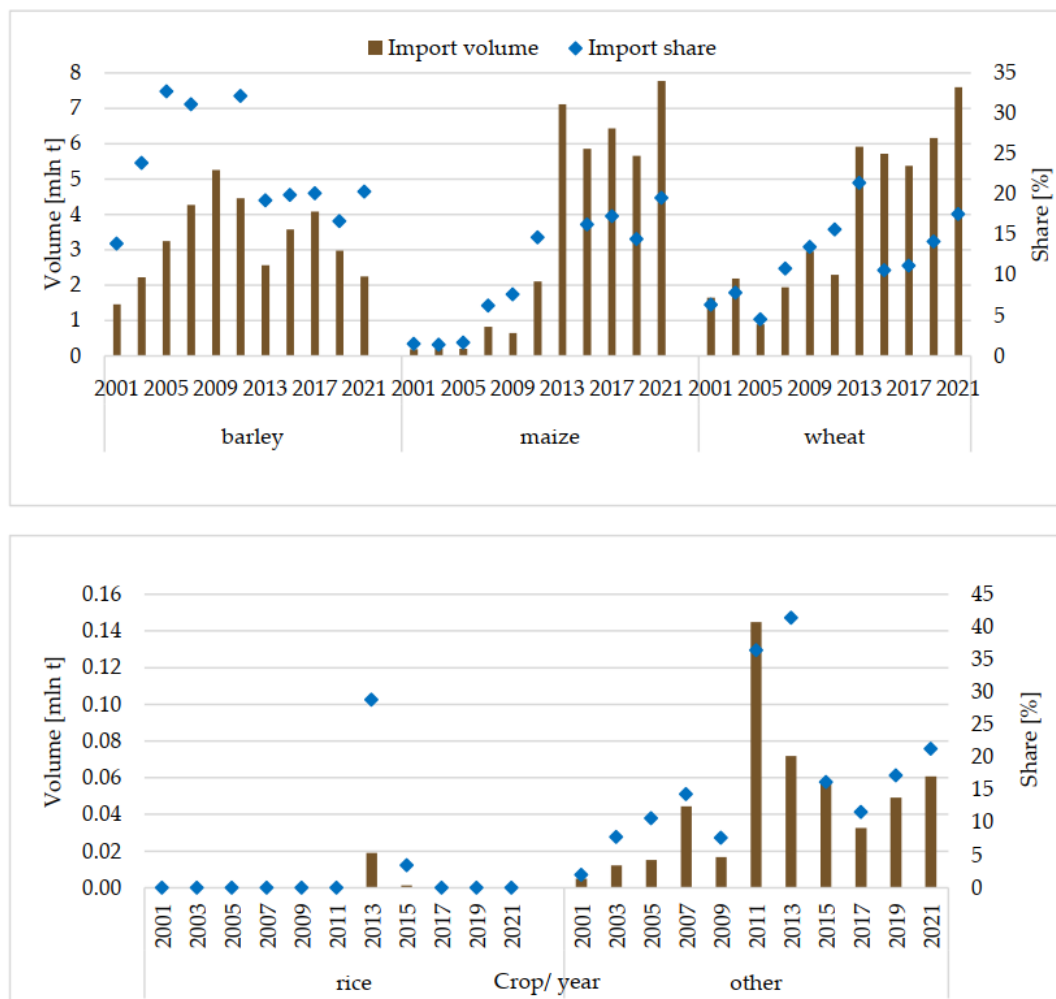


**Chart 3.** Ukraine's share in cereal imports to MENA countries from 2001 to 2021.

In summary, these data indicate that Ukraine plays a very important role in the food security of MENA countries as one of the main suppliers of cereals. However, fluctuations in the percentage share of cereal imports from Ukraine indicate potential variability, which could have significant implications for the region's food stability, and further analysis of the causes of these changes is required.

The analysis of Chart 4, which presents the structure of cereal imports to the MENA region from 2001 to 2021, indicates the following trends:

- Wheat, barley, and corn are the main cereals imported from Ukraine to the MENA region, indicating their important role in meeting the region's food requirements.
- The share of wheat, barley, and corn imports in the total import of these cereals to the MENA region in recent years ranges between 20 and 25%.
- Although rice does not dominate in the total cereal import, there are peaks in its import, which may be related to periodic domestic shortages or increased demand in certain years.
- All cereals show significant annual variability in import volume, which may reflect annual changes in production, price volatility in global markets, fluctuations in trade policy, or changes in domestic demand.



