

Coordinates of Food and Nutrition Security in States with Limited Agricultural Resources

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Abstract. Food security is a topic of a large interest, the new approach shifting towards nutrition security, from people access to sufficient towards safe and nutritious food, emphasizing the structure of the diet and the importance of the nutrients in assuring a healthy life. But malnutrition problems affect people worldwide, in different forms, both undernourishment and overweight and obesity, mostly in countries where agricultural resources, as one of the main sources of food, are scarce. Such a country is United Arab Emirate, where people have access to sufficient food, but based on imports, signaling a low level of food self-sufficiency. Furthermore, the alarming rate of obesity of 30% raises questions about the structure of the diet and nutrition security. The aim of the study is to determine the level of food security in the United Arab Emirates and identify the factors behind it. Statistical data referring to food and nutrition security in United Arab Emirate have been analysed and predictions have been made using machine learning algorithms. The results are relevant for underpinning food policy at macroeconomic level, helping decision makers in finding solutions for improving nutrition security and food self-sufficiency.

Keywords: food security, nutrition security, obesity, water and resource scarcity, machine learning algorithms.

Introduction

Food security is a topic of debate and research for many national and international bodies. Issued from the right of every people to sufficient and safe food, the term food security evolved into numerous definitions and a significant body of research is dedicated to its analysis. The topic is important because in countries where food security is accomplished, the political and economic situation is stable (Ion, 2017).

Worldwide, 767 million people suffer of undernourishment (FAO, IFAD, UNICEF, WFP and WHO, 2022), with significant differences between regions, Africa, Asia and South America being the most affected ones. The prevalence of undernourishment was 9.8% in 2021 in the world, 20% in Africa, 9% in Asia and 8.6% in Latin America and the Caribbean (Cafiero and Gennari, 2011). The magnitude of the hunger situation is bigger when speaking about absolute values. About

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half of the world's people affected by hunger in 2021 were in Asia (425 million people) and about a third in Africa (278 million people) (Pingali and Plavšić, 2022).

At the opposite pole, adult obesity has risen in all regions, increasing worldwide from 11.8% in 2012 to 13.1% in 2016, which is the last year with available data (Simmonds et al., 2016). Reports show that adults affected by obesity are more likely to live in upper-middle- or high-income countries (73% of the global burden in 2016), and the prevalence is higher among women (FAO, IFAD, UNICEF, WFP and WHO, 2022).

Agriculture production is generally one of the main sources of feeding the inhabitants of a state (Jelocnik et al., 2012). There are countries where agriculture is a significant branch of the economy, while in others, agriculture is less important or does not exist and the question is how these countries manage to ensure food and nutrition security. It is the case of the United Arab Emirates (UAE), whose agricultural area per capita is 0.04 ha/inhabitant, while the world average is 0.6 ha/inhabitant (FAOSTAT, 2023). To this, the water scarcity jeopardizes the food availability in the region and food imports absorb foreign exchange reserves (du Plessis and du Plessis, 2017).

Bearing in mind this question, the objectives of the research are to identify the level of ensuring food security in the UAE and to determine the drivers behind it. In achieving these objectives, statistical data have been analysed and predictions are made, retrieving data from international databases, such as FAO and World Bank.

The paper is structured as follows. After the introduction, the problem is stated based on a literature review and the research aims are established. Then, the methods and data are described, and the findings are presented. The conclusions are drawn at the end of the article.

Literature review

Currently, there is a thriving body of research that is expanding the limitations for definitions of food security and nutrition security in such a way that they are becoming inseparable for many of the reasons that are being discussed – the concept and the implication of climate change, economic growth, sustainability, crucial economy, resilience, population growth, and development are all becoming ingredients for the granular success of any food security and nutrition strategy (Tarhini, 2022).

