

Statistical Evaluation of Food Security Indicators in Arab Countries: A Multivariate Cluster and Factor Analysis of the Food Gap

Dr.Rimi Arafat¹

University of Blida 2_Lounici Ali, Blida, (Algeria).

Rimiarafat39@gmail.com

Dr. Djahid Saidoun²

University of Blida 2_Lounici Ali, Blida, (Algeria).

d.saidoun.etu@univ-blida2.dz

Received: 12/07/2024 Accepted: 02/01/2025 Publishing: 27/01/2025

Abstract

This study addresses the challenge of food security in the Arab world amidst a widening food gap and increasing reliance on imports, despite the availability of natural and human resources. It aims to provide a statistical assessment of food security indicators for 22 Arab countries and classify them to identify strengths and weaknesses. The study relies on updated 2023 data derived from United Nations reports and the Joint Arab Economic Report. The methodology employs advanced exploratory statistical analysis, specifically Cluster Analysis and Principal Component Analysis (PCA), using Tanagra 1.4.50 software for data processing and interpretation.

The results revealed a significant convergence between the two cluster analysis methods (K-Means and HCA) in classifying Arab countries into three distinct groups. Furthermore, Principal Component Analysis (PCA) reinforced these findings by extracting three axes that explain 82.76% of the total variance. The first axis, which includes variables such as agricultural output, the hunger index, and trade exchange, was associated with the first cluster, representing the most food-stable countries (UAE, Algeria, Egypt, Oman, Saudi Arabia, and Morocco). Conversely, the second axis reflected lagging food security indicators in the second cluster, which includes the Comoros, Mauritania, Sudan, Somalia, Syria, and Yemen. The third cluster comprised the remaining countries, which were characterized by indicators related to population size, fish production, and import dependency.

Keywords: Food Security; Cluster Analysis; Principal Component Analysis; Food Gap; Arab Countries.

1. Introduction

Food security is a pivotal issue that has garnered increasing attention from Arab countries in recent years, placing it at the forefront of their strategic priorities due to its political, economic, and social dimensions. Recently, the food situation in these countries has been heavily impacted by the repercussions of the Russian-Ukrainian war. This is particularly evident in the stagnation of the foreign trade sector concerning food commodities, grains, livestock, and fisheries. Furthermore, direct impacts have emerged through constraints on the agricultural production sector due to the lack of production inputs, such as fertilizers and energy, coupled with the surge

in primary food commodity prices facing several Arab nations. These circumstances have also led to a decrease in income and a general rise in commodity prices as a result of inflation.

According to the latest statistics from the 2022 report of the Arab Organization for Agricultural Development (AOAD, 2022), issued by the League of Arab States, total grain crop production in the Arab region reached approximately 49.5 million tons, recording a 9.1% decrease compared to the previous year. Wheat occupied about 38.3% of the grain crop area, contributing 49.3% of total grain production in the Arab world. Meanwhile, the meat production sector remained stable, with output reaching 9.4 million tons, consisting of 45% red meat and 55% poultry.

The report also noted a slight decrease in the value of the primary commodity gap, falling from 37.9\$ billion in 2021 to 36.2\$ billion in 2022, primarily due to lower demand resulting from high prices. The self-sufficiency rate for total consumption of major food commodities also witnessed a slight decline, estimated at 62.5% compared to 62.9% in 2021. The average food availability index for the Arab world was estimated at 55.6 points, which is lower than the global average of 57.0 points.

According to the Joint Arab Economic Report 2023 issued by the Arab Monetary Fund (AMF, 2023), the size of the gap remains heavily concentrated in food crop supplies due to shocks in global food markets. These political, social, economic, environmental, and geographical challenges necessitate redoubling efforts to secure food security sustainably. Simultaneously, it is essential to increase the efficiency of agricultural systems based on the principles of effectiveness, performance, and quality.

Consequently, in light of other factors such as steady population growth, climate fluctuations, and rising production, processing, and transportation costs it has become imperative for these countries to launch studies based on reliable and updated statistics. These studies should guide the formulation of policies, the development of strategies, the implementation of programs, capacity building, and the enhancement of cooperation among Arab nations.

In light of this framework, this study seeks to monitor and analyze the reality of food security in Arab countries by highlighting the magnitude of the food gap and self-sufficiency ratios, as well as classifying countries based on food security indicators. This is achieved by addressing the following primary problem: **How can Arab countries be classified according to food security indicators using cluster and factor analysis, and what are the explanatory characteristics that distinguish each group?**

To address this problem, the following sub-questions are proposed:

- What is the current status of food security indicators in the Arab region in terms of the food gap and self-sufficiency rates?
- How can Arab countries be classified based on food security indicators to determine the extent of the food gap?
- What are the most influential variables in shaping the map of Arab food security according to the results of factor analysis?

To address these questions, the following hypotheses were developed:

- **H₁:** The Arab region suffers from a relative decline in food security indicators, manifested in the widening food gap and decreasing self-sufficiency rates for strategic crops;
- **H₂:** Cluster analysis allows for the division of Arab countries into statistically distinct groups that vary among themselves, highlighting the scale of the food gap;

- **H₃:** Factor analysis enables the identification of key pivotal variables that contribute most significantly to explaining the statistical variance in Arab food security, representing the explanatory power driving the regional food map.
This research aims to:
 - Analyze the current status of food security indicators in Arab countries by highlighting the value of the food gap and the growth volume of agricultural production in light of available natural resources and potential;
 - Review the prominent trends and political interventions by Arab regimes to sustainably address food security challenges and uncover the underlying causes of the food problem;
 - Provide a clear vision regarding the classification of Arab countries based on food security indicators to identify similarities, weaknesses, and strengths, thereby assisting decision-makers in monitoring the situation with greater precision.

