

Does the agricultural sector promote food security in Algeria? An empirical investigation using a non-parametric approach of bootstrap quantile regression

Yacef Hassiba¹ / High School for Statistics and Applied Economics , Kolea , Algeria

1

Mohammed Ayoub Ledhem / AIDAL laboratory, High School for Statistics and Applied Economics , Kolea , Algeria, ledhem.edu@gmail.com

Received: 30/09/2024

Accepted: 26/11/2024

Published : 10/12/2024

Abstract :

This study aims to empirically explore the impact of the agricultural sector on food security in Algeria over the period 1992-2021. Using a non-parametric approach, it employs quantile regression combined with the bootstrap resampling technique. The research focuses on key agricultural indicators, including value-added agriculture (AGR), agricultural land area (LAND), and employment in the agriculture sector (EMAG) as the primary explanatory variables. The Food Production Index (FPI) is used to measure food security. To ensure a robust analysis, macroeconomic variables such as gross domestic product (GDP) and trade openness (TRA) are included as control factors, given their potential influence on food security in Algeria. The findings reveal that the agricultural sector significantly contributes to food security, primarily through increases in value-added agriculture and land dedicated to farming. These results offer valuable insights for policymakers and the government, supporting the development of sustainable food security strategies in Algeria.

Key words: Food security, agricultural sector, Food Production Index, Non-Parametric approach, Bootstrap quantile regression.

Jel Classification Codes: O13 ; B23

ملخص :

يهدف هذا البحث إلى دراسة تأثير القطاع الزراعي على الأمن الغذائي في الجزائر خلال الفترة 1992-2021. إذ يطبق طريقة لا معلمية باستخدام الانحدار الكمي مع تقنية المعاينة بالوتستراب ، وذلك من خلال اعتماد كل من الزراعة ذات القيمة المضافة (AGR)، ومساحة الأرض المخصصة للزراعة (LAND)، والتوظيف في قطاع الزراعة (EMAG) كعوامل تفسيرية رئيسية. حيث يعتبر مؤشر الإنتاج الغذائي (FPI) المحدد الرئيسي للأمن الغذائي في الجزائر. للتحكم في الدراسة القياسية، تم استخدام عوامل الاقتصاد الكلي الأخرى مثل الناتج المحلي الإجمالي والانفتاح التجاري بسبب التأثير المحتمل على الأمن الغذائي في الجزائر. تظهر النتائج أن القطاع الزراعي هو معزز حقيقي للأمن الغذائي في الجزائر من خلال عامل القيمة المضافة الزراعية (AGR)، ومساحة الأراضي المخصصة للزراعة (LAND). إن نتائج هذا البحث توفر الدعم العلمي لاستراتيجيات الأمن الغذائي المستدام للحكومة ووضع السياسات في الجزائر.

الكلمات المفتاحية : الأمن الغذائي، القطاع الزراعي، مؤشر الإنتاج الغذائي، النهج غير المعلمي، الانحدار الكمي

Bootstrap

تصنيف JEL : O13 ، B23

¹. Corresponding author: YACEF hassiba , e-mail address: ecoalgensea@hotmail.fr

1. INTRODUCTION

One of the primary and most effective economic levers to boost the economy is the agriculture sector, which also accomplishes self-sufficiency and ensures food security—two issues that have become burdensome for nations, particularly developing ones—while also meeting the population's basic nutritional needs by providing a variety of food options. A sense of food security was highly valued by researchers and international organizations, particularly after the 1974 World Food Conference, which raised alarms after the world's grain stocks fell below sufficient levels for one month. This led to the creation of the World Food Council, an organization tasked with monitoring the state of the food market, food production, and meeting the developing countries' basic food demands. After the FAO report was released, which focused on the worsening of malnutrition in the developing world, international agencies and organizations as well as researchers turned their attention to discovering a solution (MANSOUR, 2016).

Achieving food security is a great and increasing challenge for many countries, especially in Africa, since the UN reports say that the number of hungry people will continue to rise because of long-lasting conflicts in some African regions, along with climate change and fast-growing number of populations and economic slowdown situation (YAHIAOUI & YAHIAOUI, 2023).

Achieving food security is a significant and growing challenge for many nations, particularly in Africa, where reports from the UN indicate that the number of hungry people will continue to rise due to protracted conflicts in some African areas, as well as climate change, rapidly expanding populations, and an environment of economic slowdown (YAHIAOUI & YAHIAOUI, 2023).

The significance of food security and supplies has been highlighted by the Covid (Neveu, 2020). The health crisis is a chance to reconsider concerns about food sovereignty and security (Pouch, 2020). The conflict in Ukraine and its effects, including food supply availability and accessibility, have brought attention to the critical need for food security (Kinda, Kere, & Yogo, 2022). The world witnessed the COVID-19 pandemic and Russia's war on Ukraine, both of which played a role to the global decline in food security levels, at the time of the expected evaluation of the United Nations Development Program, which was adopted by United Nations members in 2015 with the goal of ending poverty, protecting the environment, and securing peace and prosperity for all populations by 2030 (SAADANE, 2023).

Problematic of the study: to address this topic, the study puts forward the following question:

Does the agricultural sector promote food security in Algeria?

Hypotheses of the study:

H1: The agricultural sector is affecting positively food security in Algeria.

H2: It is possible to achieve food security provided that the resources of the agriculture sector are exploited most perfectly.

Aims of the study: throughout this study, we aim to:

- Bring out the most important Algerian capabilities in the agriculture sector
- Know the impact of the agriculture sector on food security in Algeria

2. LITERATURE REVIEW

2-1- Previous studies

Study by Kamel Eddine BEN AISSA (2019), titled “Food Security and the Evolution of the Food Gap in Algeria,” explores the state of food security in Algeria, focusing on various potential risks that render the country vulnerable. The research investigates trends in food production and examines the development of the food gap, along with suggested strategies to enhance food security in the nation. The study concludes that Algeria possesses significant natural resources, with 42.4 million hectares of arable land, representing 18% of the total land area, though only 28% of this arable land is currently being utilized. Additionally, Algeria is home to one of the largest groundwater reserves globally, located in the vast Sahara desert. According to the research, Algerian agriculture predominantly depends on rainfall, which poses a challenge, as the country lies in a drought-prone region, leading to inconsistent agricultural yields. This inconsistency is exacerbated by the absence of a well-developed water management strategy, despite the availability of substantial groundwater resources (BEN AISSA, 2019).

In the study by GHARDI Mohamed (2012), “Algerian Agriculture Sector and the Problem of Support and Investment under Joining World Trade Organization,” the research concludes that agricultural development cannot occur without a comprehensive national policy. This policy must focus on increasing agricultural investment to fully utilize available resources and improve both productivity and output. It also calls for a pricing strategy aimed at securing optimal prices for agricultural goods, a marketing strategy to gain a competitive edge, and a commercial strategy to facilitate the sale of agricultural products and ensure the availability of production tools. The study emphasizes Algeria’s wealth of natural resources, such as land and water, as well as human resources, which are currently underutilized. It highlights the potential to expand agricultural production either horizontally or vertically by incorporating modern technology into land exploitation practices (GHARDI, 2012).

2-2– Agricultural Sector

The agricultural sector is critical to the economic growth and development of countries, forming a cornerstone of economic and social advancement. Since the improvement of agriculture directly supports economic growth, any downturn in this sector negatively affects the economy as a whole. Consequently, agricultural development is a top priority in the economic policies of many nations due to its role in providing essential food and raw materials while employing a large portion of the workforce.

Algeria holds substantial agricultural potential, given its strategic position as Africa's gateway and its proximity to European markets. The country benefits from vast areas of fertile land, abundant water resources, and human and financial capacities that position agriculture as a key driver of the national economy. Currently, agriculture is playing an increasingly important role in boosting exports, reducing reliance on petroleum products (KATEB & OUDDANE, 2020). Below is a summary of Algeria's agricultural potential:

2-2-1 Agricultural Land:

Algeria has an extensive agricultural area. Arable land has expanded gradually, reaching 6.2 million hectares in 1965, accounting for 18.54% of the total land area. This area grew further following the implementation of land reclamation laws through concessions, reaching 6.87 million hectares. With additional concessions to private owners, the arable land expanded to 7.40 million hectares, or 17.36% of the total area (TSABET & GUELLIL, 2021).

2-2-2 Water Resources:

Algeria's natural water resources are derived from several sources, including rainwater, groundwater, and surface water.

- **Rainwater:** Algeria spans a vast area of 2,381,741 km², of which more than 85% is desert with minimal rainfall. The average annual rainfall is approximately 12.4 billion cubic meters, mostly concentrated in the northern Tell region, which receives about 90% of the country's total precipitation. In contrast, the High Plateaus region only receives about 10% of this precipitation (ZERARAKA & DJAIREN, 2021).
- **Groundwater:** The exploitable groundwater supply is estimated at 7 billion cubic meters, of which 1.5 billion cubic meters are located in the northern region, where over 90% of it is currently being utilized. In the southern region, about 5 billion cubic meters of groundwater are available, but only 1.7 billion cubic meters are exploited. The south, despite lacking surface water, holds substantial groundwater reserves accumulated over thousands of years. These reserves are generally found at depths of up to 2,000 meters, except in the Adrar region, where groundwater is located between 200 and 300 meters deep (MEGHERBI, 2016).

- **Surface Water:** Algeria's surface water resources are estimated at 22.50 billion cubic meters, but only 12.4 billion cubic meters can be exploited. The fluctuating nature of running water, fed by seasonal rainfall, causes these waters to fill in winter and dry up in summer. Algeria's rivers are categorized into three groups (SERIR, 2021):

- **Northern Rivers:** These originate from the Tell Atlas and flow into the Mediterranean, including the Chlef, Soummam, Sig, and Habra rivers.

