Economic studies Journal
ISSN 2602-7925
https://www.asjp.cerist.dz/en/PresentationRevue/417

Volume: 19/ N°: 03 (2025), P 60-83

Determinants of Food Security Governance in Algeria Using the Fuzzy Logic Method (TOPSIS)

Belkacem BOUFATAH

Laboratory of legal and economic studies - University center of Aflou, (Algeria)

b.boufatah@cu-aflou.edu.dz

Abstract ;

This study aims to identify the determining factors for food security governance in Algeria employing the fuzzy logic approach (TOPSIS) for preference ranking through ideal solution methodology, incorporating expert judgments to establish priority among feasible alternative options. Three criteria strongly related to food security governance in Algeria were adopted: national food security strategies (C1), agricultural innovation (C2), and public-private partnerships (C3). Five alternatives were considered: risk (A1), national capacity development (A2), environmental sustainability (A3), international cooperation (A4), and infrastructure development (A5). Through a cause-and-effect relationship, the study concluded that "agricultural innovation" is the most significant factor influencing food security governance in Algeria, with the highest impact value of (0.880).

Article info

Received 27/08/2025

Accepted 26/10/2025

Keyword:

Food
Food Security
Governance
Agricultural Innovation
fuzzy logic approach (TOPSIS)

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

1. Introduction:

The concept of public-private partnership refers to arrangements that allow the private sector to provide infrastructure assets and services that were traditionally delivered by the government. These partnerships span various infrastructure, economic, and social sectors, often focusing on the construction and operation of strategic projects, including food security. Essentially, it is a contractual agreement whereby the private partner develops the infrastructure and delivers services that are typically the responsibility of the state.

Food security currently represents one of the most significant challenges facing developing countries, including Algeria. Achieving food security has become a strategic priority and a multidimensional challenge—political, economic, and social. Food security is an ideal, comprehensive concept. It does not merely refer to the availability of sufficient food, but also to the quality and safety of food consumed by individuals—this broader understanding is referred to as food security governance.

The agricultural sector is one of the most vital sectors of the economy, as it provides the population's food needs and thereby contributes to achieving food security. This requires adopting policies and designing programs aimed at developing the sector through optimal use of all available resources—natural, material, and human. Success in developing this sector can lead to improvements in other related sectors and contribute to overall economic development, while the performance of agriculture itself is also influenced by the state of other sectors.

For this reason, food security-with its economic, technical, social, and political dimensions—has become a matter of growing concern at all levels. It has taken center stage for policymakers and is a pressing issue for citizens, as it directly impacts their well-being. Ensuring food security is a sensitive topic in Algerian agriculture, as it is influenced by various internal and external factors that directly affect the sector's ability to produce food and increase incomes. Consequently, the issue has received growing attention, with Algeria making considerable efforts in recent years to develop strategies, plans, and policies aimed at achieving national food security.

Based on the above, the following research problem can be proposed:

What are the determining factors of food security governance in Algeria using the Fuzzy Logic (TOPSIS) method?

To address this research problem, the following hypothesis is proposed:

There is an effect of factors: risk (A1), international cooperation (A2), environmental sustainability (A3), national capacity development (A4), and infrastructure development (A5) There is an effect of factors on food security governance in Algeria

1.1 Study goals:

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

This investigation seeks to accomplish the subsequent aims through examining this subject matter:

- Comprehending the particular domestic elements and options concerning food security administration in Algeria.
- Establishing the degree to which individual factors impact the attainment of food security administration.

1.2 Study Methodology:

To accomplish the investigation's aims, approaches employed in economic and financial research were utilized. Consequently, the analytical method was implemented to emphasize the most significant concepts and instruments, and the frameworks associated with the topic and to familiarize them. The quantitative method was applied in the applied dimension. Within this framework, the "TOPSIS" technique, which depends on specialist judgment and its computational evaluation to attain the intended outcomes, was utilized.

2. Theoretical Outlook:

2.1 Governance:

A. Introduction and Terminological Development:

The conceptualization of governance has undergone significant theoretical and practical evolution since its formal introduction into academic and policy discourse. Within Arabic academic literature, the concept has been articulated through various terminological expressions, including governance (al-hukm), good governance (al-hukm ar-rashid), and corporate governance (hukmat al-sharikat). This linguistic diversity reflects not merely translation challenges but also the multifaceted nature of the concept itself, encompassing political, economic, and organizational dimensions that have evolved considerably since the late twentieth century.

The genesis of contemporary governance discourse can be traced to the World Bank's seminal report on economic development and anti-corruption initiatives in Sub-Saharan Africa, published in the early 1990s (World Bank, 1992). This foundational document primarily emphasized the economic dimensions of governance, positioning it as a critical mechanism for enhancing developmental outcomes and combating systemic corruption in developing economies. The World Bank's initial conceptualization focused predominantly on the instrumental value of governance structures in facilitating economic growth, improving resource allocation efficiency, and establishing transparent institutional frameworks conducive to sustainable development (Kaufmann et al., 1999).

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

However, this economically centered approach to governance proved insufficient to capture the broader implications and applications of the concept. The limitations of this narrow economic perspective became increasingly apparent as scholars and practitioners recognized the inherent interconnections between governance mechanisms and broader socio-political structures (Rhodes, 1997; Pierre & Peters, 2000). Consequently, the conceptual boundaries of governance expanded significantly throughout the 1990s, particularly within Western academic and policy circles in the United States and Europe.

B. Theoretical Expansion and Multidimensional Framework

The theoretical evolution of governance during the 1990s witnessed the emergence of multiple scholarly contributions that articulated increasingly sophisticated understandings of the concept. These contributions fundamentally challenged the initial economically deterministic approach by introducing political, social, and institutional dimensions that reflected the complex realities of contemporary organizational and state management (Lebrague et al., 2019; Stoker, 1998; Kooiman, 2003).