2. Literature Review

- Bouaziz (2022) aimed to monitor and analyze the state of food security in Arab countries and classify them based on 13 indicators during the period (2015-2020). Using Hierarchical Cluster Analysis, the study identified three distinct clusters: the first included 11 countries (notably Algeria, Sudan, and Egypt), the second comprised 7 countries (including the Gulf states and Jordan), while the third was limited to 4 countries (Tunisia, Comoros, Morocco, and Mauritania). The results indicated that food security remains a concern for most Arab nations due to low material and economic productivity of resources and a heavy reliance on imports covering more than half of consumption needs, particularly in the cereal sector. The study concluded that Arab governments lack the capacity for rapid crisis assessment and response to global market shocks;
- Khidrat (2023) highlighted the reality and challenges of Arab food security amidst consecutive international crises, from the 2008 global financial crisis to the COVID-19 pandemic and the Russo-Ukrainian war. Employing a descriptive-analytical approach, the study found that achieving Arab food security faces complex obstacles linked to internal and external factors. The Russo-Ukrainian war revealed the fragility of the link between Arab and global food systems, given the heavy dependence on these two sources, which together account for 25% of global grain exports. The study emphasized that these crises disrupted food value chains and inflated prices, leaving Arab food security vulnerable and in urgent need of strategic solutions to develop self-reliance against fluctuations in food trade and production;
- Oudina & Lalmi (2025) analyzed strategies for enhancing food security in the Arab world by reviewing the "Arab Program for Sustainable Food Security 2022" issued by the Arab Organization for Agricultural Development (AOAD). Using a descriptive-analytical method, the study found that the program is based on three strategic levels: expanding production and resource utilization, developing manufacturing and agricultural services, and reducing waste while addressing environmental and climate risks. The researchers concluded that these strategies are realistic and ambitious, capable of achieving Arab food security in the medium and long term if coupled with a strict commitment to implementation by Arab countries, focusing on maximizing the efficiency of water and land resources;
- Ouaar & Douffi (2021) aimed to identify the state of food security in Arab countries by analyzing global food security indicators from 2009 to 2018. Based on a descriptive-analytical

approach and specialized statistics, the study found that the level of food security remains modest with a widening food gap, despite agricultural reforms and investment incentives provided by Arab states. The study attributed these limited results to increased environmental pollution costs affecting crop yields, as well as deteriorating political and economic conditions, especially following the collapse of oil prices. It concluded that the inability of local production to keep pace with demand drove Arab countries toward imports, necessitating intensified efforts for sustainable agricultural development;

- Bezazi (2022) shed light on the food security situation in the Arab world by monitoring and analyzing key indicators from the AOAD. The study assessed the ability of Arab countries to overcome food dependency and implement sustainable food security pillars. Results indicated that Arab food security levels remain modest and disparate; while Gulf countries recorded acceptable levels in food access and quality, suffering persisted in countries like Syria and Yemen. The results confirmed the failure of local production to meet rising demand, and the researcher emphasized the need for collective Arab efforts to adopt comprehensive reform and development strategies to confront the negative impacts of recent crises;
- Benflis (2021) explored the reality of food security in the Maghreb region by analyzing various indicators to identify risks associated with persistent food deficits. The researcher stressed the urgent need for self-sufficiency amid reports of severe food production shortages and the troubling state of the agricultural sector. The study concluded that Maghreb countries suffer from varying degrees of food insecurity and have failed to meet increasing demand through domestic production. This situation has led to a heavy reliance on external imports, placing food supplies in the hands of foreign powers and exposing these countries to external economic and political pressures, as well as monopolistic conditions imposed by exporting nations.
- The study by Benslimane & Saidoun (2026) highlights innovation as a strategic driver of comprehensive sustainable development across the economic, educational, industrial, and agricultural sectors from a demographic perspective, emphasizing the need to align innovation policies with the agricultural sector; it demonstrates that technological innovations-such as precision agriculture, biotechnology, and sustainable practices-serve as a critical mechanism for enhancing food security, boosting productivity, and adapting to climate change, particularly amid current demographic challenges including rapid population growth, rising rural-to-urban migration, and an aging farmer workforce, thereby necessitating targeted funding and technical training for farmers to ensure resource sustainability and food production stability.

The aforementioned studies collectively agree on the modest and disparate levels of Arab food security, where the food gap and import dependency emerge as common themes resulting from the failure of local production to meet growing demand Bouaziz (2022) and Bezazi (2022) concurred on the statistical variation of this situation among Arab nations, with Gulf states leading in positive indicators compared to a sharp decline in conflict-affected and Maghreb countries. From the perspective of crisis drivers, Khidrat (2023) and Ouaar & Douffi (2021) focused on the impact of international crises (such as COVID-19 and the Russo-Ukrainian war) and political and environmental conditions in deepening food fragility. While most studies confirmed the realistic risks of foreign dependency and monopolistic conditions, Oudina & Lalmi (2025) provided an optimistic forward-looking vision that links the solution to a strict commitment to the "Arab Program for Sustainable Food Security 2022" to enhance self-reliance

and reduce waste. While the study by Benslimane & Saidoun (2026) confirms that agricultural innovation represents a strategic mechanism for enhancing food security and adapting to demographic and climate challenges to achieve sustainable development.

3. The Reality of Food Security in the Arab Countries

Food security is among the most prominent Sustainable Development Goals (SDGs). Achieving it represents a major challenge for all countries, particularly Arab nations, which continue to rely on importing primary commodities and essential food needs. Within the framework of global food security challenges-driven by successive crises such as climate change, the COVID-19 pandemic, and the Russian-Ukrainian crisis-it has become imperative to diagnose the current situation to find solutions that help reduce the food gap.

Arab food security is linked to a set of variables affecting its various domains, including political, economic, social, and natural developments. Accordingly, this section will address the concept of food security, and monitor the reality of food security indicators for Arab countries.

3.1. The Concept of Food Security and its Determinants

Food security is a flexible concept whose features have emerged through several academic attempts to provide a comprehensive definition, starting from the food crises of the 1970s. In this part, we will present the most important definitions and primary determinants.

3.1.1. The Concept of Food Security

Food security can be defined as a society's ability to provide appropriate food for its citizens in the long and short term, both quantitatively and qualitatively, at prices consistent with their income levels (Hamdan, 1999). It is also defined as a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAOUN, 2000).

The World Food Summit (Rome, 1996) defined food security as: "When all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (AOAD, 2022).

Meanwhile, the World Bank defines it as: "Access by all people at all times to enough food for an active, healthy life." Its three basic elements are: food and water availability, stability, and accessibility (Ben Obeid. et al, 2017).

3.1.2. Determinants of Food Security

According to the declaration of the 2009 World Summit on Food Security, food security is achieved when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food. Consequently, four determinants (pillars) of food security can be identified (FQOUN, 2013) :

- **Food Availability:** This plays a vital role in ensuring food security. It is essential to provide sufficient food supplies to a specific population through domestic production, imports, or food aid on a consistent basis. However, this dimension alone is insufficient to ensure adequate access to food (AFSA, 2023);
- **Access to Food:** This determinant rests on two pillars: Economic Access, determined by disposable income, food prices, and social support; and Physical Access, determined by the availability and quality of infrastructure (ports, roads, railways, communications, and storage facilities). Income from agriculture, forestry, and fisheries also plays a major role in determining food security outcomes;

- **Food Utilization:** This involves two dimensions. The first is recorded through anthropometric indicators (e.g., wasting, stunting, and underweight in children under five), which serve as effective proxies for the nutritional status of the general population. The second dimension includes input indicators reflecting food quality, preparation, and health/hygiene conditions (Dhou, 2022);
- **Stability:** Adequate food must be obtained at all times. Two types of indicators measure exposure to risks: basic indicators like the area equipped for irrigation (measuring exposure to climate shocks like drought) and the share of food imports in total merchandise exports. The second group reflects shocks directly affecting food security, such as fluctuations in food prices, production, and political instability (FAOUN, 2022).