The degree of complexity reveals intricacies beyond typical applications in food production, consumer behaviour, food waste management, resource optimization, and marginal utility maximization. This is because economics is at the core of the problem. The international importance of food security, safety, and nutrition is much greater than what governments, international organizations, and concerned scientific circles can define. More specifically, it may be traced to the fundamental issue of limited resources. These components, such as agrifood and water, cannot be divorced from the multidisciplinary sciences focused on comprehending, analysing, and locating appropriate remedies for the current food security/insecurity and nutrition issues (Tsolakis et al., 2019)

Food and Agriculture Organization (FAO), along with others in the World Bank, International Monetary Fund, and even the World Health Organization (WHO), are collaborating with governments, regions, territories, and developed and less developed countries to create a safety buffer zone to protect the vulnerable in the world, prevent hunger and famine, ensure that renewable resources are being used wisely, and reduce pollution, soil contamination, and agricultural malpractices to protect the world's food supply. These organizations are working with

governments, regions, and territories and food problems vary from one region to another (De Boeck, 2015).

Thus, the inability to access protein energy is creating malnourishment, and after one year, the undernourishment will be ignited to give way to starvation and famine (Masrizal, 2010). According to Amartya Sen (1981), “defining the world food problem; its chain reaction and a sum of distinct failures while the focal problem varies from one region to another.”

While the term “food security” has developed since the middle of the 20th century over the last decades, the term “nutrition security” emerged in the mid-1990s (Ingram, 2020). It envisages the food consumption of individuals or households, and it focuses on how the food is used by the human body (CFS, 2012). IFPRI proposed this definition in 1995: “Nutrition security can be defined as adequate nutritional status in those regarding protein, energy, vitamins, and minerals for all household members, at all times.” The need of emerging the issue of nutrition security is argued by the fact that nutrition security is only achieved when people actually consume the food they need, rather than simply having access to it, as described by the definition of food security. As a result, the phrase “food security and nutrition” has been used, describing the combination of the two concepts defined above (Sunderland et al., 2013).

“Food and nutrition security” is another term that combines elements of both food security and nutrition security. It is used mostly by the public health and nutrition communities to emphasize the need for greater integration of health and nutrition into food security policies and programs. The embedding of “nutrition” between “food” and “security” shows that raising levels of nutrition is the ultimate goal (CFS, 2012).

Finally, the development of the term food security towards food and nutrition security conducted to a new definition used in all official documents: “Food and nutrition security exists when all people at all times have physical, economic and social access to food of sufficient quantity and quality in terms of variety, diversity, nutrient content and safety in order to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health, education and care.” (FAO/AGN, 2011).

There are numerous studies in the field of food security in the UAE. Shahim and Salem (2015) provided an inside of the situation of the United Arab Emirates as a country that has limited freshwater resources and proposed reviewing the available irrigation resources and predicting the projected consumption, required to cover the agricultural sector demand. Pirani and Arafat (2016) investigated the food security in Gulf Countries, including UAE, and showed that they achieve food security through imports, looking into multiple pathways which can be used to secure food imports, particularly foreign agricultural land acquisition. Al-Qaydi (2016) described the status and prospects for food production in the UAE and explained the government's role in sourcing food to feed its people. The situation envisages a harsh environment, limited water resources, and infertile soil, jeopardized by the increasing population in recent years. The solutions for bringing more prosperity to the farming sector in the UAE refer to focusing on local farms and exploring new farming techniques that are more sustainable. Manikas (et al., 2022) underlined the fact that food security is adversely affected by regional conflicts, scarcity of freshwater, harsh environment, and rising temperatures and proposed a conceptual framework on the key enablers for the UAE agrifood supply chains through improving policy-making capacity, in order to obtain the necessary resiliency to achieve food security.

Because none of these studies analysed in deep the indicators of food security or predict them to better understand the drivers behind it, the present research fills in this gap, adding value to the knowledge.

The literature review revealed the same issues that jeopardize food security in the UAE – limited agricultural land, water scarcity, harsh environment, infertile soil, rapid population growth, and, as such, food demand. The research question is what is the level of achieving food security in the UAE and what are its drivers?

The research starts from the hypothesis that, since the UAE has limited agricultural resources, food security is achieved the based-on food imports, making the country vulnerable in front of unpredictable world agricultural markets' trends.

The purpose of the research is to provide information for policymakers in their process of underpinning macroeconomic policy of food security achieving.