- **Interior Rivers:** These arise from the Hoggar and Atlas mountain ranges and flow into basins, with the K'Sab and Mizab rivers being the most notable.

- **Saharan Rivers:** These rivers dry quickly, with the most significant being the Abiadh, Saoura, and Agargar rivers.

2-2-3 Human Resources:

Algeria possesses significant human resources, but they remain underutilized in the agricultural sector. Many farmers rely on traditional methods and are hesitant to employ agricultural engineers, viewing their involvement as an unnecessary expense. As the population continues to grow and urbanize, the agricultural sector will face increasing challenges in meeting the local demand for food and agricultural products (GHEDAMSI, 2021).

2-3- The Concept of Food Security

The term "food security" is complex (BOUBAKIR, 2023). It originated in response to global crises, particularly the food shortages and famines that plagued the world in the 1970s (CHALLAL & MESLOUB, 2022). Since then, the definition of food security has evolved multiple times (Dufy & Barsukova, 2017). Below are the key definitions of food security:

- **FAO Definition:** The United Nations Food and Agriculture Organization (FAO) defines food security as the condition in which all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life. Food insecurity arises from a combination of factors, including the economic, social, and political environment, along with the country's capacity to produce and market food (BOULASSEL, 2017).

- **World Bank Definition:** The World Bank defines food security as a state in which "all people, at all times, have access to enough food for an active, healthy life" (EDERRADJI, 2016).

According to the World Health Organization (WHO), food security is defined across all conditions and essential standards during the stages of food production, processing, storage, distribution, and preparation, to ensure that the food is safe,

certified, nutritious, and suitable for consumption. Food safety encompasses all stages, from agricultural production to final consumption (ZENAGUI, 2018).

The Arab Organization for Agricultural Development (AOAD) describes food security as ensuring the availability of food in adequate quantity and quality to support health and activity continuously for every individual within a population. This provision is primarily based on local production, with an emphasis on each nation leveraging its comparative advantage in producing certain goods, ensuring that food is accessible to all individuals at prices that align with their income and financial capacity.

Islamic scholars define food security as ensuring a consistent and appropriate supply of halal food that meets the needs of society. This standard is shaped by societal norms, and the food standard may rise to luxury levels, depending on these social benchmarks (KHEZAR, 2022).

The United States Agency for International Development (USAID) defines food security as a condition where all individuals, at all times, have both physical and economic access to sufficient food to meet their dietary needs. Achieving food security requires ensuring the availability of food, either through self-production, market access, or other sources, and that food must be used appropriately to meet individuals' nutritional needs (HEMICI & Khanfar, 2023).

At the World Food Summit (1996), food security was defined as being achieved at the individual, family, national, regional, and global levels when all people, at all times, can access adequate, safe, and nutritious food that meets their dietary needs and preferences for a healthy, active life (BENCHEHIDA, 2023).

According to experts from the European Commission (EC), food security involves eliminating all forms of hunger and malnutrition. Achieving this goal relies on making enough nutritious food available for the entire population and using those resources in a way that ensures the highest possible outcomes (MOHAMEDI & HAFSAOUI, 2023).

Food security, according to another definition, refers to the ability of failing states, or regions within failing states, to maintain desired consumption levels throughout the year. In this context, access to food is just as critical as its availability (HENI, 2017). This reflects how crucial it is that individuals have both the means and opportunity to obtain food (Tapsoba, Motel, & Combes, 2023).

Algerian law also offers a perspective on food security. Article 03 of Law 08-16, enacted on the 1st of Chaabane 1429 (corresponding to 2008), defines food security as ensuring that every person has access to adequate, healthy food that supports an active life (ALHABITRI, 2016). From these various definitions, we can infer that food security entails guaranteeing consistent access to necessary halal food through local

production while also providing luxury goods either domestically or via imports (KHEZAR, 2022).

From these different perspectives on food security, we can outline several key levels:

- The subsistence level refers to the ability of a country to provide the minimum necessary food to sustain life. This level ensures that every individual in society receives the minimum recommended caloric intake, based on international standards (2500 kcal for men and 2000 kcal for women, as per FAO recommendations) (HABOUL, 2020). This can be likened to the poverty line, which represents the minimum level of essential living expenses.
- The intermediate level, which lies between subsistence and sufficiency, is characterized by diminishing malnutrition as food availability improves. This level focuses on addressing deficiencies in essential nutrients required for proper physical development, which may result in malnutrition despite sufficient food availability. The remedy for this is ensuring that the biological nutritional needs of all individuals are met. The malnutrition crisis remains a major global issue, with FAO statistics indicating that 780 million people globally suffer from malnutrition annually, with the problem particularly acute in developing nations (DEBAR, 2019).
- The sufficiency level reflects a country's ability to raise food availability to a level where individuals can maintain optimal productivity. At this level, the goal is to ensure that each person has enough calories to work effectively. This level also considers both food supply—through production, storage, or trade—and demand, such as how individuals obtain food through self-production, market access, or food transfers. Food security in the Arab world remains modest, necessitating collective efforts to strengthen its components (BEZAZI, 2022).

2-3-2 Dimensions of Food Security:

Food security has multiple dimensions:

- **Economic Dimension:** Many developing countries face economic burdens due to their reliance on food imports, which result from an inability to meet domestic needs through local production. These imports place additional strain on the balance of payments, often leading to persistent deficits. Furthermore, importing goods can cause price inflation, which, in turn, forces governments to subsidize food prices in the domestic market (HAFIANI, 2023).
- **Social Dimension:** The social consequences of food insecurity are significant, if not more impactful, than the economic ones. When individuals cannot access sufficient or high-quality food, they face severe health challenges, such as diseases and malnutrition, which ultimately hinder their productivity. This places an additional burden on

governments to provide healthcare services to address the adverse effects of malnutrition (BEN HAFADH, 2023).

- **Political Dimension:** Food insecurity is no longer confined to being a mere agricultural or economic problem. It has evolved into a political and strategic issue, tied closely to national and regional stability. Ensuring political stability by preventing civil unrest requires governments to secure food supplies for their populations. On a global scale, countries that export food have become influential in international relations (BOUABDELLI & GHERBI, 2023). Countries dependent on food aid are more vulnerable to political pressures, as this assistance may compromise their independence and restrict their ability to make sovereign decisions. Historically, food has been used as a tool to coerce nations into compliance (ZIADI, 2023).

- **Environmental Dimension:** Research shows a strong link between food insecurity and environmental degradation. Individuals suffering from food insecurity often engage in environmentally harmful practices, such as over-exploitation of agricultural lands, forests, and pastures. This further depletes the already fragile natural resources, creating a vicious cycle of food insecurity and environmental degradation (BAALI, 2020).

3. RESEARCH METHODOLOGY

2.1. Sample and Data Collection

This research draws on data from the agriculture sector, sourced from the Food and Agriculture Organization of the United Nations (FAO) database (FAO, 2023). Additionally, food security data was obtained from the World Bank database (World Bank Group, 2023), while Algeria's macroeconomic indicators, such as gross domestic product (GDP) and trade openness, were extracted from the International Monetary Fund (IMF, 2023) database. Due to the availability of comprehensive data, the research spans an annual period from 1992 to 2021.

2.2. Variables

2.2.1. Food Security as a Dependent Variable (FPI)

The Food Production Index (FPI), which reflects the relative change in food production over time, is widely recognized as a critical agricultural metric (Campi, Dueñas, and Fagiolo, 2021; Widada, Masyhuri, and Mulyo, 2017). This indicator measures both crop and livestock outputs, offering a comprehensive view of food production trends within a specific geographic region. The FPI plays a key role in evaluating food security by providing a quantifiable assessment of a country's or region's capacity to produce a sustainable and sufficient food supply.

Moreover, the Food Production Index is closely linked to several dimensions of food security. These include food availability, which directly impacts the population's ability to meet its nutritional needs; economic access, particularly for vulnerable communities; the stability and resilience of food systems, which helps mitigate the risks of food shortages and price fluctuations; and the nutritional quality of the food supply, as the quantity of food produced indirectly affects its nutritional value (Allee, Lynd, and Vaze, 2021; Wu, Zhang, Wang, and Kong, 2016). Based on the works of Campi et al. (2021), Widada et al. (2017), Allee et al. (2021), Izraelov and Silber (2019), and Wu et al. (2016), this research employs the Food Production Index (FPI) as a proxy for food security.

2.2.2. Agricultural Sector Factors as Independent Variables

2.2.2.1. Agriculture Value-Added (AGR)

Agriculture value-added serves as a vital measure of the agricultural sector's contribution to economic growth and food security (Greenville et al., 2019; Nugroho, Bhagat, Magda, and Lakner, 2021). Numerous studies (Esnard, Lyne, and Old, 2017; Kołodziejczak, 2020; Nugroho et al., 2022) underscore the significance of agriculture value-added, as it represents the total economic value generated by the agricultural sector. This factor enhances economic resilience by diversifying farmers' income streams and improving access to stable markets (Onoja, Achike, and Ajibade, 2017). Furthermore, a higher value-added agriculture fosters resistance to external shocks, ensuring consistent food production. Comprehending the complexities of agriculture value-added is essential for developing effective policies that boost economic stability and positively influence food security (Esnard et al., 2017; Gurbuz, Nesirov, and Ozkan, 2021; Kołodziejczak, 2020; Nugroho et al., 2022). Consequently, this research uses agriculture value-added (in USD at current prices) as the primary indicator for Algeria's agricultural sector.