Within this expanded theoretical framework, governance came to be understood as encompassing two primary relational dimensions. The first dimension addresses the intricate relationships between state apparatus and governmental institutions, examining how formal governmental structures interact with broader governance mechanisms to achieve policy objectives and maintain institutional legitimacy (Clarke & Rhodes, 2003). The second dimension focuses on the complex interactions between civil society institutions and private sector entities, recognizing the increasingly important role of non-state actors in contemporary governance arrangements (sameh, 2000, p. 05)

This bifurcated understanding reflects the broader theoretical shift from government to governance that characterized public administration and political science scholarship during this period (Osborne & Gaebler, 1992; Peters & Pierre, 1998). The recognition that effective governance requires the active participation and coordination of multiple stakeholders beyond traditional governmental actors represented a paradigmatic shift in both academic understanding and practical implementation of governance mechanisms.

C. Corporate Governance: Definitional Frameworks and Institutional Perspectives

Within the specific domain of corporate governance, various international organizations and scholarly institutions have developed comprehensive definitional frameworks that reflect this broader theoretical evolution. The Organisation for Economic Co-operation and Development (OECD) has provided one of the most widely cited and influential definitions of corporate governance, characterizing it as "the set of relationships between a company's management such as the board of directors, its shareholders, and other stakeholders" (land, 2001, p. 08).

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

The OECD's definition represents a significant advancement in corporate governance conceptualization by explicitly acknowledging the multi-stakeholder nature of modern corporate structures. This definition moves beyond traditional agency theory perspectives that primarily focused on shareholder-management relationships to encompass a broader stakeholder-oriented approach (Freeman, 1984; Donaldson & Preston, 1995). The inclusion of "other stakeholders" in the OECD definition reflects recognition that effective corporate governance must account for the interests and influences of diverse constituent groups, including employees, customers, suppliers, creditors, and broader community interests.

Furthermore, the OECD's framework emphasizes the relational nature of corporate governance, positioning it not as a static set of rules or procedures but as a dynamic system of interactions and relationships that must be continuously managed and refined (Clarke, 2007). This relational perspective aligns with broader governance theories that emphasize the importance of network relationships, collaborative decision-making processes, and stakeholder engagement mechanisms in achieving effective organizational outcomes (Aguilera & Jackson, 2003).

D. Contemporary Implications and Future Directions

The evolution of corporate governance conceptualization from its initial economic development focus to its current multi-stakeholder, relational framework has profound implications for both theoretical understanding and practical implementation. Contemporary corporate governance research increasingly emphasizes the importance of contextual factors, institutional environments, and cultural considerations in shaping effective governance mechanisms (Aguilera & Cuervo-Cazurra, 2009; Judge et al., 2008).

This expanded understanding necessitates continued scholarly attention to the complex interactions between various governance dimensions and the development of more nuanced theoretical frameworks that can accommodate the diverse realities of contemporary corporate environments across different cultural, legal, and economic contexts.

2.2 Food Security:

A. Historical Foundation and Supply-Side Origins

The conceptual foundation of contemporary food security discourse was formally established during the World Food Conference of 1974, convened in Rome in response to the global food crisis that had emerged during the early 1970s. This seminal international gathering, organized under the auspices of the United Nations, articulated the first comprehensive definition of food security as: "The ability to ensure that, at all times, sufficient supplies of basic foodstuffs are available globally to maintain the steady growth of food consumption and to compensate for fluctuations in production and prices" (FAO, 2015). This foundational definition reflected the

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

predominant economic paradigm of the era, which conceptualized food security primarily through the lens of aggregate supply management and global production capacity (Maxwell, 1996). The emphasis on "sufficient supplies" and "global availability" demonstrated a macro-economic approach that prioritized production optimization and supply chain stability as the primary mechanisms for achieving food security outcomes.

The 1974 definition emerged from a specific historical context characterized by significant volatility in global commodity markets, dramatic increases in food prices, and widespread concerns about the capacity of agricultural systems to meet growing global demand (Sen, 1981; Timmer et al., 1983). The economic rationale underlying this supply-focused approach was grounded in classical economic theory, which posited that ensuring adequate aggregate supply would naturally translate into improved food access and consumption patterns across populations (Malthus, 1798; Ricardo, 1817). However, this supply-centric framework, while addressing critical production and distribution challenges, inadvertently overlooked the complex microeconomic dynamics that govern individual and household-level food access, affordability, and utilization (Drèze & Sen, 1989).

B. Theoretical Evolution and Multi-dimensional Economic Framework

The limitations of the original supply-focused definition became increasingly apparent throughout the 1980s and 1990s, as economic research demonstrated that food insecurity could persist even in contexts of adequate aggregate supply (Sen, 1981; Watts & Bohle, 1993). Amartya Sen's groundbreaking work on entitlement theory fundamentally challenged the supply-side paradigm by demonstrating that famines and food insecurity could occur not due to absolute food shortages, but rather due to failures in economic entitlements and access mechanisms (Sen, 1999). This theoretical revolution prompted a significant reconceptualization of food security within economic literature, leading to the development of more sophisticated analytical frameworks that incorporated demand-side factors, market functioning, and distributional considerations.

Contemporary economic approaches to food security have evolved to encompass four primary dimensions: availability, access, utilization, and stability, each with distinct economic characteristics and policy implications (FAO, 2008; Barrett, 2010). The availability dimension maintains the original supply-side focus, examining production capacity, agricultural productivity, and global trade mechanisms (Pinstrup-Andersen, 2009). The access dimension, heavily influenced by Sen's entitlement approach, emphasizes the economic, physical, and social factors that determine individual and household capacity to obtain adequate food, including income levels, food prices, market integration, and social protection mechanisms (Maxwell & Smith, 1992; Webb et al., 2006). The utilization dimension incorporates nutritional economics and examines how effectively consumed food translates into nutritional outcomes, considering factors such as food safety, dietary diversity, and healthcare access (Smith & Haddad, 2015).