3.2. Key Food Security Indicators for Arab Countries

Having addressed the concept and determinants of food security, this section is dedicated to reviewing the most significant food security indicators for Arab countries. This is achieved by monitoring developments in the production of key food commodities, alongside the status of food access and food availability indicators.

3.2.1. Production of Key Food Commodities

• Animal and Crop Production :

The group of agricultural crops consisting of grains, wheat, barley, maize, rice, and peanuts is considered the most important food commodities in the Arab world. They represent the largest share in terms of both cultivated land area and their contribution to the value of the primary food commodity gap.

Based on Table (1), it is evident that all these crops experienced a decline in production in 2022 compared to 2018, with decrease rates ranging from (1% to 9%). Cereal crops lead all other agricultural products, with a total production of 49.49 million tons in 2022.

Table 1. Evolution of Agricultural and Animal Production in Arab Countries

Item		2018	2019	2020	2021	2022
Crop Production (Million Tons)	Cereals	54,09	57,77	53,36	54,46	49,49
	Wheat	25,77	26,12	26,51	27,73	24,38
	Barley	6,49	8,62	7,06	5,74	4,39
	Maize	8,84	8,44	8,48	8,54	8,17
	Rice	5,59	7,78	5,83	5,8	4,41
	Groundnuts	3,19	3,16	3,17	2,59	2,58
Livestock Production (Million Head)	Fish	4,98	5,65	6,23	6,23	6,18
	Eggs	2,25	2,56	2,34	2,48	2,29
	Dairy	26,02	25,38	27,31	27,28	27,36
	Red Meat	4,29	4,39	4,31	4,36	4,24
	Cattle	58,25	58,13	55,00	57,74	54,19
	Sheep	304,91	274,76	287,13	279,63	273,16
	Camels	14,43	16,55	16,78	16,77	16,70

Source: Prepared by the researchers based on the Joint Arab Economic Report 2023.

Regarding livestock in Arab countries, it is concentrated in five primary nations: Sudan, Algeria, Somalia, Mauritania, and Egypt. Livestock farming in these regions relies heavily on natural pastures, lacking appropriate breeding and care systems that ensure adequate productive efficiency or the development of value-added production.

Some livestock categories witnessed a decline in 2022 compared to 2018, such as cattle and sheep, while fish, dairy, and camels saw a slight increase during the same period.

• The Real Sector

The Real Sector of the economy serves as the fundamental sector, as it encompasses the total economic activities prevalent in society and reflects the sector's contribution to the Gross Domestic Product (GDP). The agricultural sector is considered one of the most vital activities due to its close link to food supply and the achievement of food security for society. Accordingly, this section will focus on highlighting the agricultural GDP per capita.

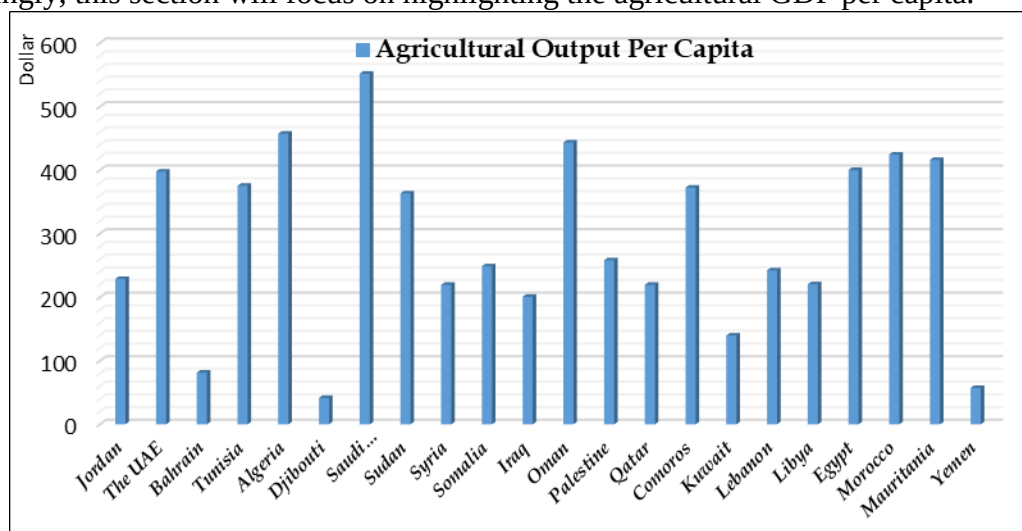


Fig. 1. Agricultural GDP per Capita by Arab Country.

Source: Prepared by the researchers based on the Joint Arab Economic Report 2023.

Income levels vary across Arab countries; it reached its peak in Saudi Arabia at approximately 551.66\$ per capita, while it hit its lowest in Djibouti at about 41.45\$ per capita (Figure 01). At the regional level, the Arab world's agricultural GDP per capita for the year 2022 witnessed a slight decrease of (-0.9%) compared to 2021, while it reached 520.75\$ per capita at the global level.

3.2.2. Food Access Indicators

This indicator provides internationally comparable data regarding the proportion of the population facing moderate or severe food insecurity in accessing food. The Self-Sufficiency Ratio (SSR) serves as a measure of the food gap and the level of food insecurity experienced by individuals or households. Furthermore, the food access indicator falls under Target 2.1 of the Sustainable Development Goals (SDGs).

• Self-Sufficiency Indicators

Self-sufficiency indicators are essential components for monitoring the size of the food gap and the extent of achieving national security from an economic perspective. These indicators represent a society's ability to secure its consumption needs of essential food commodities through local production.

The Arab region is witnessing a variation in the self-sufficiency ratio (SSR); some countries have achieved self-sufficiency in the production of certain commodities, while others have fallen short.

Table 2. Self-Sufficiency Ratio of Key Food Commodities in Arab Countries.

Year	Wheat	Barley	Rice	Maize	Vegetables	Fruits	Meat	Fish
2018	39.32	43.35	52.96	24.18	98.23	94.12	70.12	108.71
2022	35.30	45.99	48.53	23.35	96.94	96.03	69.13	108.82

Source: Prepared by the researchers based on the Arab Organization for Agricultural Development (AOAD), Yearbook of Agricultural Statistics.