2.2.2.2. Land Area for Agriculture (LAND)

An increase in agricultural land area is strongly correlated with higher food production and greater diversity (Levers, Schneider, Prishchepov, Estel, and Kuemmerle, 2018; Pender and Gebremedhin, 2008; Prishchepov et al., 2013). Expanding land used for agriculture substantially boosts economic output, promoting market stability and making food more affordable (Ma et al., 2021; Pender and Gebremedhin, 2008). Sustainable land management practices, as noted by Coca et al. (2023), play a crucial role in optimizing land productivity while reducing the risk of degradation. These environmental considerations highlight the need for balancing land expansion with conservation efforts to create sustainable food production systems (Ma et al., 2021; Rondhi et al., 2018). Furthermore, agricultural land is essential for building climate resilience, as strategic land use can enhance food system stability (Rondhi et al., 2018; Viana et al., 2022). For these reasons, this study uses the total agricultural land area (in hectares) as the second key variable for Algeria's agricultural sector.

2.2.2.3. Employment in Agriculture (EMAG)

The size of the agricultural workforce has a direct impact on food production, crop diversity, and food accessibility for vulnerable populations (Kołodziejczak, 2020; Foster and Rosenzweig, 2007; Gillespie and Mishra, 2011; Mireri, 2013; Mkwambisi, Fraser, and Dougill, 2011; Tocco et al., 2013). Agricultural employment supports sustainable farming practices, optimizes land productivity, and contributes to economic stability, all of which help alleviate food insecurity (Gillespie and Mishra, 2011). Investments in agricultural employment are critical to building a resilient global food system (Mireri, 2013; Mkwambisi et al., 2011). Thus, this research adopts the ratio of employment in agriculture to total employment (EMAG) as the third variable representing the agricultural sector in Algeria.

2.2.3. Macroeconomic Factors

2.2.3.1. Gross Domestic Product (GDP)

Several studies (Gandhi and Zhou, 2014; Mozumdar, 2012; Naylor and Falcon, 2010) demonstrate a complex relationship between GDP and food security. While increased GDP typically enhances food security by providing more resources, research by Jenkins and Scanlan (2001), Kavallari et al. (2014), and Manap and Ismail (2019) highlights how unequal wealth distribution can exacerbate food insecurity among marginalized groups. This underscores the importance of inclusive economic policies. Additionally, an environmental focus reveals the potential long-term negative effects of GDP growth on food security, suggesting the need for a balanced approach that considers both the benefits and drawbacks of GDP growth when addressing food security issues. Consequently, this study includes GDP as a control variable that may influence food security in Algeria.

2.2.3.2. Trade Openness (TRA)

Research by Assoumou-Ella and Eba-Nguema (2019) and Biniiaz and Mohamadi (2018) consistently indicates that trade openness has a positive impact on food security. Open trade policies help diversify food sources, reducing the impact of supply shortages and price volatility (Assoumou-Ella and Eba-Nguema, 2019; Biniiaz and Mohamadi, 2018). Additionally, studies by Fathelrahman, Davies, and Muhammad (2021) and Z. Sun and Zhang (2021) emphasize the role of trade in redistributing food globally, ensuring broader access to nutritional options. Trade openness also encourages agricultural productivity by giving farmers access to international markets and advanced technologies, thus contributing to a more secure and sustainable food system (Biniiaz and Mohamadi, 2018; Dithmer and Abdulai, 2017; Fathelrahman et al., 2021; Holden and Yohannes, 2002; Z. Sun and Zhang, 2021). Therefore, this research incorporates trade openness (TRA) as a control variable influencing food security in Algeria.

2.3. General Model

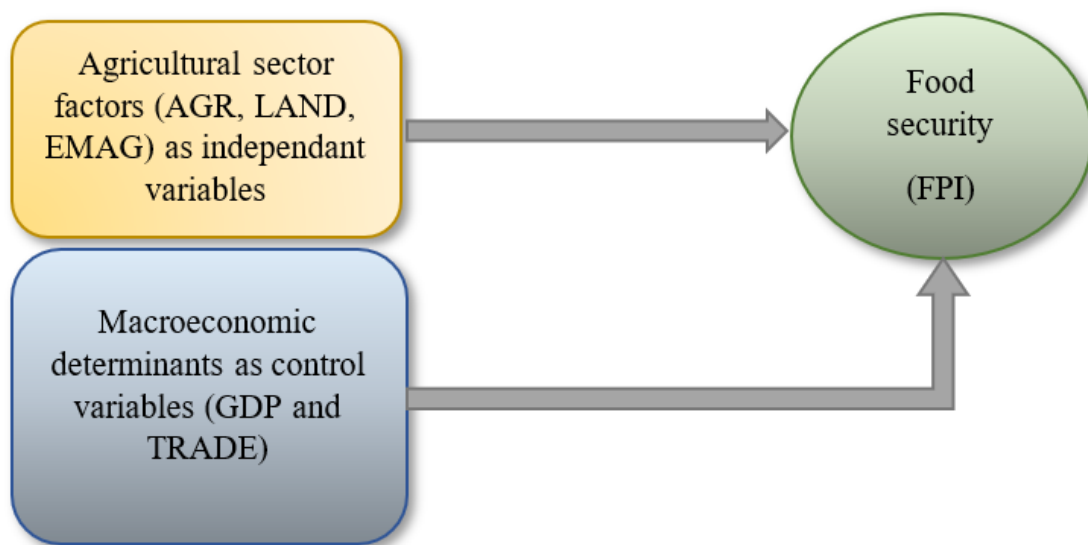
To investigate the impact of the agricultural sector on food security in Algeria from 1992 to 2021, the general model is as follows:

$$FPI = AGR + LAND + EMAG + GDP + TRA \quad (1)$$

Where:

- **Dependent variable:** FPI (Food Production Index)
- **Independent variables:** AGR (Agriculture Value-Added), LAND (Land Area), EMAG (Employment in Agriculture)
- **Control variables:** GDP [Gross Domestic Product] and TRA (Trade Openness)

Figure 1: Summary of the empirical investigation between the agriculture sector and food security in Algeria



Source: Authors' own

2.3. Econometric Methodology

Ullah (1989) and Jureckova et al. (2012) argue that non-parametric methods offer more precision and reliability in empirical analysis compared to parametric approaches. Parametric models can sometimes produce misleading results if the errors are assumed to follow particular distributions, which may not hold in practice. **Quantile regression**, identified as a robust non-parametric method by Machado et al. (2019), is considered highly reliable. In line with previous studies that have utilized non-parametric quantile regression in agriculture and food security research, Yildirim, Demirtaş, and Özgür (2022) explored the effects of climate change on food security and agricultural output using this approach. Similarly, Cheema, Imran, and Ul-Haq (2022) applied quantile regression to assess the impact of agricultural land ownership on food insecurity in Pakistan. Additionally, Sun et al. (2023) examined the asymmetric effects

of oil price fluctuations on international food prices using this non-parametric method. In the same vein, Barnwal and Kotani (2013) investigated how climatic factors affect crop yields in India, employing quantile regression as their chosen method. Given its strengths, this study adopts quantile regression to assess the role of Algeria's agriculture sector in promoting food security.

In this research, quantile regression combined with the bootstrap technique was applied over 1000 replications, ensuring robust estimations while addressing issues of heteroskedasticity (Machado and Silva, 2013; Machado et al., 2019). The quantile regression method, introduced by Koenker and Bassett (1978), is widely recognized as a reliable approach for situations where heteroskedasticity may be present. This method provides more accurate estimates when variables exhibit varying characteristics across the conditional distribution of the independent variable (Mello and Perrelli, 2003; Machado et al., 2019).

Following Koenker and Bassett's (1978) methodology, the conditional distribution of the τ -th quantile for the dependent variable Y_i , given X_i , is expressed as follows:

$$Q_{\tau}(Y_i|X_i) = X_i' \beta_{\tau} \quad (2)$$

The parameter estimates for the τ -th quantile are calculated through:

$$\hat{\beta}_{\tau} = \arg \min \sum_{i=1}^N \rho_{\tau}(Y_i - X_i' \beta) \quad (3)$$

Where the quantile loss function $\rho_{\tau}(\cdot)$ is defined as:

$$\begin{aligned} \rho_{\tau}(u) &= (\tau - 1)u \text{ for } u < 0 \\ \rho_{\tau}(u) &= \tau u \text{ for } u \geq 0 \end{aligned} \quad (4)$$

Equation 3 demonstrates that quantile regression allows for heterogeneity across various values within the interval (0,1) for τ , providing a comprehensive view of the relationship between the exogenous and endogenous variables (Koenker and Machado, 1999; Jiang et al., 2019; Machado et al., 2019). This technique is highly robust to outliers, as it can adjust the weight over the loss function, distinguishing it from the OLS method, which is more sensitive to standard errors (Koenker and Machado, 1999; Jiang et al., 2019).

Hahn (1995), Feng et al. (2011), and Nikitina et al. (2019) suggest that bootstrapping is an effective method for addressing issues in small sample sizes in empirical models, especially when using quantile regression. Since this study uses a small dataset of only 30 observations, the bootstrap resampling technique, as developed by Kocherginsky et al. (2005) and He and Kocherginsky (2007), was employed. This

method is well-suited for quantile regression when dealing with small samples, and is robust against heteroskedasticity (Kocherginsky and He, 2007).