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Finally, the stability dimension addresses the temporal and dynamic aspects of food security, examining how economic shocks, price volatility, and seasonal variations affect sustained access to adequate nutrition (Timmer, 2000; Gilbert & Morgan, 2010).

This multi-dimensional framework reflects a more nuanced understanding of food security as an economic phenomenon that transcends simple supply-demand relationships to encompass complex interactions between agricultural markets, macroeconomic policy, social protection systems, and household economic behavior (Barrett & Bevis, 2015; Headey & Fan, 2010). Contemporary research increasingly emphasizes the importance of understanding food security through the lens of welfare economics, examining how market failures, externalities, and distributional concerns create systematic barriers to food access that cannot be resolved through production increases alone (Pinstrup-Andersen & Watson, 2011; Conceição et al., 2016).

2.3 National Food Security Strategies:

A. International Commitments and Institutional Framework Development

Algeria represents one of the global entities obligated through international instruments to attaining food security at the domestic level, reflecting its commitment to multilateral frameworks established through the United Nations Sustainable Development Goals, particularly SDG 2 (Zero Hunger), and its participation in regional food security initiatives within the North African and Mediterranean contexts (United Nations, 2015; FAO, 2018). The country's engagement with international food security governance structures has been reinforced through its membership in various multilateral organizations, including the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), and the World Food Programme (WFP), which have provided both normative frameworks and technical assistance for domestic policy development (Capone et al., 2014; Lasram & Dhehibi, 2019).

For this purpose, Algeria has implemented comprehensive legislation and created specialized institutional frameworks in the food security domain, with particular emphasis on the agricultural sector as a substantial contributor to national food security objectives. Legal and institutional architecture encompasses multiple ministerial departments, including the Ministry of Agriculture and Rural Development, the Ministry of Commerce, and specialized agencies such as the National Office of Agricultural Statistics and Economic Studies (ONSE) and the Agricultural Development Support Fund (FSDA) (Bedrani, 2008; Boudjenah, 2019). This institutional multiplicity reflects the complex nature of food security governance, which requires coordination across agricultural production, food distribution, trade policy, and social protection mechanisms to achieve comprehensive food system resilience (Diao et al., 2012; Jouve & Bellabed, 2020).

B. Historical Evolution of Agricultural Policy Reforms

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

To achieve enhanced food security outcomes, Algeria has adopted a series of sequential reform policies in the agricultural sector, beginning with the policy of self-management (autogestion), followed by the agricultural revolution (révolution agraire), sectoral restructuring programs, and culminating in the contemporary national strategies for food security and agricultural development, which collectively serve as an integrated policy framework designed to enhance the country's agricultural productive capacity and food system performance. The initial self-management policy, implemented during the immediate post-independence period (1962-1971), represented an attempt to establish collective agricultural enterprises based on socialist principles, though economic analysis suggests this approach generated significant efficiency losses and productivity constraints due to inadequate incentive structures and limited technical capacity (Sutton, 1982; Benissad, 1991).

The subsequent agricultural revolution (1971-1980) constituted a more radical restructuring initiative that involved extensive land redistribution programs, the establishment of agricultural production cooperatives, and significant state investment in rural infrastructure development (Lawless, 1984; Brahimi, 2009). From an economic perspective, this policy phase demonstrated mixed results, achieving notable improvements in rural social infrastructure and agricultural mechanization while simultaneously generating institutional inefficiencies and coordination problems that limited overall sectoral productivity growth (Roberts, 2003; Bessaoud, 2016). The economic rationale underlying these early reform initiatives reflected broader development economics thinking of the era, which emphasized state-led industrialization strategies and collective ownership models as mechanisms for achieving rapid economic transformation in post-colonial contexts (Lewis, 1954; Hirschman, 1958).

C. Contemporary Strategic Framework and Market-Oriented Reforms

The transition toward sectoral restructuring during the 1980s and 1990s marked a fundamental shift in Algeria's agricultural policy paradigm, moving from collectivist approaches toward more market-oriented mechanisms that emphasized private ownership, competitive markets, and integration with global agricultural trade systems (Anderson et al., 2013; Belkacem & Mekhlouf, 2021). This policy evolution coincided with broader economic liberalization programs implemented under structural adjustment initiatives, reflecting international development consensus regarding the efficiency advantages of market-based resource allocation mechanisms in agricultural sectors (World Bank, 1986; Krueger et al., 1991).

The contemporary national strategies for food security and agricultural development represent the culmination of this policy evolution, incorporating lessons learned from previous reform experiences while addressing emerging challenges related to climate change adaptation, water resource management, and global food price volatility (Ministry of Agriculture and Rural Development, 2020; Lamiri et al., 2023). These integrated strategic frameworks emphasize diversification of agricultural production systems, enhancement of value chain efficiency,

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

promotion of sustainable farming practices, and strengthening of food distribution networks to improve both production-side and access-side dimensions of food security (Ait-Amara, 2010; Harbouze et al., 2019). From an economic efficiency perspective, these contemporary approaches reflect recognition that sustainable food security requires comprehensive policy coordination across multiple sectors, incorporating both supply-side interventions to enhance agricultural productivity and demand-side measures to ensure equitable access to adequate nutrition across diverse socioeconomic populations (Barrett, 2010; Conceição et al., 2016).