Methodology

Statistical data referring to food security in UAE have been retrieved from FAOSTAT database and analysed. "UAE Agricultural Area as a share of the Total Land", meaning the portion of the total land area that can be farmed and includes both arable land and land used for permanent crops and pastures. Data have been retrieved from the World Bank database.

Other indicators revealing the food security situation, such as "prevalence of undernourishment", "average protein supply", "average supply of animal protein", "average dietary energy supply adequacy", "GDP per capita", "share of adult obesity in the total population", "value of food imports in total merchandise exports", and "cereal import dependency ratio", have been retrieved from FAO database and analysed.

Besides statistical analysis of secondary data, predictions are made for some indicators, using machine learning prediction.

Countless research and different literature/methodologies are mentioned and discussed to emphasize the importance of ARIMA as a univariate classical parametric time series tool – and nowadays, one of the methods used to compute and apply machine learning techniques to implement inferential statistical models as well as econometric regressions.

Box and Jenkins (1970) first implemented Autoregression Integrated Moving Average – and that's why when preparing the study, the main configuration is about testing Ljung-Box to examine the correlation of the variable in terms of time series analysis before proceeding with forecasting (Dash and Mahapatra, 2020).

ARIMA is a model that takes past historical data/events while still considering the present and past information about error terms – to create a conjugation of all types of information that is delimited with the univariate times series during the forecasting (Padhan, 2012).

To apply the ARIMA model, the procedure consists in following these steps:

- Exploratory analysis: This consists of autocorrelation analysis to test the serial dependencies within the data frame, the spectral analysis part will check for the cyclical behaviour of the data values (p) given at the time, and the trend estimation test will implement decomposition of data point to check for seasonal adjustments. The removal of seasonality and the conversion to data stationarity is conducted by ACF (Autocorrelation function)

- Fitness of the model: A Ljung-Box Q test should be conducted to study and examine the degree of “fitness”. Usually the statistical test is achieved by applying the following to the time series data:

$$Q_{(m)} = n(n+2) \sum_{j=1}^m \frac{r_j^2}{n-j'}$$

while: H0: Model does not show lack of fit (data are random)

H1: Model does show lack of fit (data are not random)

r_j = accumulated sample autocorrelation (in time-series)

m = time log

- Diagnostics for results: Examining and analysing the resultants and check how it can be validated to confirm the findings (as compared to empirical applications of the data).

Results and discussions

These data referring to agricultural sector and food security in the UAE are shown below and analysed in dynamics.

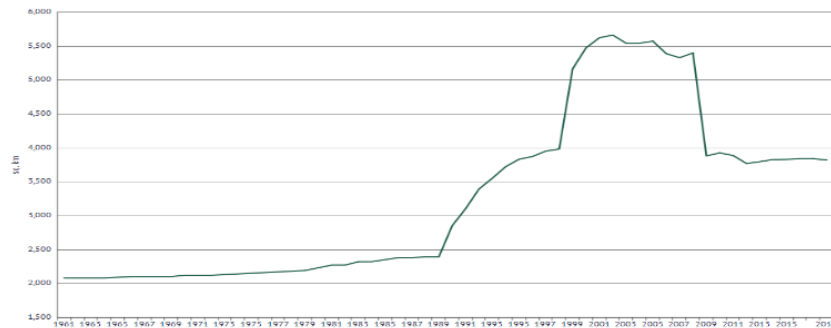


Figure 1. UAE Area of agricultural land (sq. km) (1961-2018)

Source: World Bank data base, 2022.

Figure 1 reflects the area of land used for agricultural purposes in the UAE between 1961 and 2018. In 1961 the space used was 2,080 sq. km, and in 1989, it was expanded to the limit of 2,390 sq. km. In 1998 the area covered almost doubled after ten years and reached 3,980 sq. km. The peak was achieved in 2001, when the area used for agriculture at that time was 4,620 sq. km before the beginning of the second Gulf War, and it was the period when UAE achieved the highest Food Production Index and the highest crop yield.

In 2008 and the beginning of the global financial meltdown, the area used was 3,879 sq. km, and in 2018, it reached the level of 3 818 sq. km.