The bootstrap resampling process works by resampling residuals $u_i(\tau)$ and independent variables X_i separately. Letting u^* represent a resampled residual vector and X^* an independent resampled matrix ($m \times p$ ($m \neq n$ where n is the sample size)), the dependent variable is expressed as:

$$Y^* = X^* \hat{\beta}(\tau) + u^* \quad (5)$$

Using X^* and Y^* , the bootstrap estimate of $\beta(\tau)$ is calculated by repeating the process for M (chain length) bootstrap iterations. The estimated form for the asymptotic covariance matrix $V(\hat{\beta})$ is given as:

$$V(\hat{\beta}) = n \left(\frac{m}{n} \right) \frac{1}{B} \sum_{j=1}^B (B_j(\tau) - \overline{B(\tau)})(B_j(\tau) - \overline{B(\tau)})' \quad (6)$$

where $\overline{B(\tau)}$ is the mean of the bootstrap elements, and the bootstrap covariance matrix $V(\hat{\beta})$ represents an estimate of the sample variance of the bootstrap estimates $\hat{\beta}(\tau)$ (Kocherginsky and He, 2007).

The estimated model using the bootstrap quantile regression in this study is:

$$FPI_t = \alpha_\tau + \alpha_{\tau 1} AGR_t + \alpha_{\tau 2} LAND_t + \alpha_{\tau 3} EMAG_t + \alpha_{\tau 4} GDP_t + \alpha_{\tau 5} TRA_t, \quad \tau \in (0,1) \quad (7)$$

Where α_τ is the constant term. While $\alpha_{\tau 1}$, $\alpha_{\tau 2}$, $\alpha_{\tau 3}$, $\alpha_{\tau 4}$, and $\alpha_{\tau 5}$ represent the coefficients. Here, t is the time period (quarter), FPI is the dependent variable, and AGR, LAND, and EMAG are independent variables. GDP and TRA are used as control variables. This study applies quantile regression with the bootstrap resampling method over 1000 replications to assess the influence of AGR, LAND, and EMAG on FPI.

Results and Discussion

Koenker and Bassett's (1978) quantile regression extends the linear least squares regression by estimating the conditional mean of the response variable over a range of values of the independent variables. To validate the model's fitness for the autoregressive (AR) process, it is necessary to test the stationarity of the variables.

The Augmented Dickey-Fuller (ADF) test was employed to check for stationarity, ensuring the avoidance of spurious regression (Granger et al., 1974; Leong and Huang, 2010), as detailed in Table 1.

Table 1: Stationarity tests using the ADF test

Variables	Stationarity levels	P-value		
		No trend, no intercept	Including intercept	Including trend and intercept
FPI	Level	0.9922	0.9316	0.3656
	1 st difference	0.0002**	0.0005**	0.0038**
AGR	Level	0.9811	0.9437	0.5616
	1 st difference	0.0008**	0.0044**	0.0234**
LAND	Level	0.0000	0.0000	0.0000
	1 st difference	0.0000**	0.0000**	0.0000**
EMAG	Level	0.0581	0.7697	0.2350
	1 st difference	0.0237*	0.0620	0.196
GDP	Level	0.8925	0.7837	0.8392
	1 st difference	0.0000**	0.0004**	0.0023**
TRA	Level	0.6856	0.3260	0.9677
	1 st difference	0.0051**	0.0600	0.0007**

Note: ** significant at the 0.01 level; * significant at the 0.05 level

Source: ADF test performed by the authors based on the Akaike Info Criterion (AIC) for choosing the optimal lag length

According to the ADF test results shown in **Table 2**, the AR(1) coefficients for FPI, AGR, LAND, EMAG, GDP, and TRA are all statistically significant at the 1% level. This suggests that these variables do not possess a unit root when evaluated in their first difference. As a result, the findings confirm that all variables included in this study are stationary and adhere to a linear AR(1) process. This further indicates that there is no issue of spurious regression (Granger et al., 1974; Leong and Huang, 2010).

To obtain robust estimated results, this paper performed the quantile regression with the bootstrap (Table 2).

Table 2: Bootstrap quantile regression outputs

<i>Number of observations = 30</i>		<i>Estimated equation tau (τ) = 0.5</i>		
<i>Pseudo R-squared = 0.894443</i>		<i>Adjusted R-squared = 0.872452</i>		
<i>S.E. of regression = 4.118891</i>		<i>Sparsity = 11.59912</i>		
<i>Quasi-LR statistic = 218.2637</i>		<i>Prob (Quasi-LR stat) = 0.000</i>		
Variables	Coefficient	Stand. Err.	t-Stat	Prob
AGR	4.59E-09	7.89E-10	5.813064	0.0000**
LAND	122.1280	32.17847	3.795331	0.0009**
EMAG	0.667166	0.866017	0.770384	0.4486
GDP	-1.27E-10	1.31E-10	-0.968451	0.3425

TRA	0.567358	0.159797	3.550489	0.0016**
C	-29087726	7664088.	-3.795328	0.0009**

Notes: Bootstrap quantile regression with 1000 replications; Number of observations = 25; ** significant at the 0.01 level.

Source: Quantile regression outputs computed by the authors

Table 2 reveals that the agricultural sector's added value (AGR) has a significant positive impact on food security in Algeria, with a 1% significance level (p-value: 0.000 < 0.01). This result supports the hypothesis (H1), confirming that the agricultural sector positively contributes to food security in the country. Similarly, the land area used for agriculture (LAND) also demonstrates a positive effect on food security at a 1% significance level (p-value: 0.0009 < 0.01), further validating the hypothesis that agriculture has a beneficial influence on food security in Algeria over the 1992-2021 period. Although employment in agriculture (EMAG) shows a positive relationship with food security, it is not statistically significant at the 5% level (p-value: 0.4486 > 0.05), indicating that Algeria's agricultural sector may require more employment to achieve a significant impact on food security.

Regarding GDP, there is no significant effect on food security, as evidenced by a high p-value (0.3425 > 0.05), suggesting that economic growth in Algeria does not drive improvements in food security. Additionally, Table 2 demonstrates that trade openness (TRA) has a positive influence on food security at a 5% significance level (p-value: 0.0016 < 0.05), suggesting that Algeria has effectively leveraged trade openness to enhance food security. Furthermore, the constant term (C) is negatively significant at the 1% level (p-value: 0.0009 < 0.01), indicating that food security is adversely affected by external factors not included in the model, accounting for 10.56% of the variance. However, the model explains 89.44% of the variation in food security ($R^2 = 0.894443$) based on the independent variables.

In terms of the goodness-of-fit tests for quantile regression, as described by Koenker and Machado (1999), Table 2 shows an adjusted R-squared of 0.87245%. This implies that 83.61% of the variation in the conditional median of food security (FPI) is attributable to AGR, LAND, EMAG, GDP, and TRA. The Quasi-LR statistic of 218.2637, with a p-value of 0.000 (less than 0.05), confirms the stability of the estimated model.

To assess the estimates across different quantiles, Table 3 presents estimates for the 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 quantiles. The lower quantiles (0.10 to 0.30) represent the impact of agriculture sector factors (AGR, LAND, and EMAG) on lower levels of food security (FPI) in Algeria, while the middle quantiles (0.40 to 0.70) reflect the effect of these factors on moderate levels of food security. The upper quantiles (0.70 to 0.90) depict the influence of the agriculture sector on higher levels of food security in Algeria between 1992 and 2021.

Table 3: Bootstrap quantile process estimates

Variables	Quantile	Coefficient	Stand. Err.	t-Stat	Prob
AGR	0.1	4.48E-09	8.53E-10	5.243809	0.0000**
	0.2	5.18E-09	7.07E-10	7.321761	0.0000**
	0.3	6.65E-09	7.00E-10	9.496212	0.0000**
	0.4	5.94E-09	7.75E-10	7.660154	0.0000**
	0.5	4.59E-09	7.93E-10	5.783925	0.0000**
	0.6	5.52E-09	8.08E-10	6.830489	0.0000**
	0.7	4.15E-09	8.48E-10	4.890534	0.0001**
	0.8	4.24E-09	8.63E-10	4.916099	0.0001**
	0.9	4.84E-09	7.84E-10	6.167917	0.0000**
LAND	0.1	83.74901	31.67911	2.643667	0.0142*
	0.2	118.2067	28.87452	4.093806	0.0004**
	0.3	80.34719	34.04392	2.360104	0.0267*
	0.4	94.22960	36.89212	2.554193	0.0174*
	0.5	122.1280	32.34058	3.776307	0.0009*
	0.6	45.80021	32.47680	1.410244	0.1713
	0.7	117.3478	30.00689	3.910697	0.0007**
	0.8	135.5118	33.46694	4.049124	0.0005**
	0.9	130.1600	32.93235	3.952344	0.0006**
EMAG	0.1	-1.363381	0.697149	-1.955652	0.0622
	0.2	-0.672474	0.728280	-0.923373	0.3650
	0.3	0.744730	0.771020	0.965903	0.3437
	0.4	0.799736	0.812739	0.984001	0.3349
	0.5	0.667166	0.870380	0.766523	0.4508
	0.6	-0.360059	0.792139	-0.454540	0.6535
	0.7	0.050705	0.886094	0.057223	0.9548
	0.8	-1.023926	0.949361	-1.078542	0.2915
	0.9	-1.440366	0.783966	-1.837280	0.0786
GDP	0.1	-3.82E-10	1.32E-10	-2.888839	0.0081**
	0.2	-4.27E-10	1.25E-10	-3.412582	0.0023**
	0.3	-4.34E-10	1.25E-10	-3.459522	0.0020**
	0.4	-3.22E-10	1.43E-10	-2.253311	0.0337**
	0.5	-1.27E-10	1.32E-10	-0.963597	0.3449
	0.6	-3.71E-10	1.41E-10	-2.637301	0.0144*
	0.7	-1.48E-10	1.42E-10	-1.044825	0.3065
	0.8	-2.96E-10	1.57E-10	-1.886658	0.0714
	0.9	-4.39E-10	1.32E-10	-3.317732	0.0029*
TRA	0.1	0.371636	0.163253	2.276447	0.0320*
	0.2	0.542947	0.138719	3.913999	0.0007**
	0.3	0.617372	0.159702	3.865778	0.0007**

	0.4	0.574938	0.165539	3.473136	0.0020**
	0.5	0.567358	0.160602	3.532692	0.0017**
	0.6	0.513675	0.165766	3.098800	0.0049**
	0.7	0.506943	0.153877	3.294462	0.0031**
	0.8	0.566737	0.161493	3.509364	0.0018**
	0.9	0.648830	0.140397	4.621383	0.0001**
C	0.1	-19946796	7545147.	-2.643659	0.0142*
	0.2	-28153743	6877168.	-4.093799	0.0004**
	0.3	-19136638	8108388.	-2.360104	0.0267*
	0.4	-22443067	8786758.	-2.554192	0.0174*
	0.5	-29087726	7702699.	-3.776303	0.0009**
	0.6	-10908411	7735143.	-1.410240	0.1713
	0.7	-27949206	7146872.	-3.910691	0.0007**
	0.8	-32275362	7970971.	-4.049113	0.0005**
	0.9	-31000691	7843642.	-3.952334	0.0006**

Notes: Bootstrap quantile regression with 1000 replications; Number of observations = 30; * significant at the 0.05 level; ** significant at the 0.01 level.