The self-sufficiency rate of the total food available for consumption of major commodities in 2022 witnessed a slight decrease to 62.5%, compared to 62.9% in 2021. As observed in the table above, the self-sufficiency ratios for wheat, rice, maize, vegetables, and meat declined, while barley, fruits, and fish saw an increase during the period 2018–2022.

• Food Gap

In light of the lack of growth in natural agricultural resources, the scarcity of agricultural investment, and steady population growth, the demand for agricultural commodities is increasing, and the food gap is widening year after year.

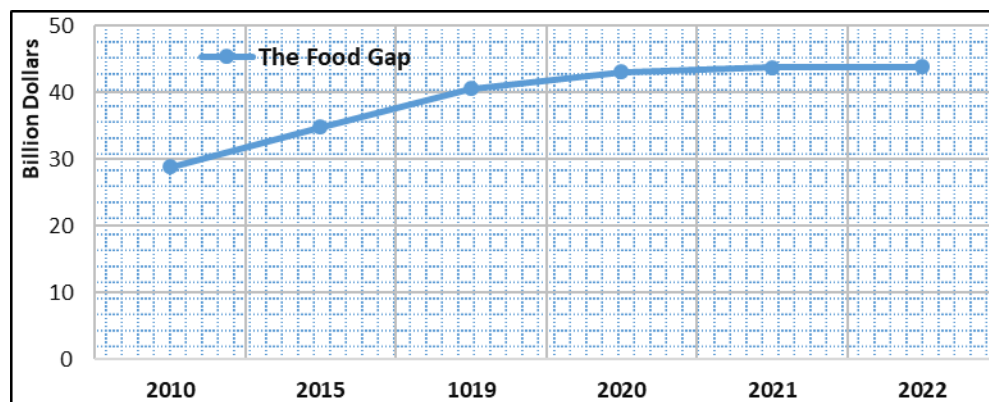


Fig .2. Development of the Food Gap in the Arab World.

Source: Prepared by the researchers based on the Joint Arab Economic Report 2023.

The value of the food gap rose by a slight margin of 0.2% between 2021 and 2022, increasing from 43.8\$ billion to 43.9\$ billion. The steady growth of the food gap becomes evident when viewed in Figure (02) over a longer period, as it rose from approximately 34.8\$ billion to about 43.8\$ billion, representing an annual growth rate of approximately 3.4% during the period 2015–2022.

3.3. Food Availability Indicators

Undernutrition is linked to many factors that have impacted nutritional status, such as price hikes, natural disasters, and instability. In recent years, the phenomena of hunger and undernutrition have increased in several Arab countries that have experienced periods of instability, unfavorable natural conditions, widespread droughts, increasing desertification, and the effects of international conflicts.

According to Figure (3), undernutrition in the Arab world can be monitored through the Hunger Index, which ranges in value from (0–100). Three countries were recorded below the hunger line: Syria, Somalia, and Yemen, with scores estimated at (50.8, 49.1, and 48.7) respectively.

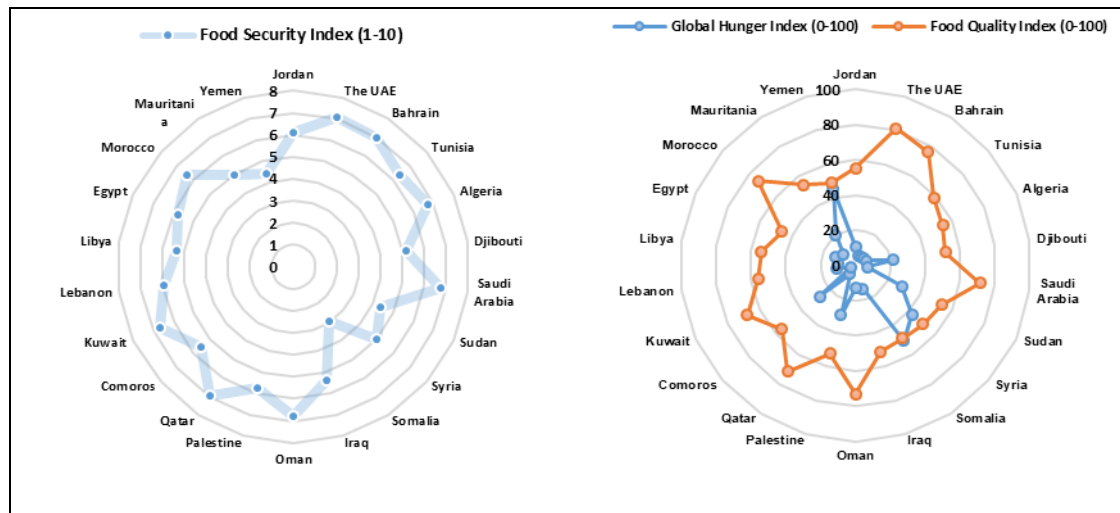


Fig.3. Food Availability Indicators in Arab Countries

Source: Prepared by the researchers based on the Arab Organization for Agricultural Development report, 2022.

Regarding the Food Quality Index, which also ranges from (0–100), we observe that only seven (07) out of (22) Arab countries achieved a score exceeding 60 points. These countries are: the United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar, Kuwait, and Morocco.

By monitoring the General Food Security Index, we find that oil-producing Arab countries obtained higher scores than the rest. Meanwhile, Arab countries experiencing conflicts and security instability ranked at the bottom of the international classification. Jordan, the UAE, Bahrain, Tunisia, Algeria, Saudi Arabia, Oman, Qatar, Kuwait, and Morocco obtained an index score between (6.1 – 7.07). Furthermore, Djibouti, Syria, Iraq, Palestine, Comoros, Lebanon, Libya, and Egypt scored between (5.01 – 5.94). Finally, Sudan, Somalia, Mauritania, and Yemen ranked at the bottom with index scores ranging between (2.97 – 4.98).

4. Interpretation of Key Food Security Indicators Using Cluster Analysis

In the previous section, we addressed the descriptive analysis of the current state of food security indicators in Arab countries. We now turn to analyzing these indicators using Cluster Analysis, specifically employing two of its primary methods: the K-Means method and Hierarchical Cluster Analysis (HCA). These methods are instrumental in identifying the strength and direction of the correlation between indicators, as well as highlighting the significance of each indicator and its impact on the food security of these nations.

4.1 Major Methods of Cluster Analysis

Before proceeding with the application of this analysis, this section will define Cluster Analysis as used in our study and highlight the primary methods employed to classify Arab countries.