2.4 Agricultural innovation:

A. Definitional Framework and Conceptual Evolution

Agricultural innovation is fundamentally defined as the process of developing and applying new ideas and methods to improve agricultural production and increase efficiency, encompassing a broad spectrum of technological, organizational, and institutional changes that enhance the productive capacity of agricultural systems (FAO, 2015). This comprehensive conceptualization includes improving cultivation techniques, developing enhanced crop varieties, implementing advanced agricultural production systems, and integrating modern technologies such as artificial intelligence, precision agriculture tools, and sophisticated data analysis methodologies into contemporary farming operations. From an economic perspective, agricultural innovation represents a critical driver of total factor productivity growth in the agricultural sector, enabling producers to achieve higher output levels with equivalent or reduced input utilization, thereby contributing to enhanced profitability and competitive advantage in increasingly globalized agricultural markets (Fuglie, 2018; Pardey et al., 2016).

The theoretical foundations of agricultural innovation economics draw extensively from endogenous growth theory and innovation systems literature, which emphasize the role of knowledge creation, technology transfer, and institutional capacity in facilitating sustained productivity improvements (Romer, 1990; Lundvall, 1992). Agricultural innovation can also be defined as the systematic application of new ideas or knowledge to enhance agricultural production processes, improve crop quality, and promote environmental sustainability, reflecting the multidimensional nature of contemporary agricultural development challenges (OCED, 2016). This expanded definition incorporates not only economic efficiency considerations but also environmental and social sustainability dimensions, recognizing that modern agricultural innovation must address complex trade-offs between productivity enhancement, resource conservation, and ecosystem preservation (Pretty et al., 2018; Tilman et al., 2011).

B. Economic Dimensions and Innovation Systems Framework

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

The economic analysis of agricultural innovation requires understanding the complex interplay between public and private research investments, knowledge spillovers, and market incentives that drive technological development and adoption processes (Alston & Pardey, 2014; Byerlee & Fischer, 2002). Agricultural innovation systems encompass multiple interconnected components, including formal research and development institutions, extension services, input supply chains, financial markets, and regulatory frameworks, all of which contribute to the generation, diffusion, and adoption of new technologies and practices (Klerkx et al., 2012; World Bank, 2012). From a welfare economics perspective, agricultural innovation generates significant positive externalities through enhanced food security, reduced environmental degradation, and improved rural livelihoods, though market failures in innovation markets often necessitate public sector intervention to ensure socially optimal levels of research investment (Ruttan, 2001; Alston et al., 2009).

Contemporary agricultural innovation increasingly emphasizes digital transformation and precision agriculture technologies, including Internet of Things (IoT) applications, satellite-based monitoring systems, automated machinery, and machine learning algorithms for crop management optimization (Wolfert et al., 2017; Klerkx & Rose, 2020). The economic implications of these technological advances are profound, offering opportunities for significant productivity gains while simultaneously requiring substantial capital investments and new forms of human capital development (Trendov et al., 2019). Economic research demonstrates that successful agricultural innovation adoption depends critically on factors such as farm size, access to credit, educational attainment, risk preferences, and market integration, highlighting the importance of complementary policies that address these enabling conditions (Foster & Rosenzweig, 2010; Sunding & Zilberman, 2001).

C. Innovation Economics and Sustainability Integration

The contemporary agricultural innovation paradigm increasingly incorporates sustainability considerations, reflecting growing recognition that long-term productivity growth must be compatible with environmental stewardship and climate change adaptation requirements (Godfray et al., 2010; Campbell et al., 2017). This sustainability-oriented approach to agricultural innovation economics emphasizes the development and adoption of climate-smart agricultural technologies, resource-efficient production systems, and circular economy principles that minimize waste and optimize nutrient cycling (Lipper et al., 2014; FAO, 2013). Economic analysis of sustainable agricultural innovation reveals complex dynamics involving multiple market failures, including environmental externalities, imperfect information, and coordination problems that require sophisticated policy interventions combining research subsidies, environmental regulations, and market-based incentives (Just & Zilberman, 1988; Schneider et al., 2011).

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

The measurement and evaluation of agricultural innovation impacts present significant methodological challenges for economists, requiring sophisticated analytical frameworks that can capture both direct productivity effects and broader spillover benefits across economic, environmental, and social dimensions (Thirtle et al., 2003; Evenson, 2001). Contemporary economic research increasingly employs advanced econometric techniques, including randomized controlled trials, quasi-experimental methods, and general equilibrium modeling approaches to assess the welfare impacts of agricultural innovation interventions and inform evidence-based policy design (Duflo et al., 2008; Anderson et al., 2010).

2.5 Public-Private Partnership:

The concept of Public-Private Partnership (PPP) refers to arrangements that allow the private sector to provide infrastructure assets and services that were traditionally managed by the government. This partnership spans various areas including infrastructure, economic, and social sectors, often focusing on the construction and operation of strategic projects, such as food security. Therefore, it is a contract through which the private partner develops the infrastructure and provides services that are typically the responsibility of the state. (FMI, 2004)

2.6 Fuzzy TOPSIS Theory:

The American researcher “Lotfi Zadeh” is regarded as the pioneer in establishing fuzzy theory during 1965 through his investigation (Fuzzy sets: inform control), wherein he examined the concept that the presence of a fuzzy set offers a convenient foundation for constructing a theoretical framework that closely corresponds, and in a comprehensive sense, the framework employed in traditional sets. Furthermore, it transcends that by providing a broader viewpoint in the practical domain. Fuzzy theory imposes rigorous mathematical limitations and can be perceived as a linguistic framework that accommodates fuzzy relationships. The utilization of this theory expanded during the 1970s, particularly in Japan, within the industrial sector. Fuzzy logic, in its comprehensive sense, represents a logical system founded on the generalization of classical (Boolean) binary logic, designed for reasoning under uncertain circumstances. This approach provides multiple solutions to real-world challenges and delivers an efficient and rational description compared to alternative techniques that depend on the notion of classical sets. (Abbott & Doucouliagos, 2003, pp. 89-97)

2.7 Fuzzy Set:

The fuzzy set comprises a collection of ordered pairs, wherein we consider (X) whose values range between zero and one as a subset of the collection of real numbers ®, and it is termed the membership function and is expressed by the following relation:

$\psi_{\tilde{A}}(X)$

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

The fundamental principle of TOPSIS is that the optimal alternative among the choices is the one with the minimal distance to the ideal positive solution, while the maximum distance represents the negative solution. Consequently, before employing the TOPSIS algorithm, it becomes essential to dentify the optimal and worst solutions for the issue to be examined, as demonstrated in the following figure:

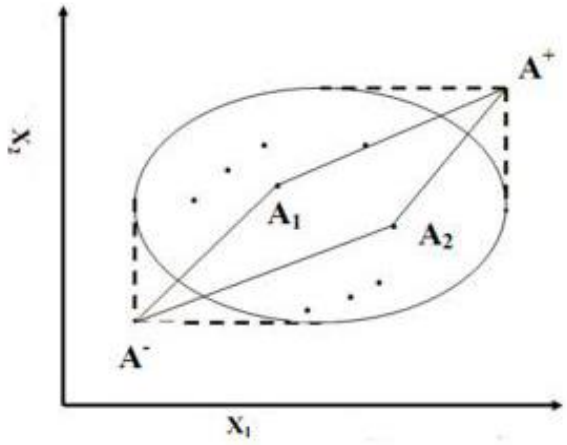


Fig. 1. The distance between the positive solution and the negative solution.
Source: Balioti, 2018, p. 342.

A_i^+ : The positive ideal solution

A_i^- : The negative ideal solution

2. Applied Study

To confirm the accuracy of the primary hypothesis or reject it, the investigator chose five specialists, upon whom three criteria strongly connected to the Determinants of food security governance in Algeria. Through these, the following dimensions were extracted: national food security strategies (C1), agricultural innovation (C2), public-private partnerships (C3). Five alternatives were considered: risk (A1), international cooperation (A2), environmental sustainability (A3), national capacity development (A4), and infrastructure development (A5).

2.1 Phases of the fuzzy TOPSIS algorithm:

We shall examine the methodological phases of the fuzzy TOPSIS algorithm, which identifies the optimal alternative according to the proposed criteria to comprehend the role of Determinants of food security administration in Algeria. Accordingly, MDL (Modified Digital Logic) weights are employed to compare with all the criteria investigated that follow the philosophy of fuzzy logic with the TOPSIS method to achieve the ideal alternatives, through the following phases: (Ataeian & Darbandi, 2011, pp. 112-122)

A. Weight calculation MDL (Modified Digital Logic):

The weights are as follows:

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

$$Wj = \frac{Pj}{\sum_{j=1}^{n} Pj}$$

Therefore, the decision matrix can be granted as:

Table 1. Decision Matrix 1

	Alternatives				
Dimensions	A1	A2	A3	A4	A5
C1	Medium High	Medium High	Very High	Very Low	Medium Low
C2	Low	Medium	Medium Low	Medium	High
C3	High	Very Low	Medium Low	Very High	Very Low

Source: Prepared by the researcher

Table 2. Decision Matrix 2

Linguistic Expression	Triangular fuzzy numbers
Very good	(8,9,10)
Good	(7,8,9)
Middle Good	(5,7,8)
Fair	(4 ,5,6)
Middle poor	(2,3,5)
poor	(0,2,3)
Very Poor	(0,0,2)

Source: Prepared by the researcher

Table 3. Decision matrix by experts

criteria	Alternatives	Decision-makers		
		D1	D2	D3
A1	C1	Good	Good	Fair
	C2	Middle Good	Good	Very Good
	C3	Good	Middle Good	Middle Good
A2	C1	Good	Very Good	Very Good
	C2	Middle Good	Middle Good	Good
	C3	Fair	Good	Very Good
A3	C1	Middle Good	Middle Good	Middle Good
	C2	Very Good	Fair	Very Good
	C3	Fair	Middle Good	Middle Good
A4	C1	Middle Good	Middle Good	Fair
	C2	Good	Good	Very Good
	C3	Good	Fair	Fair
A5	C1	Middle Good	Very Good	Middle Good
	C2	Very Good	Good	Good
	C3	Good	Very Good	Very Good

Source: Prepared by the researcher

Table 4. Value Decision Matrix2

criteria	Alternatives	Decision-makers		
		D1	D2	D3
A1	C1	(7,8,9)	(7,8,9)	(4 ,5,6)
	C2	(5,7,8)	(7,8,9)	(8,9,10)
	C3	(7,8,9)	(5,7,8)	(5,7,8)
A2	C1	(7,8,9)	(8,9,10)	(8,9,10)
	C2	(5,7,8)	(5,7,8)	(7,8,9)
	C3	(4 ,5,6)	(7,8,9)	(8,9,10)

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

A3	C1	(5,7,8)	(5,7,8)	(5,7,8)
	C2	(8,9,10)	(4 ,5,6)	(8,9,10)
	C3	(4 ,5,6)	(5,7,8)	(5,7,8)
A4	C1	(5,7,8)	(5,7,8)	(4 ,5,6)
	C2	(7,8,9)	(7,8,9)	(8,9,10)
	C3	(2,3,5)	(4 ,5,6)	(4 ,5,6)
A5	C1	(5,7,8)	(8,9,10)	(5,7,8)
	C2	(8,9,10)	(7,8,9)	(7,8,9)
	C3	(7,8,9)	(8,9,10)	(8,9,10)

Source: Prepared by the researcher

B. Compute the aggregated fuzzy ratings for alternatives and the aggregated fuzzy weights for criteria.

The aggregated fuzzy rating $X_{ij} = (a_{ij}, b_{ij}, c_{ij})$

Of i^{th} alternative w.r.t j^{th} Criterion is obtained as: (Neelima, Ravi, & Patil, 2017, pp. 342-347)