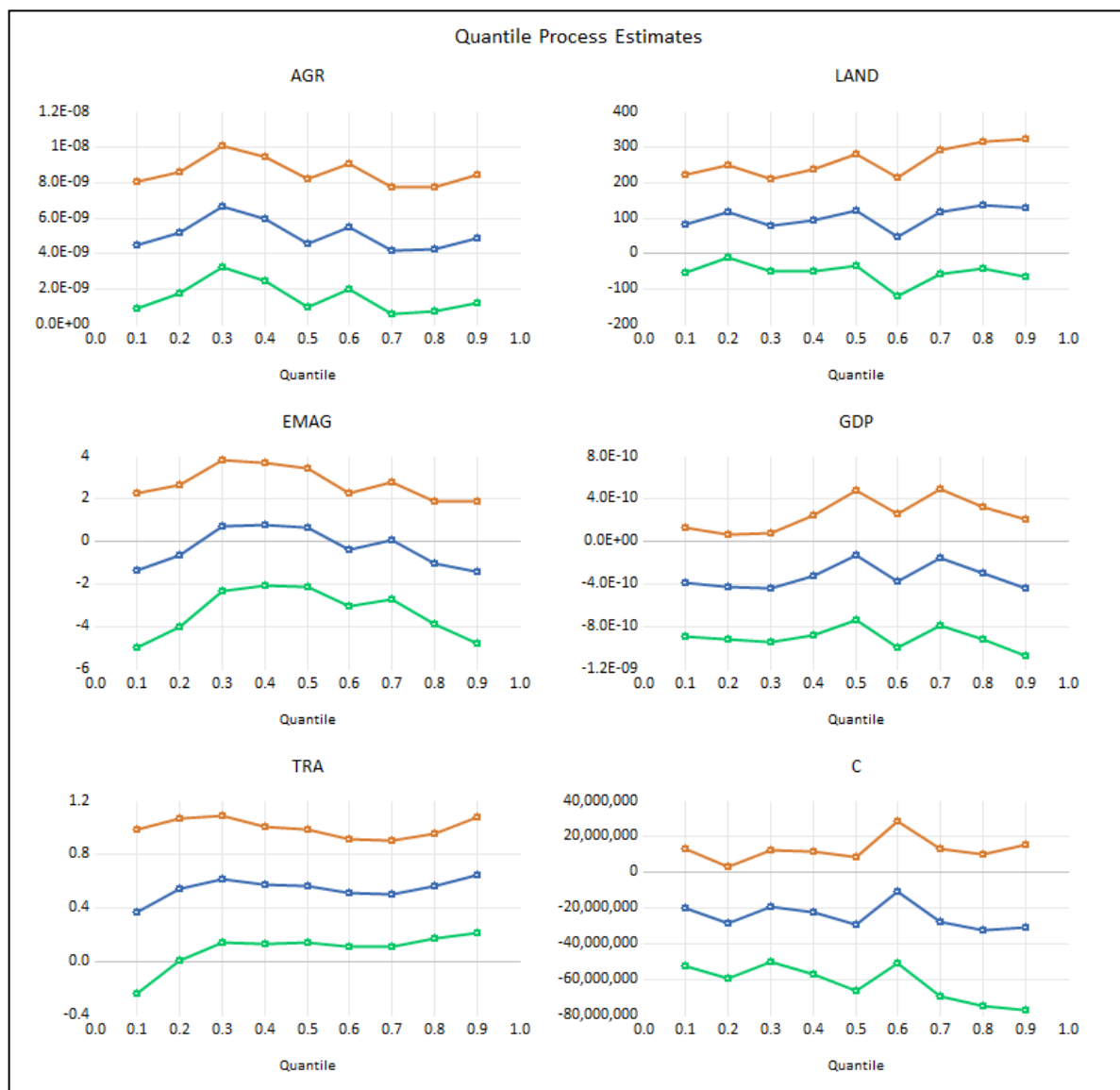
Source: Quantile regression outputs computed by the authors

Table 3 highlights that across the 10th quantile (0.1 quantiles) through to the 90th quantile (0.9 quantiles), including lower, medium, and upper quantiles, an increase in the agricultural value-added (AGR) significantly boosts Algeria's food security (see Figure 2). This confirms that the agricultural sector's contribution to food security in Algeria is substantial, thereby validating the hypothesis that the agricultural sector (AGR) plays a key role in enhancing food security in the country. Additionally, the expansion of agricultural land (LAND) similarly results in a marked increase in food security from the 10th to the 90th quantile, further affirming the hypothesis that the agricultural sector bolsters food security in Algeria. On the other hand, the growth in employment in agriculture (EMAG) does not yield a sufficient impact on improving food security across all quantiles. Ultimately, the hypothesis that the agricultural sector (AGR) improves food security in Algeria between 1992 and 2021 is supported by the contributions of agricultural value-added and expanded land area.

Regarding the control variables, Table 3 indicates that an increase in GDP does not significantly contribute to improvements in food security across any quantile (see Figure 2). This result can be attributed to unequal distribution of wealth from GDP growth, insufficient attention to the agricultural sector, and environmental degradation linked to rapid development, all of which hinder sustainable agriculture and adversely affect farmers' livelihoods, leading to food insecurity in developing countries (Jenkins and Scanlan, 2001; Kavallari et al., 2014; Manap and Ismail, 2019).

Furthermore, Table 3 demonstrates that trade openness (TRA) consistently enhances food security in Algeria across all quantiles during the study period (Figure 2). This outcome aligns with findings from Clapp (2014), Dithmer and Abdulai (2017), and Holden and Yohannes (2002), which indicate that trade openness positively affects food security by providing access to a wider range of affordable food, thus enhancing global food availability. Trade openness facilitates efficient resource allocation, enabling nations to capitalize on their comparative advantages and increase agricultural productivity, ultimately leading to higher overall food production. Additionally, participation in international markets allows trade to act as a safeguard against local food shortages, mitigating risk.

Figure 2: Bootstrap quantile process estimates graphs



Source: Authors' own

In reference to the diagnostic checks for the estimated model, as outlined by Koenker and Machado (1999), the quantile regression approach necessitates the application of specific tests: the Koenker and Bassett (1982) test for slope equality, and the Ramsey (1969) Reset test to assess model stability (see Table 4).

Table 4: Bootstrap quantile regression diagnostics

Ramsey Reset test of stability				
Null Hypothesis: The model has no misspecification				
Test summary		Value	D.F.	Prob
QLR L-statistic		3.412579	1	0.0647
Slope equality test				
Null Hypothesis: Slope Equality is not different				
Test summary		Chi ² Stat	Chi ² D.F.	Prob
Wald Test		26.23509	10	0.0034
Restriction details over quantiles				
Quantiles	Variable	Restricted Value	Std.Error	Prob
0.25, 0.5	AGR	1.48E-09	8.73E-10	0.0899
	LAND	4.064765	36.03094	0.9102
	EMAG	0.298924	0.942241	0.7511
	GDP	-2.18E-10	1.30E-10	0.0949
	TRA	0.017714	0.160418	0.9121
0.5, 0.75	AGR	4.27E-10	9.26E-10	0.6445
	LAND	-40.93722	32.45628	0.2072
	EMAG	0.569880	0.985808	0.5632
	GDP	2.04E-11	1.49E-10	0.8910
	TRA	0.047130	0.169663	0.7812

Source: Authors' own

Table 4 presents the Chi-square statistic for the slope equality test, with a value of 26.23509, which is statistically significant (p-value: $0.0034 < 0.05$). This indicates that slope equality is rejected at the 5% significance level, meaning that the slopes differ across quantiles and the conditional quantile is not consistent. Additionally, **Table 4** shows that the Ramsey (1969) stability test fails to reject the null hypothesis due to an insignificant p-value (p-value: $0.0647 > 0.05$). As a result, all coefficients across the powers are jointly insignificant in the quantile regression, confirming that the estimated model is both stable and resistant to issues of autocorrelation and heteroskedasticity.

This study confirms the robustness of the estimated results by conducting diagnostic tests, including the slope equality assessment of Koenker and Bassett (1982) and the Ramsey (1969) stability test, within the framework of bootstrap quantile regression.