4.1.1. Definition of Cluster Analysis

Cluster Analysis is a multivariate statistical technique where inputs are represented in a matrix format, illustrating how each observation or case under study resembles or differs from all others (Mutlaq, 2012). It can also be defined as a set of procedures aimed at classifying and organizing a group of cases or variables into specific groups called "clusters." This is done such that all cases within a single cluster are homogeneous and share specific characteristics, while remaining distinct from cases in other clusters (Mahfoud, 2008).

4.1.2. Cluster Analysis Methods

There are several methods used in cluster analysis, categorized into Hierarchical and Non-Hierarchical clustering. In this section, we will focus on highlighting the most prominent methods relevant to our empirical study.

a. K-Means Cluster Analysis

This method is considered one of the most popular non-hierarchical clustering techniques. It is based on classifying a number of cases into homogeneous groups based on specific characteristics or features, utilizing algorithms capable of processing a large number of observations. This method is often referred to as Quick Clustering because it minimizes the time required for processing, analysis, and classification (Ahmed, 2015).

$$d(x, y) = \sqrt{\sum_{j=1}^p (x_j - y_j)^2} \dots \text{formula (1)}.$$

b. Hierarchical Cluster Analysis (HCA)

This is a hierarchical clustering method that does not require prior knowledge of the number of clusters into which cases are classified. This type of analysis is suitable for small samples, as it links similar groups within the data using a computationally efficient technique (Rencher, 2002). The classification consists of a series of partitions, starting from a single group containing all items and ending with a group "n", each containing a single item (Everitt, et al, 2011).

$$N(n, g) = \frac{1}{g} \sum_{k=1}^g \binom{g}{k} (-1)^{g-k} k^n \dots \text{formula (2)}.$$

There are two main types of hierarchical clustering methods:

- **Single Linkage Clustering:** This is one of the oldest and simplest clustering methods, also known as the Nearest Neighbor method. It considers the distances or similarity coefficients between pairs of observations as inputs for the linkage method, which originally represents the cluster core. The process begins by grouping the items between the two closest elements (finding the smallest distance in the matrix) to form a new cluster core, according to the following formula (Mutlaq, 2012):

$$D_{IJ} = \text{Min}(d_{ij}) \dots \text{formula (3)}.$$

Where:

- D_{ij} : Represents the cluster resulting from merging the two closest elements in the distance matrix.
- d_{ij} : The distance between elements (i, j).

- We then calculate the distance between the new cluster and all other clusters, denoted by the symbol k .

➤ **Complete Linkage Clustering:** Also referred to as the Farthest Neighbor method. This method begins by grouping observations by merging the two closest adjacent elements to form a new cluster core. Subsequently, this method operates in the opposite manner of the Single Linkage method; the distance between the selected cluster and each of the other clusters is calculated based on the farthest distance, according to the following formula (Rencher, 2002):

$$D_{(IJ)k} = \text{Max}(d_{ki}, d_{kj}) \dots \text{formula (4)}.$$

4.2. Results of Cluster Analysis for Food Security Indicators in Arab Countries

This section is dedicated to applying the cluster analysis method to classify Arab countries based on their food security indicators.

4.2.1. Methodology and Procedures

Prior to conducting the analysis, statistics were collected for eleven (11) variables representing food security indicators across 22 Arab countries.

a. Study Variables

A set of variables related to food security was identified, as summarized in the following table:

Table 3. List of Variables Used in the Study

Nº.	Variables	Nº.	Variables
01	Population (Thousands)	07	Agriculture, Forestry, and Fishing GDP (Million USD)
02	Agricultural GDP per Capita (USD)	08	Food Security Index (1-10)
03	Agricultural Production Index	09	Global Hunger Index (0-100)
04	Agricultural Imports (Million USD)	10	Fish Production (Thousand Tons)
05	Agricultural Exports (Million USD)	11	Agriculture's Contribution to GDP (%)
06	GDP per Capita (USD)		

Source: Prepared by the researchers

b. The Model and Statistical Processing

Cluster analysis is an appropriate method for exploring the underlying structure of a dataset. It functions by reducing the number of observations and organizing them into highly similar cases based on specific criteria, without requiring prior knowledge of group membership, structure, or count, relying instead on data-merging algorithms (Ramdeen & Yim, 2015).

This study relies on the most recent data regarding key food security indicators for 22 Arab countries. Data were compiled from the World Bank and the Joint Arab Economic Report 2023, issued by the Arab Monetary Fund.

Statistical processing was conducted using TANAGRA (V.1.4.50) software. This platform provides an extensive and integrated package of algorithms used in exploratory statistical

analysis and multi-indicator data processing, along with multi-dimensional graphical representations that assist researchers in immediate decision-making.

4.2.2. Study Results

a. K-Means Clustering Method

This method was applied because it requires a prior determination of the number of clusters to be formed relative to the number of observations. Given the number of countries proposed for the study (22 Arab countries), the number of clusters was set to three (K=3). The results are shown below:

Table 4. Distribution of Arab Countries by Number of Clusters using K-Means

- Clusters		03
- Trials		05
- R-Square		0.9402
Clusters	Size	Pays
Cluster n°1	05	Algeria, Egypt, Morocco, Saudi Arabia, and UAE.
Cluster n°2	06	Comoros, Mauritania, Somalia, Sudan, Syria, and Yemen.
Cluster n°3	11	Bahrain, Djibouti, Iraq, Jordan, Kuwait, Lebanon, Libya, Oman, Palestine, Qatar, and Tunisia.

Source: Prepared by the researchers based on TANAGRA software (V.1.4.50).

By applying this method, as illustrated in Figure (4), the formation of three homogeneous clusters based on the variables used was confirmed through five iterations. We also note that the correlation coefficient (R) indicates a strong intra-cluster correlation, demonstrating the high similarity of variables within each cluster. The results of the Analysis of Variance (ANOVA) and the intra-cluster distances for each indicator are presented in Table (5).