Wj = (Wj1, Wj2, Wj3)

$$W_{j1} = min_K \{W_{j1}^K\}$$

$$W_{j2} = \frac{1}{K}\sum_{K=1}^{K} = W_{j2}^K$$

$$W_{j3} = max_K \{W_{j3}^K\}$$

Therefore, the matrix of uncertain decision-making would be:

Table 5. fuzzy decision matrix

criteria	Alternatives	Decision-makers			
		D1	D2	D3	$W_{j1=min_K}\{W_{j1}^K\}$ $W_{j2=}\frac{1}{K}\sum_{K=1}^{K} = W_{j2}^K$ $W_{j3=max_K}\{W_{j3}^K\}$
A1	C1	(7,8,9)	(7,8,9)	(4 ,5,6)	(4,7,9)
	C2	(5,7,8)	(7,8,9)	(8,9,10)	(5,8,10)
	C3	(7,8,9)	(5,7,8)	(5,7,8)	(5,7.33,9)
A2	C1	(7,8,9)	(8,9,10)	(8,9,10)	(7,8.67,10)
	C2	(5,7,8)	(5,7,8)	(7,8,9)	(5,7.33,9)
	C3	(4 ,5,6)	(7,8,9)	(8,9,10)	(4,7.33,10)
A3	C1	(5,7,8)	(5,7,8)	(5,7,8)	(5,7,8)
	C2	(8,9,10)	(4 ,5,6)	(8,9,10)	(4,7.67,10)
	C3	(4 ,5,6)	(5,7,8)	(5,7,8)	(4,6.33,8)
A4	C1	(5,7,8)	(5,7,8)	(4 ,5,6)	(4,6.33,8)
	C2	(7,8,9)	(7,8,9)	(8,9,10)	(7,8.67,10)
	C3	(2,3,5)	(4 ,5,6)	(4 ,5,6)	(2,3.33,6)
A5	C1	(5,7,8)	(8,9,10)	(5,7,8)	(5,7.67,10)
	C2	(8,9,10)	(7,8,9)	(7,8,9)	(7,8.33,10)
	C3	(7,8,9)	(8,9,10)	(8,9,10)	(7,8.67,10)

Source: Prepared by the researcher

C. Determining linguistic variables according to the fuzzy conversion scale to compare all alternatives for each criterion.

Table 6. Matrix of linguistic variables according to the fuzzy transformation scale

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Fuzzy numbers	Linguistic Variables
(0،0،0,1)	Very Low
(0،0,1،0,3)	Low
(0،1،0,3،0,5)	Medium Low
(0,3 ،0,5، 0,7)	Medium
(0,5 ،0,7، 0,9)	Medium High
(0,7 ،0,9، 1)	High
(0,9 ،1، 1)	Very High

Source: Prepared by the researcher

Therefore, the fuzzy decision matrix would be

Hence, the fuzzy decision matrix for the alternatives according to each criterion is: (Mohammadi & Aryaeefar, pp. 150-159)

Table 7. Fuzzy decision matrix for alternatives according to each criterion

	Standards (weights)		
Alternative	C1	C2	C3
A1	(0,5 ،0,7، 0,9)	(0،0,1،0,3)	(0,7 ،0,9، 1)
A2	(0,5 ،0,7، 0,9)	(0,3 ،0,5، 0,7)	(0،0،0,1)
A3	(0,9 ،1، 1)	(0،1،0,3،0,5)	(0،1،0,3،0,5)
A4	(0،0،0,1)	(0,3 ،0,5، 0,7)	(0,9 ،1، 1)
A5	(0،1،0,3،0,5)	(0,7 ،0,9، 1)	(0،0،0,1)

Source: Prepared by the researcher

D. Determining the fuzzy weights related to the factors:

Table 8. Fuzzy weight matrix

	Standards (weights)			
Alternative	C1	C2	C3	Wj=(Wj1, Wj2, Wj3)
A1	(0,5 ،0,7، 0,9)	(0،0,1،0,3)	(0,7 ،0,9، 1)	(0 ،0,57 ،1)
A2	(0,5 ،0,7، 0,9)	(0,3 ،0,5، 0,7)	(0،0،0,1)	(0،0,4 ،0,9)
A3	(0,9 ،1، 1)	(0،1،0,3،0,5)	(0،1،0,3،0,5)	(0,1 ،0,53 ،1)
A4	(0،0،0,1)	(0,3 ،0,5، 0,7)	(0,9 ،1، 1)	(0 ،0,5 ،1)
A5	(0،1،0,3،0,5)	(0,7 ،0,9، 1)	(0،0،0,1)	(0 ،0,4 ،1)

Source: Prepared by the researcher

And thus, the weights of the criteria are as follows:

Table 9. Weights of the standards

A1	A2	A3	A4	A5
(0 ،0,57 ،1)	(0،0,4 ،0,9)	(0,1 ،0,53 ،1)	(0 ،0,5 ،1)	(0 ،0,4 ،1)

Source: Prepared by the researcher

E. The ambiguous decision matrix

$$= \dot{max}\, j\{Cij\}\dot{C}_{ij}$$
$$= \dot{min}\, j\{aij\}\dot{a}_{j}^{-}$$

Table 10. The ambiguous decision matrix

	A1	A2	A3	A4	A5
C1	(4,7,9)	(7,8.67,10)	(5,7,8)	(4,6.33,8)	(5,7.67,10)
C2	(5,8,10)	(5,7.33,9)	(4,7.67,10)	(7,8.67,10)	(7,8.33,10)
C3	(5,7.33,9)	(4,7.33,10)	(4,6.33,8)	(2,3.33,6)	(7,8.67,10)

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

$\frac{C_j^*}{a_j^-}$	$=10\frac{C_1^*}{a_1^-}$	$=10\frac{C_2^*}{a_2^-}$	$=10\frac{C_3^*}{a_3^-}$	$=10\frac{C_4^*}{a_4^-}$	$=4\frac{a_5^-}{a_5^-}$