**Chart 4.** Structure of cereal imports from Ukraine to MENA from 2001 to 2021.

#### 4.3. Food Price Index Analysis

In this section, attention is focused on the analysis of the Food Price Index (FPI), which is recognized as essential for understanding trends in international food commodity prices. The examination of the FPI, especially the Cereals Price Index, is conducted with the aim of identifying patterns that are of significant importance for food security and economic stability, particularly in regions dependent on food imports. The period from 2001 to 2023, marked by significant global economic events, is covered in the analysis. These events, reflected in the fluctuations observed in the FPI data, are essential in providing context to the broader impacts on food prices and are pivotal in addressing the research objectives related to global food market dynamics.

The Food Price Index (FPI), as measured by the FAO, is constituted by the annual changes in international prices of a diversified basket of food commodities. This index comprises the average prices of meat, dairy, cereals, vegetable oils, and sugar, each weighted according to their respective shares in global trade. Higher values of the index are indicative of more expensive food commodities, signaling potential issues in terms of affordability and accessibility, which can have implications for global food security.

The Food Price Index data, encapsulating the period from 2001 to 2023, is presented in Table 4, which indicates varying trends with a generally upward trajectory, particularly in the Cereals Price Index. A close look at the data shows intermittent periods of price spikes, which could be attributed to specific economic events or supply chain disruptions. These fluctuations are particularly evident in the years 2007–2008, 2010–2011, and 2020–2022, which correspond to known periods of global economic instability or events affecting food

supply, such as the financial crisis and geopolitical conflicts that have historically impacted the supply and prices of cereals. The cereals index, critical for understanding food security, reflects the vulnerability of global food markets to such shocks, especially in regions heavily reliant on grain imports, like the MENA countries.

**Table 4.** Food Price Index.

Year	Food Price Index	Meat Price Index	Dairy Price Index	Cereals Price Index	Oils Price Index	Sugar Price Index
2001	55.0	61.7	60.9	51.8	42.5	53.5
2002	53.1	55.2	46.1	55.6	55.1	42.6
2003	57.8	58.3	54.5	59.4	62.6	43.9
2004	65.6	67.6	69.8	64.0	69.6	44.3
2005	67.4	71.8	77.2	60.8	64.4	61.2
2006	72.6	70.5	73.1	71.2	70.5	91.4
2007	94.3	76.9	122.4	100.9	107.3	62.4
2008	117.5	90.2	132.3	137.6	141.1	79.2
2009	91.7	81.2	91.4	97.2	94.4	112.2
2010	106.7	91.0	111.9	107.5	122.0	131.7
2011	131.9	105.3	129.9	142.2	156.5	160.9
2012	122.8	105.0	111.7	137.4	138.3	133.3
2013	120.1	106.2	140.9	129.1	119.5	109.5
2014	115.0	112.2	130.2	115.8	110.6	105.2
2015	93.0	96.7	87.1	95.9	89.9	83.2
2016	91.9	91.0	82.6	88.3	99.4	111.6
2017	98.0	97.7	108.0	91.0	101.9	99.1
2018	95.9	94.9	107.3	100.8	87.8	77.4
2019	95.1	100.0	102.8	96.6	83.2	78.6
2020	98.1	95.5	101.8	103.1	99.4	79.5
2021	125.7	107.7	119.1	131.2	164.9	109.3
2022	143.7	118.8	142.4	154.7	187.8	114.5
2023	124.0	114.6	118.8	130.9	126.3	145.0

Source: The United Nations Food and Agriculture Organization (FAO) <https://www.fao.org/faostat/en/#home>. (accessed on 7 January 2024).

In Table 5, the Pearson correlation coefficient for the relationship between the Cereals Price Index and cereal imports from Ukraine to the MENA region over the period 2001–2021 is presented. A coefficient value of 0.0117 is revealed by the analysis, indicating a very weak positive linear correlation. This is suggestive of the changes in the Cereals Price Index being minimally associated with changes in cereal imports to the MENA region. The statistical significance of this correlation is assessed through a t-statistic of 0.0511 and a *p*-value of 0.9598, both of which indicate that the correlation observed is not statistically significant.

**Table 5.** Pearson correlation coefficient for the relationship between the Cereals Price Index and cereal imports from Ukraine to the MENA Region (2001–2021).

Variables	Correlation Coefficient (r)	t-Statistic	p-Value
Cereals Price Index vs. Cereal imports from Ukraine to MENA region	0.0117	0.0511	0.9598

Source: Author's own elaboration based on FAOSTAT data (2001–2021), <https://www.fao.org/faostat/en/#home> (accessed on 7 January 2024).