Economic Analysis:

The positive relationship between agricultural value-added and food security is economically reasonable, as an increase in agricultural activity enhances the supply of food products, thus improving food availability. Since 2000, the agricultural sector's added value has shown considerable growth (Saidoun, Ait Hammou, & Chehat, 2022). The sector's growth during the implementation of the National Plan for Agricultural Development (2000-2008) is attributable to increased investments and expanded support across most agricultural branches (Ghardi, 2012). The National Plan for Agricultural Development, introduced as a mechanism to boost agriculture and provide financial support to farmers, resulted in successful agricultural projects across several Algerian provinces and spurred growth in specific agricultural crops (Ben Souilah, 2018). Additionally, the five-year plan (2009-2013), which focused on agricultural development and rural renewal, further contributed to this growth (Echaref Benatia, 2021).

5. Conclusion:

Algeria's agricultural sector plays a pivotal role in achieving food security, thanks to the country's vast resources, especially arable and reclaimable land. However, despite these assets, Algeria still faces food shortages and has yet to achieve self-sufficiency, leading to external dependence. This reliance extends beyond food supply, affecting the country's political and economic landscape. In light of climate change and its repercussions, food security has become one of the greatest challenges of this century, and the agricultural sector remains the key to addressing this issue.

Key findings from this study include: Through the application of the bootstrap quantile regression method, the research concludes that the agricultural sector has contributed to food security in Algeria between 1992 and 2021. The non-parametric analysis across various quantiles (0.1 to 0.9) demonstrates that increases in agricultural value-added and agricultural land area have continuously improved food security by enhancing the Food Production Index (FPI). Thus, this study answers the research question, confirming that Algeria's agricultural sector is indeed promoting food security.

From this, the direct relationship between the agricultural sector and food security in Algeria is evident, supporting the first hypothesis. Furthermore, the results show that increases in agricultural value-added and land area have bolstered food security, validating the second hypothesis.

- Focusing on food security leads to addressing agriculture, the primary food source. Agriculture is the lifeblood of food supply worldwide, and to enhance its output, policies and strategies must be implemented that encourage agricultural investment and the food-processing industry. Although the main goal is achieving food security, other important objectives can also be realized, including reducing unemployment, boosting purchasing power, fostering economic development, increasing GDP, and achieving economic prosperity. Agricultural investment is key for Algeria's future.

Some of the key recommendations include:

- Increasing agricultural investments by guiding and encouraging the private sector to invest in agriculture.
- Enhancing focus on agricultural research and providing necessary funding to support research centers in this field.
- Adopting advanced farming technologies to strengthen the agricultural sector and mitigate the effects of climate variability.
- Creating a favorable environment to attract foreign investments, ensuring they are directed toward food production sectors.
- Learning from successful international models of agricultural investment and applying these lessons to Algeria's context.

6. BIBLIOGRAPHY LIST:

6.1. Articles

Allee, A., Lynd, L. R., and Vaze, V. (2021). Cross-national analysis of food security drivers: Comparing results based on the Food Insecurity Experience Scale and Global Food Security Index. *Food Security*, 13(5), 1245–1261. <https://doi.org/10.1007/s12571-021-01156-w>

Assoumou-Ella, G., and Eba-Nguema, I. (2019). Trade Openness and Food Security in Africa: A Comparative Study of CEMAC and WAEMU Countries. In D. Seck (Ed.), *The External Sector of Africa's Economy* (pp. 119–135). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-97913-7_6

Barnwal, P., and Kotani, K. (2013). Climatic impacts across agricultural crop yield distributions: An application of quantile regression on rice crops in Andhra Pradesh, India. *Ecological Economics*, 87, 95–109. <https://doi.org/10.1016/j.ecolecon.2012.11.024>

BEN AISSA, K. (2019). Food security and the evolution of the food gap in Algeria. *Journal of finance, investment and sustainable development*, 04(02), pp 168-179.

BEN SOUILAH, A. (2018). National Plan for Agricultural Development, Strategic Tool to Promote Agriculture Sector in Algeria. *Annals of Guelma university for social and human sciences*(23 - Part One –), pp 185-205.

BENCHEHIDA, S. (2023). The role of agricultural investment in achieving food security in Algeria : an econometric study using the vector error correction model (VECM) during the period (1990 – 2021). *Al Basaer Journal of Economics, Commercial and Management Sciences Research*, 2(1), pp 97-115.

BEZAZI, S. (2022). The food security situation in the Arab world between reality and the need for reform. *Review of studies economic development*, 05(02), pp 70-84.

Biniaz, A., and Mohamadi, H. (2018). The Effect of Agriculture Trade Openness on Food Security in Iran (ARDL Approach). *Agricultural Economics Research*, 10(38), 81–104.

BOUABDELLI, Y., & GHERBI, R. (2023). Smart agriculture as a strategic option to achieve food security in Algeria. *Beam Journal of Economic Studies*, 07(01), pp 308-327.

BOUBAKIR, A. (2023). Algeria Between Achieving Sustainable Food Security or Food Sovereignty, Evaluation Study for the Period (1998-2018). *Journal of Economics and Human Development*, 14(1), pp 296-309.

Campi, M., Dueñas, M., and Fagiolo, G. (2021). Specialization in food production affects global food security and food systems sustainability. *World Development*, 141, 105411. HYPERLINK "<https://doi.org/10.1016/j.worlddev.2021.105411>"
<https://doi.org/10.1016/j.worlddev.2021.105411>

CHALLAL, O., & MESLOUB, S. (2022). Evolution of food security over time. *Maalim Revue of Media and Communication Studies*, 4(01), pp 184-196.

Chan, K.S. and Tong, H. (1986), "On estimating thresholds in autoregressive models", *Journal of Time Series Analysis*, Vol. 7 No. 3, pp. 179–190.

Cheema, A. R., Imran, K., and Ul-Haq, J. (2022). Estimating the Impacts of Agricultural Land and Livestock Ownerships on Insecurity of Food in Pakistan: Evidence from Quantile Regression Analysis. *Competitive Social Science Research Journal*, 3(1), 79–94.

Clapp, J. (2014). Trade Liberalization and Food Security: Examining the Linkages. <https://doi.org/10.13140/RG.2.1.4667.2408>

Coca, O., Creangă, D., Viziteu, Ștefan, Brumă, I. S., and Ștefan, G. (2023). Analysis of the Determinants of Agriculture Performance at the European Union Level. *Agriculture*, 13(3), 616. <https://doi.org/10.3390/agriculture13030616>

Dithmer, J., and Abdulai, A. (2017). Does trade openness contribute to food security? A dynamic panel analysis. *Food Policy*, 69, 218–230. <https://doi.org/10.1016/j.foodpol.2017.04.008>

Dufy, C., & Barsukova, S. (2017). Food Security and Market, Representation of Actors of Agriculture World in Russia during the Years (1990-2010). *Revue d'études comparatives Est-Ouest*, 2017/1(48), pp 57-84.

ECHAREF BENATIA, S. (2021). The contribution of the agriculture sector to economic diversification in Algeria is an empirical and analytical study during the period (2000-2019). *Journal of North African Economies*, 17(26), pp 35-46.

Esnard, R., Lyne, M., and Old, K. (2017). Factors affecting the value added by agricultural cooperatives in Saint Lucia: An institutional analysis. *Journal of Co-*



Operative Organization and Management, 5(2), 73–79.
<https://doi.org/10.1016/j.jcom.2017.10.003>

FAO. (2023). Statistics| FAO | Food and Agriculture Organization of the United Nations. Food and Agriculture Organization of the United Nations. Retrieved from Food and Agriculture Organization of the United Nations website: <https://www.fao.org/statistics/en>

Fathelrahman, E., Davies, S., and Muhammad, S. (2021). Food Trade Openness and Enhancement of Food Security—Partial Equilibrium Model Simulations for Selected Countries. Sustainability, 13(8), 4107. HYPERLINK
"https://doi.org/10.3390/su13084107" <https://doi.org/10.3390/su13084107>

Feng, X., He, X. and Hu, J. (2011), "Wild bootstrap for quantile regression", Biometrika, Vol. 98 No. 4, pp. 995–999

Foster, A. D., and Rosenzweig, M. R. (2007). Economic Development and the Decline of Agricultural Employment. In T. P. Schultz and J. A. Strauss (Eds.), Handbook of Development Economics (Vol. 4, pp. 3051–3083). Elsevier.
[https://doi.org/10.1016/S1573-4471\(07\)04047-8](https://doi.org/10.1016/S1573-4471(07)04047-8)

Gandhi, V. P., and Zhou, Z. (2014). Food demand and the food security challenge with rapid economic growth in the emerging economies of India and China. Food Research International, 63, 108–124. <https://doi.org/10.1016/j.foodres.2014.03.015>

Gillespie, J., and Mishra, A. (2011). Off-farm employment and reasons for entering farming as determinants of production enterprise selection in US agriculture. Australian Journal of Agricultural and Resource Economics, 55(3), 411–428.
<https://doi.org/10.1111/j.1467-8489.2011.00542.x>

Granger, C.W., Newbold, P. and Econometrics, J. (1974), "Spurious regressions in econometrics", in Baltagi, B.H. (ed.), A Companion of Theoretical Econometrics, Wiley Online Library, pp. 557–61.

Greenville, J., Kawasaki, K., and Jouanjean, M.-A. (2019). Value Adding Pathways in Agriculture and Food Trade: The Role of GVCs and Services. Paris: OECD. HYPERLINK
"https://doi.org/10.1787/bb8bb93d-en" <https://doi.org/10.1787/bb8bb93d-en>

Gurbuz, I. B., Nesirov, E., and Ozkan, G. (2021). Does agricultural value-added induce environmental degradation? Evidence from Azerbaijan. Environmental Science and Pollution Research, 28(18), 23099–23112. <https://doi.org/10.1007/s11356-020-12228-3>

Hahn, J. (1995), "Bootstrapping quantile regression estimators", Econometric Theory, Vol. 11 No. 1, pp. 105–121.