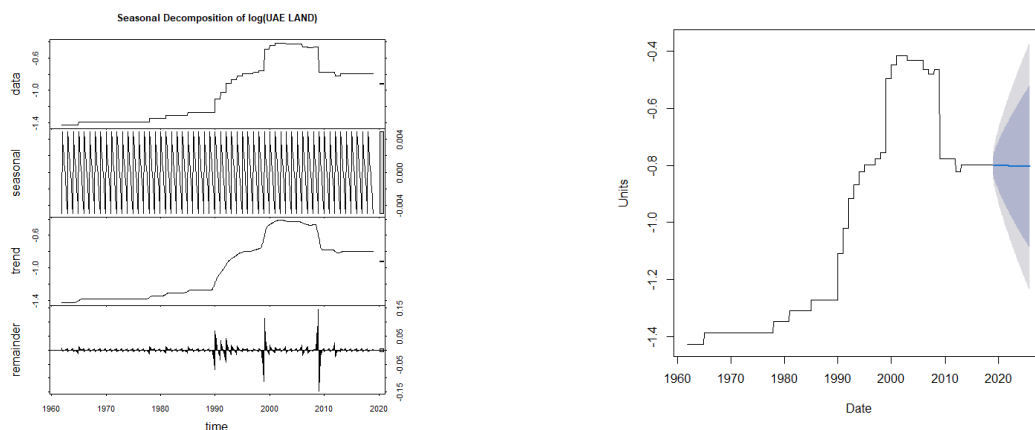


Figure 2. UAE Seasonal Decomposition of Time Series Analysis for agricultural land use (1980-2025) and Prediction of UAE agricultural land after using ARIMA model for machine learning till 2025

Source: authors, based on data compilation.

According to Figure 2, Prediction of UAE agricultural land after using ARIMA model for machine learning till 2025, the exact current prediction will likely remain constant for the coming three years.

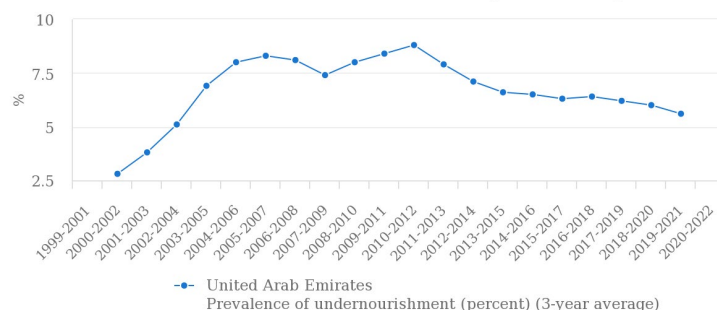


Figure 3. UAE Prevalence of undernourishment (%) (3-year average)

Source: FAOSTAT, 2023.

The case of undernourishment is a structural indicator for the nutrition landscape in a country – Figure 3 shows how undernourishment started at a 2.8% low level in 2000 and moved gradually up to 8.3% in 2005 before reaching its highest point in the year 2010 when it indicated 8.8 %, before dropping moderately to 5.6% in 2021 (during COVID-19).

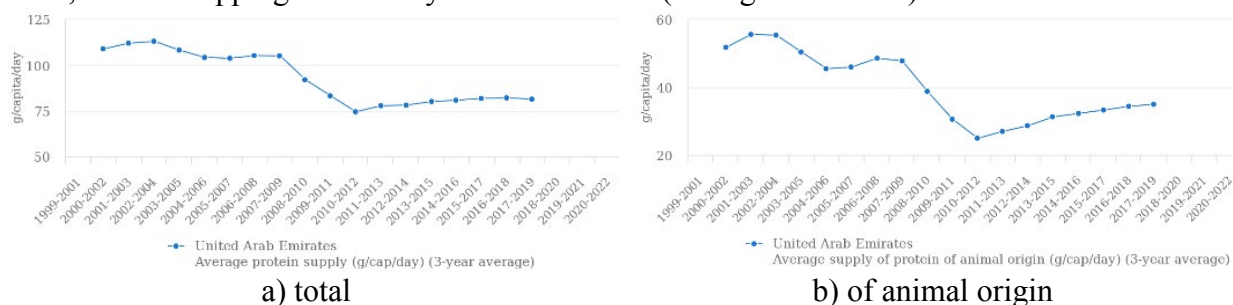


Figure 4. UAE Average protein supply (g/cap/day) (3-year av. 1999 - 2019)

Source: FAOSTAT, 2023.