Table 5. Analysis of Variance (ANOVA) and Intra-Cluster Distances by Variable

Attribute_Y	Statistical test		Cluster centroids		
	Fisher's F Value	Prob a	Cluster n1	Cluster n2	Cluster n3
GDP of Agriculture, Forestry, and Fishing (Million USD)	19,895	0,000	11,782	35,783	8,160
Global Hunger Index (1-100)	16,968	0,000	3,518	23,050	7,280
Agriculture's contribution to GDP (%)	15,040	0,000	4179,727	2065,167	15370,400
Agricultural Imports (Million USD)	13,049	0,000	6,135	4,558	6,546
Global Food Security Index (1-10)	10,545	0,001	811,727	650,667	6938,800
Agricultural Exports (Million USD)	10,195	0,001	2211,364	5602,500	24033,000
Agricultural GDP per capita (USD)	6,867	0,006	222,800	279,547	446,236
Agricultural Production Index	6,547	0,007	2267,09	6815,00	21264,0

			1	0	00
GDP per capita (USD)	1,528	0,242	19554,738	1144,685	19258,282
Fish Production (Thousand Tons)	1,092	0,356	91,683	198,150	404,582
Population (Thousands)	0,771	0,476	129,151	23,988	26,890

Source: Prepared by the researchers based on TANAGRA software (V.1.4.50)

Table (5) presents the analysis of variance (ANOVA) for each of the studied indicators using cluster analysis. The statistical test indicates a high level of significance for the following variables: GDP of the agriculture, forestry, and fishing sector; the Global Hunger Index; the contribution of agriculture to GDP; agricultural imports; the Food Security Index; agricultural exports; and the agricultural production index.

These variables are significant at the 0.05 level, demonstrating that they are fundamental and influential factors in classifying Arab countries into clusters. Conversely, the remaining variables were not statistically significant, indicating that they did not contribute optimally to the categorization of these countries into clusters.

b. Hierarchical Cluster Analysis (HCA)

At this stage, we utilized data from 22 countries; therefore, the Hierarchical Cluster Analysis (HCA) algorithm is appropriate for estimating the number of clusters. We employed agglomerative hierarchical clustering, which begins the grouping process by considering each case as an independent cluster. Similar clusters are then merged in subsequent stages. We can determine the number of clusters based on the maximum height of the dendrogram. The results of this application are illustrated in Figure (4).

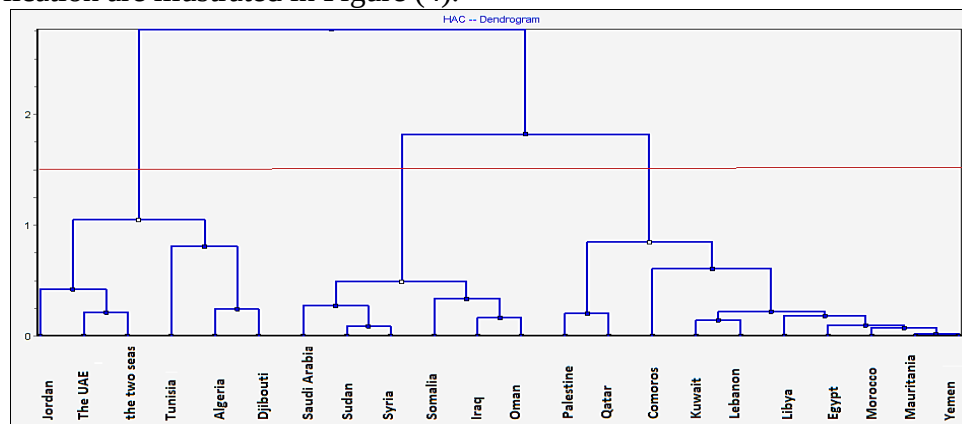


Fig .4. Dendrogram

Source: Prepared by the researchers using TANAGRA software (V.1.4.50).

Looking at Figure (4), we observe that each country initially clusters with itself, resulting in 22 clusters. By moving from bottom to top toward a solution with fewer clusters and fewer observations, we see countries beginning to merge into homogeneous groups. At Height = 1, four groups emerge. If we move to Height = 1.5, two groups merge, resulting in three (03) clusters distributed as shown in Table (6).

Table 6. Distribution of Cases by Clusters using HCA

Clusters	Size	Pays
----------	------	------

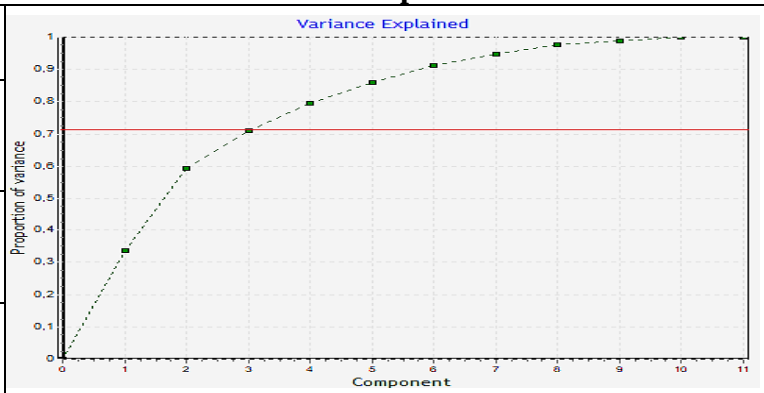
Cluster n°1	06	UAE, Algeria, Egypt, Oman, Saudi Arabia, and Morocco.
Cluster n°2	06	Comoros, Mauritania, Sudan, Somalia, Syria, and Yemen.
Cluster n°3	10	Bahrain, Djibouti, Iraq, Palestine, Jordan, Kuwait, Lebanon, Libya, Qatar, and Tunisia.

Source: Prepared by the researchers using TANAGRA software (V.1.4.50).

By observing the cluster components, we find them to be similar with no significant differences between the two methods, except for Oman; it belongs to the first cluster in the Hierarchical Cluster Analysis (HCA), whereas it falls within the third group when using the K-Means method. To understand the nature of the relationship between the variables and the number of studied observations, we employed Principal Component Analysis (PCA). This allowed us to identify the most influential indicators on food levels by extracting the eigenvalues of the variables as well as their factor loadings within the clusters.

Table 7. Eigenvalues and Total Variance Explained

Axis	Eigen value	Difference	Proportion (%)
1	3,713	0,891	%33,76
2	2,823	1,548	%59,42
3	1,275	0,325	%71,01



Source: Prepared by the researchers using TANAGRA software (V.1.4.50).

From the figure showing the eigenvalues and explained variance, we note that the first three factors have eigenvalues located in the steep region of the Scree Plot before the leveling-off point. This indicates that these three factors should be retained while discarding the others.

Based on these indicators, the following primary factors are extracted:

- The first factor represents an Eigenvalue of 3.71 and explains 33.71% of the total variance in food security variables.
- The second factor represents an Eigenvalue of 2.82 and explains 25.66% of the total variance.
- The third factor represents an Eigenvalue of 1.27 and explains 11.59% of the total variance.

Accordingly, the majority of the variables are interpreted through the first three factors, with a cumulative variance of 71.01%. This percentage is considered sufficient to summarize the overall variables into primary factors.