Source: Prepared by the researcher

Calculating the fuzzy decision matrix: by dividing the columns of the fuzzy decision matrix values (A1,A2,A3,A4) On value $\frac{C_j^*}{a_j^-}$ And dividing the column value(A5) On value $\frac{a_j^-}{a_j^-}$ (Indahingwati, Wajdi, & Susilo, pp. 109 – 114)

F. Result of the standard fuzzy decision matrix

Table 11. Standard fuzzy decision matrix

	A1	A2	A3	A4	A5
C1	(0.4,0.7,0.9)	(0.7,0.867,1)	(0.5,0.7,0.8)	(0.4,0.633,0.8)	(0.8,0.52,0.4)
C2	(0.5,0.8,1)	(0.5,0.733,0.9)	(0.4,0.767,1)	(0.7,0.867,1)	(0.57,0.48,0.4)
C3	(0.5,0.733,0.9)	(0.4,0.733,1)	(0.4,0.633,0.8)	(0.2,0.333,0.6)	(0.57,0.46,0.4)
$\frac{C_j^*}{a_j^-}$	$=10\frac{C_1^*}{a_1^-}$	$=10\frac{C_2^*}{a_2^-}$	$=10\frac{C_3^*}{a_3^-}$	$=10\frac{C_4^*}{a_4^-}$	$=4\frac{a_5^-}{a_5^-}$

Source: Prepared by the researcher

G. Weighted fuzzy decision matrix calculation

Let's assume we have a set of weights for each criterion Wj=(Wj1, Wj2, Wj3) for j =1,2,3 …..,n

We multiply each column of the fuzzy decision matrix by its associated weight.

One of the elements of the new matrix is: (Ali, Sultan, & Khan, 2016, pp. 35-41)

$$V_{ij}^- = r_{ij}^- \times W_j^-$$

Weight matrix

$$V_{ij}^- = \begin{pmatrix} w1 \times r11 & w2r21 & w3r31 \dots\dots\dots\dots\dots wnrn1 \\ w1 \times r12 & w2r22 & w3r32 \dots\dots\dots\dots\dots wnrn2 \\ w1 \times r11 & w2r21 & w3r31 \dots\dots\dots\dots\dots wnrn3 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ w1 \times r1m & w2r2m & w3r3m \dots\dots\dots\dots\dots wnrnm \end{pmatrix}$$

Table 12. Weights of the standards

	A1	A2	A3	A4	A5
	(0 ،0,57 ،1)	(0،0,4 ،0,9)	(0,1 ،0,53 ،1)	(0 ،0,5 ،1)	(0 ،0,4 ،1)
Wj	W1	W2	W3	W4	W5

Source: Prepared by the researcher

We are lifting weights (W1, W2, W3, W4, W5) In the corresponding columns of the matrix.

$$X \times Y = \begin{pmatrix} a1 \\ b1 \\ c1 \end{pmatrix} \times \begin{pmatrix} a2 \\ b2 \\ c2 \end{pmatrix} = \begin{pmatrix} a1a2 \\ b1b2 \\ c1c2 \end{pmatrix}$$

Thus, the weight matrix is as follows:

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Table 13. Weight matrix

	A1	A2	A3	A4	A5
C1	(0,0. 39,0.9)	(0,0.34,0.9)	(0.05,0.37,0.8)	(0,031,0.8)	(0,0.20,0.4)
C2	(0,0.45,1)	(0,0.29,0.81)	(0.04,0.40,1)	(0,0.43,1)	(0,0.19,0.4)
C3	(0,0.41,0.9)	(0,0.29,0.9)	(0.04,0. 33,0.8)	(0,0.16,0.6)	(0,0.18,0.4)

Source: Prepared by the researcher

2.2 The calculation of the ideal fuzzy positive and negative solution is as follows:

$$\dot{A}^* = \dot{V}_1^*, \dot{V}_2^*, \dot{V}_3^* \ldots\ldots\ldots \dot{V}_n^*$$
$$\dot{V}_j^* = \dot{m}ax_j = \{V_{ij}\}$$
$$\dot{A}^- = \dot{V}_1^-, \dot{V}_2^-, \dot{V}_3^- \ldots\ldots\ldots \dot{V}_n^-$$
$$\dot{V}_j^- = \dot{m}in_j = \{V_{ij}\}$$

Table 14. The positive and negative fuzzy solution

	A1	A2	A3	A4	A5
C1	(0,0. 39,0.9)	(0,0.34,0.9)	(0.05,0.37,0.8)	(0,031,0.8)	(0,0.20,0.4)
C2	(0,0.45,1)	(0,0.29,0.81)	(0.04,0.40,1)	(0,0.43,1)	(0,0.19,0.4)
C3	(0,0.41,0.9)	(0,0.29,0.9)	(0.04,0. 33,0.8)	(0,0.16,0.6)	(0,0.18,0.4)
$\dot{A}^*$	(0,0.45,1)	(0,0.34,0.9)	(0.04,0.40,1)	(0,0.43,1)	(0,0.20,0.4)
$\dot{A}^-$	(0,0. 39,0.9)	(0,0.29,0.81)	(0.04,0. 33,0.8)	(0,0.16,0.6)	(0,0.18,0.4)

Source: Prepared by the researcher

A. Calculating the distance from each alternative to the fuzzy solution positive:

(Vahdani, Mousavi, & Tavakkoli-Moghaddam, pp. 4257–4269)

$$\dot{d}_j^* = \sum_{j=1}^{n} d(V_{ij}, A^*)$$
$$\dot{d}(x,y) = \sqrt{(a1-a2)^2 + (b1-b2)^2 + (c1-c2)^2}$$