The availability of protein supply measured in grams per capita per day is an important indicator to check how to fit the nutritional supplies in terms of components because protein is essential for life support. Data in Figure 4a) show a level of 108.8 g in the year 2000 with a slight increase to 112.9 g between 2002 and 2004, followed by a phase of 104.9 g between 2007 and 2009 while the lowest being in 2010 when it reached 74.4 g (it was one direct effect of 2008 food crises) and finally reaching 81.3 g in 2019. Figure 4b) shows data about the average supply of protein of animal origin (to make it different from vegetable-based protein), and the unit of measurement is gram/capita/day. In 2001 it was 55.6 g, moved to 45.5 g between 2004 and 2006 before dropping to 25 g in 2010 after the food crisis and slightly shifted up again in 2019 by reaching 35 g.

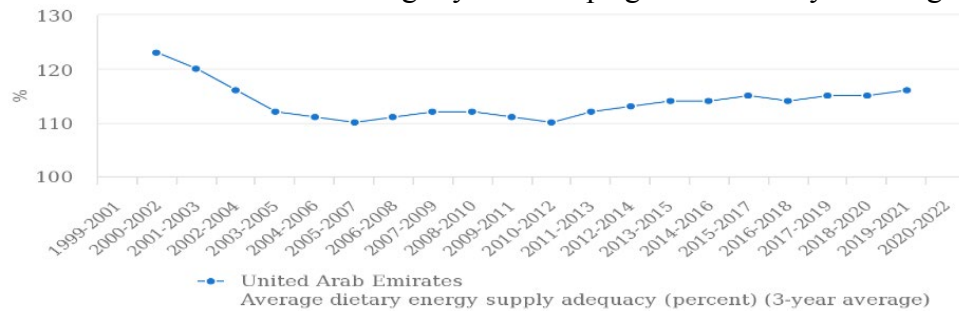


Figure 5. UAE Average dietary energy supply adequacy (%) (3-year average)

Source: FAOSTAT, 2023.

Adequacy and sufficiency are critical indicators to understanding how the nutritional value is a required impact in terms of survival and a perfect print for physical activity. Figure 5 shows how adequacy is changing between the years 2000 and 2021. In the year 2000, it was relatively the highest point level in the graph, reaching 123%, dropping to 110% in 2010 and the lowest after the global food crisis before climbing slightly back to 116% in 2021.

GDP per capita is over 50,000 international dollars in UAE, demonstrating the high power purchase of consumers.

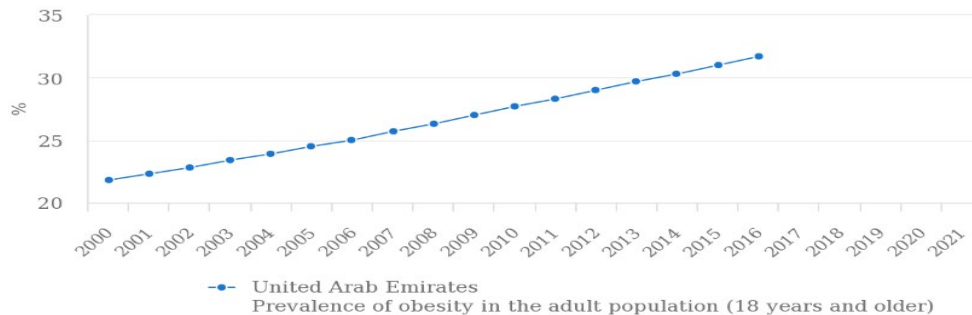


Figure 6. UAE Adult Obesity (over 18 years old) % of the total population (2000-2016)

Source: FAOSTAT, 2023.

Figure 6 UAE: Adult Obesity (over 18 years old) % of the total population (2000-2016) is projecting the obesity level and trend between the year 2000 and year 2016 – data shows how this is alarming and becoming an increasing issue for healthy authority in UAE – this is also an important indicator when studying utilization of food resources.