By studying the factor loadings (represented as correlation coefficients), it is observed that higher loading values indicate that the variable or cluster is more distinct and explanatory. The results are shown in the table below:

Table 8. Factor Loadings of Variables on Primary Axes

Axis	Variables	Loading Value
First Axis	GDP of Agriculture, Forestry, and Fishing (Million USD)	0.857
	Global Hunger Index (1-100)	0.740
	Agriculture's contribution to GDP (%)	-0.681
	Agricultural Imports (Million USD)	0.676
	Global Food Security Index (1-10)	0.668
	Agricultural Exports (Million USD)	0.650
Second Axis	Agricultural GDP per capita (USD)	0.649
	Agricultural Production Index	0.717
	GDP per capita (USD)	-0.683
Third Axis	Fish Production (Thousand Tons)	-0.863
	Population (Thousands)	0.754

Source: Prepared by the researchers using TANAGRA software (V.1.4.50).

The First Axis: Contains variables with high loading levels, ranked by their importance in explaining total variance. This indicator is highly significant in determining food security levels, as it includes six (06) key variables: Agricultural Sector GDP, Global Hunger Index, Agriculture's contribution to GDP, Agricultural Imports, Food Security Index, and Agricultural Exports.

The Second Axis: Includes three (03) variables: Agricultural GDP per capita, Agricultural Production Index, and GDP per capita.

The Third Axis: Is strongly correlated with two variables: Fish production and population size.

Regarding the correlation between the main axes and the clusters obtained via Hierarchical Clustering, these are represented graphically in Figure (5).

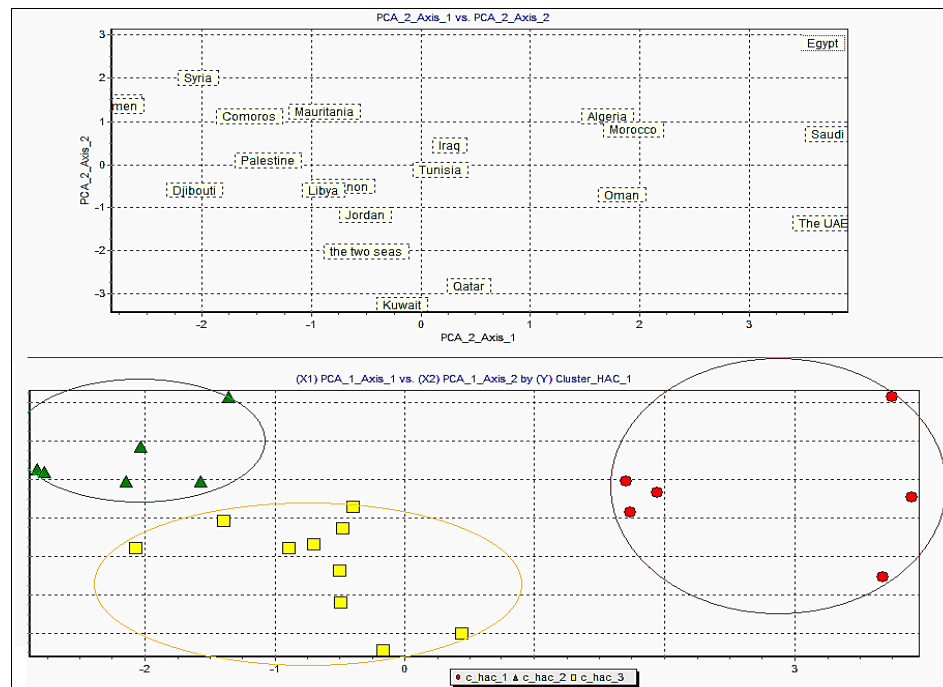


Fig.5. Representation of Cluster Loadings on Axes

Source: Prepared by the researchers using TANAGRA software (V.1.4.50).

- **Cluster 1:** Includes six (06) Arab countries (UAE, Algeria, Egypt, Oman, Saudi Arabia, and Morocco). It is strongly and positively correlated with the First Axis, showing a high loading level.
- **Cluster 2:** Includes five (05) Arab countries (Comoros, Mauritania, Sudan, Somalia, Syria, and Yemen). It is strongly and positively correlated with the Second Axis.
- **Cluster 3:** Includes ten (10) countries (Bahrain, Djibouti, Iraq, Palestine, Jordan, Kuwait, Lebanon, Libya, Qatar, and Tunisia), which are negatively correlated with the First Axis.

5. Study Results and Discussion

5.1. Analysis of Study Results

The statistical processing of data from 22 Arab countries using Cluster Analysis algorithms (K-Means & HCA) and Principal Component Analysis (PCA) yielded the following substantial results:

- The results of both the K-Means and Hierarchical Cluster Analysis (HCA) methods were similar regarding the categorization of countries into clusters, distributed respectively as (6, 6, 10) and (5, 5, 11).
- Principal Component Analysis (PCA) was employed to understand the nature of the relationship between variables and the number of cases (countries) by extracting initial eigenvalues. The results indicate the existence of three (03) primary components that explain the majority of the variables, with a total cumulative variance of 82.76%.

- The First Axis comprises six (06) key variables: GDP of the agriculture, forestry, and fishing sector; Global Hunger Index; the contribution of agriculture to GDP; agricultural imports; Food Security Index; and agricultural exports. This axis is strongly and positively correlated with the First Cluster, which includes six Arab countries: UAE, Algeria, Egypt, Oman, Saudi Arabia, and Morocco. These countries are characterized by an improvement in food security indicators.
- The Second Axis carries three (03) variables: GDP per capita and the Agricultural Production Index. This axis is strongly and positively correlated with the Second Cluster, which includes five countries: Comoros, Mauritania, Sudan, Somalia, Syria, and Yemen. These countries suffer from a lag in food security indicators.
- The Third Axis includes the variables of fish production and population size. The Third Cluster includes ten (10) countries that are negatively correlated with the first axis, namely: Bahrain, Djibouti, Iraq, Palestine, Jordan, Kuwait, Lebanon, Libya, Qatar, and Tunisia.
- The results also recorded a decline in strategic self-sufficiency rates (Wheat at 35.3%) against an expansion in the food gap, which reached a value of 43.9\$ billion in 2022, with livestock wealth concentrated in a limited number of countries suffering from poor production efficiency.

5.2. Discussion of Results and Hypothesis Testing

The study confirmed the validity of the first hypothesis; statistical analysis showed a 9.1% decrease in grain production and a drop in total self-sufficiency to 62.5%. This result is consistent with the studies of Waer and Doufi (2021) and Ben Fles (2021), which confirmed that Arab domestic production does not keep pace with increasing demand, thereby deepening external dependency. This result also reinforces the findings of Khodirat (2023) regarding the impact of international crises (Russia-Ukraine) in exacerbating this gap.