In summation, Tables 4 and 5 collectively shed light on the intricate nature of the global food market. Table 4 emphasizes how food prices are influenced by economic events, highlighting their dynamic behavior. Meanwhile, Table 5 reveals that the relationship between cereal imports and the Cereals Price Index is not straightforward, suggesting the involvement of other factors. This comprehensive perspective enhances our understanding of the complex dynamics that impact food prices and trade, with implications for global food security.

## 5. Discussion

In the context of Russian aggression against Ukraine and its impact on the global food market, significant and complex consequences are observed. The intensification of logistical and insurance costs, as a direct consequence of warfare, leads to rising food prices in global markets. This trend aligns with previous research, which indicates a significant relationship between supply chain disruptions and retail prices. Research conducted by Arizona State University shows that disruptions in food supply chains, caused by pandemics, armed conflicts, and shortages due to climate change, have become the norm [64]. These disruptions affect food availability, distribution efficiency, and lead to unsold stocks. Jagtap et al. also emphasize that the war in Ukraine poses a considerable threat to the global food supply chain [65]. Ukraine and Russia are key global grain suppliers, and the conflict in this region significantly impacts global food access, leading to price increases. Researchers note that the rise in wheat prices directly affects the prices of basic food products such as bread [65].

Food security in the Middle East and North Africa (MENA) region is threatened by a range of complex challenges that have a profound impact on the stability and development of this area. The region, characterized by economic, social, and political diversity, struggles with issues arising from conflicts and political instability. Conflicts such as in Syria, Yemen, and between Israel and Palestine disrupt food supply chains and contribute to market instability, making food less accessible, especially for residents of conflict areas [66]. These political upheavals, combined with a growing dependency on imported food, make the region particularly vulnerable to global price fluctuations and supply issues.

Additionally, problems associated with the desert climate, limited water resources, and climate change directly impact agriculture—a key sector for many MENA economies [60]. These changes, especially the increasing risk of droughts, have an unprecedented impact on food production in a region that is one of the driest in the world. The World Bank report highlights that climate change can significantly affect the frequency and intensity of droughts in the MENA region, leading to serious challenges for food production [57]. The report indicates that a reduction in arable land, heat, and drought may increase the region's dependency on food imports, making it particularly vulnerable to fluctuations in global food supply chains and markets. In the context of the current crisis in Ukraine, many countries in the region are heavily dependent on wheat from Ukraine and Russia, which could lead to significant social unrest [67].

The analysis of the Global Food Security Index (GFSI) shows clear inequalities in food security among countries in the MENA region, with a distinct divide between countries with high and low levels of food security. Almost all countries in the region score lower in

the category of sustainable development and adaptation, highlighting the need for better adaptation to climate change and other environmental issues.

Population growth and urbanization further increase pressure on natural resources, especially water and soil, which are crucial for food production [68]. These phenomena compound existing problems, such as malnutrition among children in rural communities and the growing problem of obesity in cities.

The demographic analysis of the Middle East and North Africa (MENA) region from 2001 to 2021 sheds light on critical aspects of food security that are directly related to the dynamics of population growth and changes in malnutrition and obesity [69]. As emphasized in a World Bank report, in 2020, the MENA region's share of the global population suffering from acute food instability was 20%, disproportionately high compared to its 6% share of the global population [51]. The 48.3% population increase during this period presents a significant challenge for the region in ensuring a sufficient quantity of food. This substantial increase in population, with the additional burden of a 65.4% increase in the number of undernourished people, indicates growing problems with food availability and quality, which may be linked to both limited natural resources and social inequalities. Furthermore, the sharp 150.6% increase in obesity among adults since 2001 signals a growing need to focus on nutritional and health aspects within food policy. This trend not only reflects changes in lifestyles and diets but also underscores the need to promote healthy food and nutrition education in the region. This phenomenon may also indicate unequal access to healthy nutritional options and a growing divide between different social groups in the MENA region.

The Food Price Index (FPI), particularly the Cereals Price Index, reflects significant price volatilities during the periods of 2007–2008, 2010–2011, and 2020–2022. The 2007–2008 spike corresponds to the global food crisis, exacerbated by droughts, high oil prices, and increased biofuel demand, which led to export restrictions by major cereal-producing countries. The 2010–2011 peak was influenced by Russian wheat export bans due to severe droughts. The substantial rise in 2020–2022 can be associated with the COVID-19 pandemic's disruption to food supply chains, followed by the Russia–Ukraine conflict, which further strained global cereal supplies due to both countries being significant grain exporters. These events underscore the sensitivity of the cereals market to climatic, economic, and geopolitical factors.