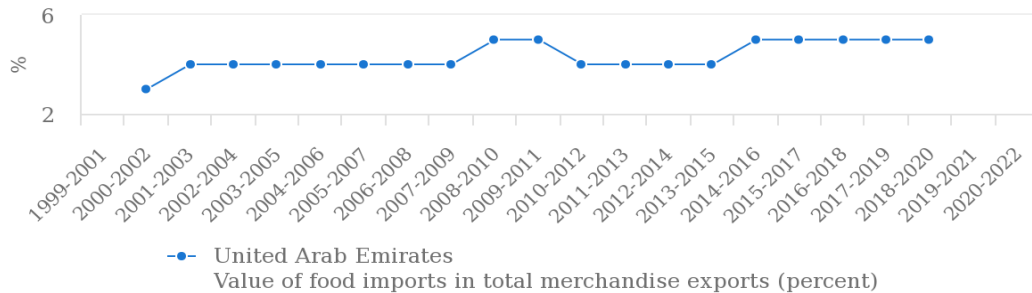


Figure 7. UAE Value of food imports in total merchandise exports (%) (3-year average 2000-2020)

Source: FAOSTAT, 2023.

Figure 7 UAE: Value of food imports in total merchandise exports % (3-year average 2000-2020) shows how the value of foods imported is increasing compared to the exports – even though UAE’s economy is based on the oil sector (oil exports). The percentage level is moving from 3% in 2000 to 4% in 2009 and reaching 5% level in 2020 again.

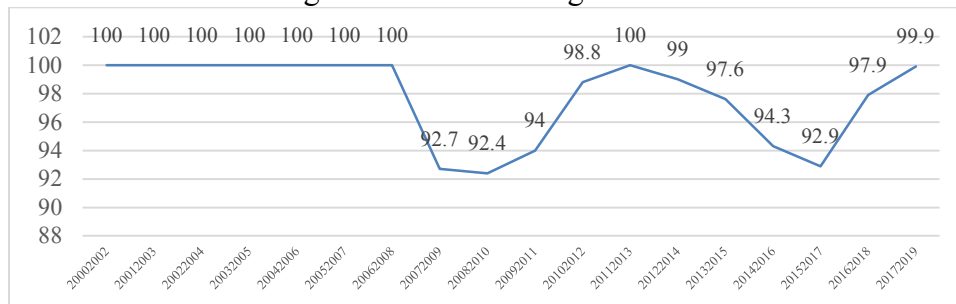


Figure 8. UAE Cereal import dependency ratio (%) (3-year average)

Source: FAOSTAT, 2023.

Figure 8 UAE Cereal import dependency ratio shows that the UAE is totally dependent on cereal imports for ensuring domestic consumption, the level of this indicator being almost 100%. This low level of self-sufficiency for cereals makes the country vulnerable in front of unstable international market and price volatility.

Conclusion

The United Arab Emirates achieved high levels of food security, since the value of the average dietary energy supply adequacy, 116%, is above 100%. This level shows that the dietary energy supply exceeds the average dietary energy requirement of individuals, so they consume larger food quantities than their needs.

Referring to the structure of the diet, the consumption of protein indicates that in UAE the average protein supply is 80 g/person/day, lower than WHO recommendations of 100 g per person/day. This could be explained by the fact that food consumption patterns in UAE is more vegetable oriented. This assumption is sustained moreover by the average supply of protein of animal origin, its value in UAE reaching a low level of 35 g/person/day.

The value of adult obesity indicates alarming level in UAE, 30%, showing the poor nutrition in this country.

Behind the food security situations stands not only water and agricultural resources scarcity, but also the socio-economic and political context, described as being marked by oscillating trends of inflation, unemployment, and GDP per capita.

The research has its limitations, since it reveals only the situation of food security and does not reveal the situation of nutrition security which completes the food security overview, as demonstrated in literature. Research focuses primarily on food security, which refers to the availability, accessibility, and affordability of food. Nutritional security, on the other hand, goes beyond basic food availability and looks at the quality and nutritional value of the food consumed. It considers factors such as dietary diversity, micronutrient content and overall nutritional well-being.

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