He, X. and Hu, F. (2002), "Markov Chain Marginal Bootstrap", Journal of the American Statistical Association, Vol. 97 No. 459, pp. 783–795.



HEMICI, A., & Khanfar, M. (2023). The reality of agricultural and animal production and its impact on food security in Algeria. *Journal of Economic and Financial Research*, 10(01), pp 227-251.

Holden, S., and Yohannes, H. (2002). Land redistribution, tenure insecurity, and intensity of production: A study of farm households in Southern Ethiopia. *Land Economics*, 78(4), 573–590.

IMF. (2023). IMF Data. USA: International Monetary Fund. Retrieved from International Monetary Fund website: <https://www.imf.org/en/Data>

Izraelov, M., and Silber, J. (2019). An assessment of the global food security index. *Food Security*, 11(5), 1135–1152. <https://doi.org/10.1007/s12571-019-00941-y>

Jenkins, J. C., and Scanlan, S. J. (2001). Food security in less developed countries, 1970 to 1990. *American Sociological Review*, 718–744.

Jureckova, J., Sen, P., Picek, J., Sen, P. and Picek, J. (2012), *Methodology in Robust and Nonparametric Statistics*, CRC Press.

KATEB, M., & OUDDANE, B. (2020). Exports excluding hydrocarbons in Algeria : " Agriculture as a development strategy ". *Knowledge of aggregates magazine*, 05(02), pp 89-104.

Kavallari, A., Fellmann, T., and Gay, S. H. (2014). Shocks in economic growth = shocking effects for food security? *Food Security*, 6(4), 567–583. <https://doi.org/10.1007/s12571-014-0368-y>

Kinda, S., Kere, N., & Yogo, U. (2022). Rush to the Lands and Food Security in Sub-Saharan Africa. *Revue d'économie et de développement*, 31(2022/2), pp 51-56.

Kocherginsky, M. and He, X. (2007), "Extensions of the Markov chain marginal bootstrap", *Statistics and Probability Letters*, Vol. 77 No. 12, pp. 1258–1268.

Kocherginsky, M., He, X. and Mu, Y. (2005), "Practical confidence intervals for regression quantiles", *Journal of Computational and Graphical Statistics*, Vol. 14 No. 1, pp. 41–55.

Koenker, R. and Bassett, G. (1978), "Regression quantiles", *Econometrica*, Vol. 46 No. 1, pp. 33–50.

Koenker, R. and Bassett, G. (1982), "Robust tests for heteroscedasticity based on regression quantiles", *Econometrica*, Vol. 50 No. 1, pp. 43–61.

Koenker, R. and Machado, J.A.F. (1999), "Goodness of fit and related inference processes for quantile regression", *Journal of the American Statistical Association*, Vol. 94 No. 448, pp. 1296–1310.



Kołodziejczak, W. (2020). *Employment and Gross Value Added in Agriculture Versus Other Sectors of the European Union Economy*. Sustainability, 12(14), 5518. <https://doi.org/10.3390/su12145518>

Leong, C.K. and Huang, W. (2010), "Testing for spurious and cointegrated regressions: a wavelet approach", *Journal of Applied Statistics*, Vol. 37 No. 2, pp. 215–233.

Levers, C., Schneider, M., Prishchepov, A. V., Estel, S., and Kuemmerle, T. (2018). Spatial variation in determinants of agricultural land abandonment in Europe. *Science of The Total Environment*, 644, 95–111. <https://doi.org/10.1016/j.scitotenv.2018.06.326>

Ma, L., Long, H., Tang, L., Tu, S., Zhang, Y., and Qu, Y. (2021). Analysis of the spatial variations of determinants of agricultural production efficiency in China. *Computers and Electronics in Agriculture*, 180, 105890. <https://doi.org/10.1016/j.compag.2020.105890>

Machado, J.A. and Silva, J. (2013), "Quantile regression and heteroskedasticity", *Https://Jmcss. Som. Surrey. Ac. Uk/JM_JSS. Pdf*. Accessed, Vol. 5 No. 7, p. 2015.

Manap, N. M. A., and Ismail, N. W. (2019). Food security and economic growth. *International Journal of Modern Trends in Social Sciences*, 2(8), 108–118.

MEGHERBI, K. (2016). *Water Resources Economics in Algeria : Analytical Study of Water Resources (Capabilities and Challenges)*. POIDEX Journal Review(6), pp 103–120.

Mello, M. and Perrelli, R. (2003), "Growth equations: a quantile regression exploration", *The Quarterly Review of Economics and Finance*, Vol. 43 No. 4, pp. 643–667.

Mireri, P. C. (2013). Assessment of the contribution of urban agriculture to employment, income and food security in Kenya: A case of Kisumu municipality. *African Journal of Agricultural Research*, 8(23), 2884–2896.

Mkwambisi, D. D., Fraser, E. D. G., and Dougill, A. J. (2011). Urban agriculture and poverty reduction: Evaluating how food production in cities contributes to food security, employment and income in Malawi. *Journal of International Development*, 23(2), 181–203. <https://doi.org/10.1002/jid.1657>

MOHAMEDI, N., & HAFSAOUI, N. (2023). Study of the reality of food security in Algeria. *Journal of Economics Studies and Researches in Renewables Energies*, 10(01), pp 170–196.

Mozumdar, L. (2012). Agricultural productivity and food security in the developing world. *Bangladesh Journal of Agricultural Economics*, 35(454–2016–36350), 53–69.

Naylor, R. L., and Falcon, W. P. (2010). Food Security in an Era of Economic Volatility. *Population and Development Review*, 36(4), 693–723. <https://doi.org/10.1111/j.1728-4457.2010.00354.x>



- Neveu, A. (2020). Food Security: Main Objective of the Post-Covid. *Revue Paysans & Société*, 2020/5(383), pp 22-27.
- Newey, W.K. and Powell, J.L. (1987), "Asymmetric least squares estimation and testing", *Econometrica*, Vol. 55 No. 4, pp. 819–847.
- Nikitina, L., Paidi, R. and Furuoka, F. (2019), "Using bootstrapped quantile regression analysis for small sample research in applied linguistics: some methodological considerations", *PLOS ONE*, Vol. 14 No. 1, p. e0210668.
- Nugroho, A. D., Bhagat, P. R., Magda, R., and Lakner, Z. (2021). The impacts of economic globalization on agricultural value added in developing countries. *PLOS ONE*, 16(11), e0260043. <https://doi.org/10.1371/journal.pone.0260043>
- Nugroho, A. D., Istvan, F., Fekete-Farkas, M., and Lakner, Z. (2022). How to improve agricultural value-added in the MENA region? Implementation of Diamond Porter's theory in agriculture. *Frontiers in Sustainable Food Systems*, 6. Retrieved from <https://www.frontiersin.org/articles/10.3389/fsufs.2022.956701>
- Onoja, A. O., Achike, A. I., and Ajibade, T. B. (2017). Econometric analysis of short-run and long-run determinants of agricultural value addition in Africa. *Agrosearch*, 17(1), 26–43. <https://doi.org/10.4314/agrosh.v17i1.3>
- Pender, J., and Gebremedhin, B. (2008). Determinants of Agricultural and Land Management Practices and Impacts on Crop Production and Household Income in the Highlands of Tigray, Ethiopia. *Journal of African Economies*, 17(3), 395–450. <https://doi.org/10.1093/jae/ejm028>
- Petkovski, M. and Kjosovski, J. (2014), "Does banking sector development promote economic growth? An empirical analysis for selected countries in Central and South Eastern Europe", *Economic Research-Ekonomska Istraživanja*, Vol. 27 No. 1, pp. 55–66.
- Pouch, T. (2020). Food Security in a Society of Risk. *Revue Paysans & Société*, 2020/3(381), pp 9-14.
- Prishchepov, A. V., Müller, D., Dubinin, M., Baumann, M., and Radeloff, V. C. (2013). Determinants of agricultural land abandonment in post-Soviet European Russia. *Land Use Policy*, 30(1), 873–884. <https://doi.org/10.1016/j.landusepol.2012.06.011>
- Quantile Regression with Robust and Clustered Standard Errors, available at: <https://ideas.repec.org/c/boc/bocode/s457369.html> (accessed 10 February 2020).
- Ramsey, J.B. (1969), "Tests for specification errors in classical linear least-squares regression analysis", *Journal of the Royal Statistical Society: Series B (Methodological)*, Vol. 31 No. 2, pp. 350–371.
- Rondhi, M., Pratiwi, P. A., Handini, V. T., Sunartomo, A. F., and Budiman, S. A. (2018). Agricultural Land Conversion, Land Economic Value, and Sustainable Agriculture: A

Case Study in East Java, Indonesia. *Land*, 7(4), 148.
<https://doi.org/10.3390/land7040148>

SAADANE, A. (2023). Shifting towards a green economy as a mechanism for achieving food security. *Journal of the développements policies and the prospective studies*, 08(01), pp 170-183.

SAIDOUN, R., AIT HAMMOU, S., & CHEHAT, F. (2022). Agricultural and Rural Policy in Algeria: From Centralization to Governance. *Les Cahiers du Cread*, 38(03), pp 473-506.

SERIR, A. (2021). Mechanisms for managing water resources to achieve agricultural development in Algeria. *The Algerian journal of political studies*, 08(02), pp 260-280.

Sun, Y., Gao, P., Raza, S. A., Shah, N., and Sharif, A. (2023). The asymmetric effects of oil price shocks on the world food prices: Fresh evidence from quantile-on-quantile regression approach. *Energy*, 270, 126812.
<https://doi.org/10.1016/j.energy.2023.126812>

Sun, Z., and Zhang, D. (2021). Impact of Trade Openness on Food Security: Evidence from Panel Data for Central Asian Countries. *Foods*, 10(12), 3012.
<https://doi.org/10.3390/foods10123012>

Tapsoba, T., Motel, P., & Combes, J.-L. (2023). Migrants' Transfer, Food Security and Climate Variability: Burkina Faso case. *Revue Économique*, 74(2023/2), pp 53-81.