The weak and statistically insignificant correlation suggested by the analysis may imply that the Cereals Price Index is not a strong predictor of cereal import volumes to the MENA region. Considering the lengthy period (2001–2021) over which the data were collected, it is plausible that various external factors like geopolitical events, trade policies, and other economic variables have influenced the trade dynamics, overshadowing any direct correlation between these two variables. The findings highlight the complexity inherent in trade analysis and the necessity of considering a wide array of factors beyond simple price indices. The high *p*-value suggests that the observed correlation could very likely be due to random variation in the data. To gain a more comprehensive understanding of the factors influencing cereal imports to the MENA region, further research should incorporate more granular data or additional variables, potentially offering richer insights into these trade patterns.

In light of these findings, an integrated approach to food security is essential, encompassing not just access to food but also its quality and impact on public health. Food policy should focus on sustainable agricultural development, access to healthy food for all social strata, and promoting healthy eating habits. Given the growing population and increased food demand, attention to sustainable food production practices that minimize environmental impact and ensure the long-term availability of the region's natural resources is also crucial. In summary, food security in the MENA region is threatened by a series of interconnected challenges that require urgent action at various levels of policy and development. Addressing these issues necessitates an integrated approach that includes



both improving food production and distribution and building community resilience to food and climate shocks.

This study, analyzing cereal production and import in the Middle East and North Africa (MENA) region from 2001 to 2021, reveals several key trends with significant impacts on the region's food security. This study sheds light on the region's growing dependence on grain imports, which has been particularly evident since 2014 when imports began to exceed domestic production. This increasing reliance on external supplies indicates challenges in food security, especially in the context of potential global supply chain disruptions. The decline in domestic cereal production in the MENA region could result from various factors, including climate change, natural resource shortages, and infrastructural limitations. This decline underscores the need to enhance domestic production efficiency and adapt to changing environmental conditions. Despite this decline, the overall availability of cereals (sum of production and imports) maintains an upward trend, suggesting an increase in the volume of imported food in response to insufficient internal production capacities. The growing dependency on imports highlights the need for diversification of food sources and increased resilience to disruptions in supply chains. This is particularly crucial in the face of potential external disruptions such as armed conflicts, climate change, price fluctuations in global markets, and demographic changes.

The analysis also emphasizes the significant role of Ukraine as one of the main cereal suppliers to the MENA region. According to the OECD report, the Black Sea basin is a key area for grain and agricultural product exports from Ukraine [12]. Ukraine exports 95% of its grains through the Black Sea, with over 50% of its wheat exports going to the MENA region in 2020. This report also points to the potential impact of the Ukrainian–Russian conflict on the MENA region, with possible disruptions in agricultural trade and grain production in the Black Sea basin, potentially leading to a food crisis. Fluctuations in the percentage share of cereal imports from Ukraine could have significant implications for the region's food stability, necessitating further analysis of the causes of these changes. Annual variability in the import volumes of various cereals, such as wheat, barley, corn, rice, and others, may reflect changes in production, global prices, trade policy, and internal demand. This variability underscores the need for flexibility and adaptability in managing the region's food resources.

## 6. Conclusions

Given the challenges identified in the discussion, such as the impact of Russian aggression against Ukraine on the global food market, regional conflicts, climate change, and population growth, it is crucial to apply an integrated approach to food security in the MENA region. The following recommendations can support the implementation of this approach:

- Diversification of food import and production sources: in the context of rising food prices and dependency on imports, the MENA region should seek alternative import sources and invest in the development of local production, especially in terms of climate-resilient agriculture.
- Investment in infrastructure and technology: expanding agricultural infrastructure and investing in modern technologies can increase the efficiency of local production while minimizing post-harvest losses and enhancing distribution efficiency.
- Sustainable management of natural resources: sustainable management of water and soil resources is essential to ensuring the long-term productivity of agriculture in the region.
- Support for small food producers: small farms play a significant role in food production in the MENA region; providing them with access to financing, technology, and markets can significantly contribute to improving food security.
- Education and public awareness: raising awareness about healthy eating habits, sustainable consumption, and food production can help reduce food waste and improve the health of the population.

- Trade policy and regional cooperation: international and regional cooperation can help stabilize food markets and ensure access to food during crises.
- Adaptation to climate change: developing and implementing strategies for adapting to climate change is crucial to protect food production in the region.
- Strengthening monitoring systems and crisis response: establishing effective early warning systems and responses to food crises can help minimize their impact on the most vulnerable populations.

In summary, the MENA region faces a series of interconnected challenges that require urgent action at various levels of policy and development. An integrated approach that includes both improving food production and distribution and building community resilience to food and climate shocks is key to ensuring long-term food security in the region. In the context of a growing population and increased food demand, attention to sustainable food production practices that minimize environmental impact and ensure the long-term availability of the region's natural resources is necessary.

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