The study also proved the validity of the second hypothesis. Cluster analysis succeeded in statistically sorting Arab countries into distinct groups based on the similarity of their nutritional characteristics, with a strong correlation coefficient ($R = 0.94$). This result intersects with the study of Bouaziz (2022), which used the same method and identified three groups, confirming that Arab food security is not a monolith but is influenced by financial capabilities (as seen in Gulf countries) versus political stability (as seen in conflict-affected countries).

As for the third hypothesis, it was validated through Principal Component Analysis (PCA). The "driving" variables of food security emerged, with (Agricultural Output and the Hunger Index) being the most saturated variables in the first axis, making them the largest explainers of variance between countries. This result differs from the descriptive study by Bazazi (2022) in that it provided a precise statistical weight for each variable, supporting the vision of Oudina and Laalmi (2025) on the necessity of focusing on raising the efficiency of productive resources as an obligatory entry point for achieving sustainability.

6. Conclusion

This study concludes that the reality of Arab food security is going through a critical stage characterized by "structural dependency" on global markets. Advanced statistical tools revealed a deep gap separating the production capacities of Arab countries from their consumption needs. The classification of countries into clusters was not merely a statistical division, but a mirror reflecting the disparity in economic capabilities and political stability. The latent agricultural

potential in countries like Sudan and Somalia has not been exploited to achieve Arab integration, while financially affluent countries remain dependent on external supply chains affected by geopolitical crises.

In light of these results, researchers can interpret the reality of food security indicators by summarizing the set of influential variables into primary factors. However, the generalizability of these results depends on several other factors, whether direct or indirect, such as environmental factors and external shocks like the Russia-Ukraine crisis and the COVID-19 pandemic.

Finally, this topic remains open to benefit from international research aimed at improving food security indicators, in addition to investigating the political, social, economic, and environmental obstacles that prevent the improvement of this sector in the Arab world. This simplifies the vision for policymakers to develop policies and programs based on scientific evidence.

References

- AFSA. (2023). *Food security and development: Building a global orientation*. Agriculture and Food Safety Authority, Abu Dhabi. <https://www.adafsa.gov.ae/Arabic>
- Ahmed, T. (2015). Classification of Syrian governorates according to household consumption using cluster analysis. *Journal for Research and Scientific Studies*, 37(12), 45 - 64.
- AMF. (2023). *Joint Arab economic report 2023*. Arab Monetary Fund, Abu Dhabi, United Arab Emirates. https://www.amf.org.ae/sites/default/files/publications/2024-03/62591_Joint%20Arab%20Economic%20Report%202023_Inner_Edit.pdf
- AOAD. (2022). *The state of Arab food security*. Arab Organization for Agricultural Development. Khartoum, Republic of Sudan: League of Arab States.
- Ben Obeid, F., Matai, A., & Salah, M. (2017). Food security in the Arab world: An analytical study of the reality and a forward-looking view for solutions. *Journal of Rights and Human Sciences*, 11(3), 138-153. <https://asjp.cerist.dz/en/article/63099>
- Benflis, L. (2021). Analysis of food security indicators in the Maghreb countries. *Ilyas Journal for Research and Studies*, 6(Special Issue), 238–252. <https://asjp.cerist.dz/en/article/158056>
- Benslimane, T., & Saidoun, D. (2026). Innovation as a Strategic Mechanism for Economic, Educational, Industrial, and Agricultural Development in the Modern Era: A Demographic Perspective. *Corps et Psychisme. Recherches en Psychanalyse et Sciences Humaines*, 13(1), 506-514. Retrieved from <https://corpsetpsychisme.com/cp/article/view/178>
- Bezazi, S. (2022). The food security situation in the Arab world between reality and the need for reform. *Journal of Economic Development Studies*, 5(2), 70–84. <https://asjp.cerist.dz/en/article/212068>
- Bouaziz, O. (2022). Classification of Arab countries according to food security indicators using hierarchical cluster analysis for the period 2015-2020. *Al-Maqrizi Journal for Economic and Financial Studies*, 6(2), 74–94. <https://asjp.cerist.dz/en/article/205968>
- Dhou, K. (2022). International Concern to Achieving Food Security and its Protection Methods. *Algerian Journal of Historical and Legal Studies*, 6(3), 77–94. <https://asjp.cerist.dz/en/article/178504>
- Everitt, B. S., Landau, S., Leese, M., & Stahl, D. (2011). *Cluster Analysis* (5th ed.). London: Wiley Series.

- FAOUN. (2000). *The state of food insecurity in the world 2000*. Food and Agriculture Organization of the United Nations.
- FAOUN. (2022). *Food security and nutrition*. Food and Agriculture Organization of the United Nations. <https://openknowledge.fao.org>
- FQOUN. (2013). *The state of food insecurity in the world: Food security and its determinants*. Food and Agriculture Organization of the United Nations, Rome, Italy.
- Hamdan, M. R. (1999). *Food security: Theory, system, and application*. Amman, Jordan: Dar Wael for Publishing.
- Khidrat, O. Y. (2023). Arab food security in light of the current international crises and conflicts. *Journal of Development Studies and Business Entrepreneurship*, 1(2), 38–50. <https://asjp.cerist.dz/en/article/243388>
- Mahfoud, D. (2008). *Advanced statistical analysis using SPSS*. Amman, Jordan: Dar Wael.
- Mutlaq, T. M. (2012). *8.Models and quantitative methods in planning and their computer applications*. Amman, Jordan: Dar Al-Hamid.
- Ouaar, W., & Douffi, G. (2021). An analytical study of the state of Arab food security according to the global food security indicators during the period 2009-2018. *Journal of Economic Research and Studies in Renewable Energies*, 8(2), 64–84. <https://asjp.cerist.dz/en/article/167197>
- Oudina, A., & Lalmi, A. (2025). Ways to enhance food security in the Arab world: A review of the Arab Program for Sustainable Food Security 2022. *Journal of Scientific Research and Studies*, 19(1), 717–733. <https://asjp.cerist.dz/en/article/263031>
- Ramdeen, K., & Yim, O. (2015). Hierarchical Cluster Analysis: Comparison of Three Linkage Measures and Application to Psychological Data. *The Quantitative Methods for Psychology*, 11(1), 8-21.
- Rencher, A. C. (2002). *Methods of Multivariate Analysis* (2nd ed.). Jhon Wiley et sons, New York.