Tocco, B., Bailey, A., and Davidova, S. (Eds.). (2013). Determinants to Leave Agriculture and Change Occupational Sector: Evidence from an Enlarged EU.
<https://doi.org/10.22004/ag.econ.155704>

TSABET, A., & GUELLIL, M. (2021). The agricultural lands use planning in the agricultural sector using goal programming approach, the case of Algeria, 2030 horizons. *Journal of north African economies*, 17(2), pp 363-376.

Tsay, R.S. (1986), "Nonlinearity tests for time series", *Biometrika*, Vol. 73 No. 2, pp. 461–466.

Ullah, A. (Ed.). (1989), *Semiparametric and Nonparametric Econometrics*, Physica-Verlag Heidelberg, available at: <https://doi.org/10.1007/978-3-642-51848-5>.

Viana, C. M., Freire, D., Abrantes, P., Rocha, J., and Pereira, P. (2022). Agricultural land systems importance for supporting food security and sustainable development goals: A systematic review. *Science of The Total Environment*, 806, 150718.
<https://doi.org/10.1016/j.scitotenv.2021.150718>

Widada, A. W., Masyhuri, M., and Mulyo, J. H. (2017). Determinant Factors of Food Security in Indonesia. *Agro Ekonomi*, 28(2), 205–219.
<https://doi.org/10.22146/jae.26245>



World Bank Group. (2023). World Bank Open Data. Retrieved from <https://data.worldbank.org>

Wu, J., Zhang, J., Wang, S., and Kong, F. (2016). Assessment of Food Security in China: A New Perspective Based on Production-Consumption Coordination. *Sustainability*, 8(3), 183. <https://doi.org/10.3390/su8030183>

YAHYI, D., & YAHIAOUI, H. (2023). Policies to support agricultural investment in southern Algeria and their implications for achieving national food security : "A case study of the wilaya of El Oued ". *Journal of Rights and Freedoms*, 11(1), pp 886-914.

YILDIRIM, E. S., DEMİRTAŞ, C., and ÖZGÜR, M. I. (2022). THE EFFECT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION AND FOOD SECURITY: QUANTILE REGRESSION ANALYSIS. *DISCUSSIONS BETWEEN*, 119.

ZERARAKA, A., & DJAIKEN, A. (2021). Management of water resources in Algeria. *Future journal for legal and political studies*, 5(1), pp 151-169.

ZIADI, S. (2023). The contribution of the agricultural sector in achieving food security, case study of Arab states. *Journal of Management and Economic Sciences Prospects*, 07(01), pp 362-379.

6.2. Theses

ALHABITRI, N. (2016). *Food Security in Algeria : Capabilities and Challenges – PhD in Commercial Sciences*. p 5. Faculty of Economic, Commercial and Management Sciences, Mostaganem: Abdelhamid Ibn Badis University.

BAALI, H. (2020). *Agricultural Policies and their Role in Achieving Food Security for Arab Maghreb Countries, with Particular Indication of Algeria Case – PhD in Management Sciences - Faculty of Economic, Commercial and Management Sciences*. p 41. Algiers University 3.

BEN HAFADH, H. (2023). *Food Security in Algeria, Prospective Study – PhD in Sciences*. p 24. Faculty of Economic Sciences: Abdelhamid Mahri University – Constantine 2.

BOULASSEL, M. (2017). *The Role of Arab Economy Integration in Achieving Arab Food Security – PhD in Management Sciences*. p 64. Faculty of Economic, Commercial and Management Sciences, Média: Yahia Fares University.

DEBAR, H. (2019). *Role of Agriculture Sector in Achieving Food Security in Arab Countries, Case Study of Algeria during (2005-2016) – PhD in Economic Sciences*. p 26. Faculty of Economic, Commercial and Management Sciences, Biskra: Mohamed Kheidar University.

EDERRADJI, L. (2016). *Agriculture Sector and Food Security in Algeria: Reality and Challenges – PhD in Sciences*. p 68. Faculty of Economic and Management Sciences, Annaba: Badji Mokhtar University.



GHARDI , M. (2012). *Algerian Agriculture Sector and the Problem of Support and Investment under Joining World Trade Organization - PhD in Economic Sciences*. p 268, 33. University of Algiers 3.

GHEDAMSI , A. (2021). *Protected Agriculture in Algeria, Reality and Horizons - PhD in Economic Sciences*. p 157. Faculty of Economic Sciences, Commercial Sciences and Management Sciences: Abdelhamid Mahri University — Constantine 2.

HABOUL , M. (2020). *Agricultural Policies and the Food Security Problem in Algeria, Analytical and Estimation Study during (2000-2016) – PhD in Economic Sciences*. p 36. Faculty of Economic, Commercial and Management Sciences: Algiers University 3.

HAFIANI , C. (2023). *Food Security Challenges in Arab World, Comparative Study Between Algeria and Morocco – PhD*. p 52. Faculty of Political Sciences: University of Constantine 3.

HENI , S. (2017). *The Role of Sahara Agriculture in Achieving Food Security of Algeria under Sustainable Development –PhD in Political Sciences and International Relations*. p 15. National Higher School of Political Sciences.

KHEZAR, B. (2022). *Policies to Achieve Food Security in Arab Maghreb Countries (Comparative Study Between Algeria, Morocco and Tunisia) – PhD in Sciences*. p 3,4. Faculty of Economic, Commercial and Management Sciences, Boumerdes: Amhamed Bouguera University.

MANSOUR , M. (2016). *Grain Production in Algeria and Food Security Achievement under Sustainable Development after Promulgating the Law 19/87 - PhD in Economic Sciences*. p 40. Faculty of Economic Sciences, Commercial Sciences and Management Sciences: Algiers University 3.

ZENAGUI , I. (2018). *Upgrading Agricultural Productivity as a Way to Achieve Food Security in Algeria – PhD in Economic Sciences*. p 5. Faculty of Economic, Commercial and Management Sciences, Boumerdes: Amhamed Bouguera University.

7. APPENDICES

Years	Agriculture, Value Added, Current Prices (USD)	Trade openess	GDP (USD)	Food Production Index (2014- 2016=100)
1992	5941430251	47,6423	34,945,645,178.44	39,02
1993	5673542544	43,9409	36,496,964,872.26	37,34
1994	4196229340	51,7142	29,633,465,383.95	34,79
1995	4166416689	57,4683	27,729,563,971.70	38,88
1996	5127063267	53,7503	32,334,314,197.31	45,69
1997	4249036439	51,6116	35,012,345,144.48	37,28
1998	5587245125	46,3393	35,525,063,127.68	41,78
1999	5458106319	51,0436	35,683,651,267.59	43,84

2000	4647015416	62,9145	41,546,654,704.95	40,87
2001	5392216075	58,3519	43,003,045,184.50	44,02
2002	5290017205	61,0617	43,836,120,930.09	45,47
2003	6657818547	62,1248	48,454,085,963.14	53,29
2004	8055792109	65,7014	57,618,987,063.75	58,19
2005	7937297023	71,2786	69,871,988,871.75	59,76
2006	8827458433	70,73	79,543,094,685.04	63,06
2007	10218617411	71,9381	88,186,082,625.73	58,12
2008	11263264104	76,6845	108,219,702,236.93	59,06
2009	12820127465	71,3243	89,039,990,105.09	73,12
2010	13648522725	69,8667	105,660,527,959.58	76,45
2011	16222244032	67,4723	126,700,157,042.44	84,49
2012	18335919885	65,405	136,489,379,197.28	89,77
2013	20663212742	63,6108	138,026,666,231.38	98,04
2014	21993348927	62,1458	140,726,262,121.45	96,95
2015	19218248623	59,6952	118,631,640,067.55	100,26
2016	19556329745	55,9257	115,135,472,040.79	102,79
2017	19996432166	55,3214	122,678,546,080.57	102,87
2018	20769268927	58,0652	123,539,480,843.41	108,6
2019	21189984072	51,8097	124,314,149,019.94	112,16
2020	20089637852	45,3307	104,635,209,625.67	112,31
2021	19903888815	53,1955	114,757,336,185.51	104,62
Sources	FOA	IMF	IMF	FOA

Years	Land Area (in Thousands)hectares	Employment in Agriculture, % of Total Employment	Agriculture, Value Added, Constant 2015 Prices (USD)
1992	238174	23,7	5960004401
1993	238174	23,7	5739484099
1994	238174	23,7	5222930511
1995	238174	23,5	6004280799
1996	238174	23,3	7439303722
1997	238174	23,1	6438717747
1998	238174	22,7	7172731216
1999	238174	22,5	7366395029
2000	238174	22,2	7027540858
2001	238174	21,7	7927066088
2002	238174	21,7	7831941295
2003	238174	21,7	9359169847
2004	238174	21,3	9864565019
2005	238174	19,4	10091450014
2006	238174	17,9	10908857465



2007	238174	16,2	11181578902
2008	238174	14,7	10756678904
2009	238174	13,3	13026338152
2010	238174	12	13664628722
2011	238174	10,8	15249725654
2012	238174	10,9	16347705901
2013	238174	11	17688217785
2014	238174	9,3	18130423229
2015	238174,1	9,6	19218248623
2016	238174,1	9,9	19564177098
2017	238174,1	10,2	19681562161
2018	238174,1	10	20370416836
2019	238174,1	9,9	20920418091
2020	238174,1	10,5	21276065198
2021	238174,1	10,3	20871819960
Sources	FOA	FOA	FOA