Table 15. Distance from each alternative to the positive fuzzy solution

		A1	A2	A3	A4	A5
C1		(0,0.39,0.9)	(0,0.34,0.9)	(0.05,0.37,0.8)	(0,031,0.8)	(0,0.20,0.4)
C2		(0,0.45,1)	(0,0.29,0.81)	(0.04,0.40,1)	(0,0.43,1)	(0,0.19,0.4)
C3		(0,0.41,0.9)	(0,0.29,0.9)	(0.04,0. 33,0.8)	(0,0.16,0.6)	(0,0.18,0.4)
	$\dot{A}^*$	(0,0.45,1)	(0,0.34,0.9)	(0.04,0.40,1)	(0,0.43,1)	(0,0.20,0.4)
$\dot{d}(V_{ij}, A^*)$	A1	0,11	0	0,20	0,23	0
	A2	0	0,10	0	0	0,01
	A3	0,10	0,05	0,21	0,48	0,02

Source: Prepared by the researcher

B. Calculating the distance from each alternative to the fuzzy solution Negative:

$$\dot{d}_j^- = \sum_{j=1}^{n} d(V_{ij}, A^-)$$
$$\dot{d}(x,y) = \sqrt{(a1-a2)^2 + (b1-b2)^2 + (c1-c2)^2}$$

Table 16. distance from each alternative to the negative fuzzy solution

	A1	A2	A3	A4	A5

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

C1		(0,0. 39,0.9)	(0,0.34,0.9)	(0.05,0.37,0.8)	(0,031,0.8)	(0,0.20,0.4)
C2		(0,0.45,1)	(0,0.29,0.81)	(0.04,0.40,1)	(0,0.43,1)	(0,0.19,0.4)
C3		(0,0.41,0.9)	(0,0.29,0.9)	(0.04,0. 33,0.8)	(0,0.16,0.6)	(0,0.18,0.4)
	A^-	(0,0. 39,0.9)	(0,0.29,0.81)	(0.04,0.33,0.8)	(0,0.16,0.6)	(0,0.18,0.4)
$d(V_{ij}, A^-)$	A1	0	0,10	0,04	0,25	0,02
	A2	0,11	0	0,21	0,48	0,01
	A3	0,02	0,09	0	0	0

Source: Prepared by the researcher

C. Calculating the closeness coefficient for alternative

select the option with closest to 1

$$C_j = \frac{d_j^-}{d_j^- + d_j^*}$$

Table 17. The distance from each alternative to the negative fuzzy solution

	C1	C2	C3	C4	C5	d_i^*
A1	0,11	0	0,20	0,23	0	0,54
A2	0	0,10	0	0	0,01	O,11
A3	0,10	0,05	0,21	0,48	0,02	0,86

Source: Prepared by the researcher

Table 18. The distance from each alternative to the positive fuzzy solution

	C1	C2	C3	C4	C5	d_i^-
A1	0	0,10	0,04	0,25	0,02	0,41
A2	0,11	0	0,21	0,48	0,01	O,81
A3	0,02	0,09	0	0	0	0,11

Source: Prepared by the researcher

D. Alternatives Arrangement

Table 18: Alternatives Arrangement

	d_i^*	d_i^-	$C_j = \frac{d_j^-}{d_j^- + d_j^*} C$	Rank
C1	0,54	0,41	0,431	2
C2	O,11	O,81	O,880	1
C3	0,86	0,11	0,113	3

Source: Prepared by the researcher

According to the preceding table, it becomes apparent that the symbol "$\frac{d_j^-}{d_j^- + d_j^*} = C_j\ C$" denotes the degree of influence each factor has in determining food security governance in Algeria.

According to the cause-and-effect relationship, the factor “Agricultural Innovation” is identified as the most influential in the evaluation, with a value of (0.880). The factor “National Food Security Strategies” ranks second, with an estimated value of (0.431), while the factor “Public-Private Partnership” is the least important, with an estimated value of (0.113).

As for the prioritization of factors, this analysis highlights for Algerian executives and experts the importance of making informed decisions, particularly regarding the significant emphasis on factor A2, due to its positive impact on other factors in achieving effective food security governance in Algeria.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

When the value "$\frac{d_j^- - d_j^+}{d_j^- + d_j^+} = C_j$ " is positive in this instance, the factor is categorized within the cause group and directly influences others (direct impact), and the greater the value, the more it influences others. Factors "A1," "A2," "A3," "F4," and "F5" are categorized within the cause group.

When the value "$\frac{d_j^- - d_j^+}{d_j^- + d_j^+} = C_j$ " is negative in this instance, these factors are categorized as the impact or effect group. In our present study, there is no factor from the effect group, as one factor influences all the other factors.

3. Conclusion:

The significance of the agricultural sector in Algeria goes beyond being merely a source of food; it is a vital element in achieving food security, making it a constant focus of national policies. Despite the significant potential this sector holds, it faces numerous challenges such as climate change and reliance on traditional farming techniques. Under these conditions, innovation becomes an urgent necessity to stimulate growth and improve productivity. Innovation can contribute to the development of modern agricultural methods, better resource management, and enhanced competitiveness among farmers. This includes the use of modern technology, the development of sustainable strategies, and the adoption of new agricultural practices.

Indicators in Algeria suggest that adopting modern techniques such as organic farming and smart agriculture can help improve crop productivity. Additionally, strengthening collaboration between universities, research centers, and the private sector is essential to support innovation through the development of national strategies that encourage the adoption of new technologies. By doing so, Algeria can enhance its competitiveness in regional and international markets, contributing to sustainable economic growth and strengthening food security. In this context, the investigation achieved a number of significant findings, which are:

- Algeria has made numerous efforts to promote the agricultural sector, mainly through supporting agricultural development and introducing various financing schemes for agricultural and rural activities.
- Despite these efforts, the various agricultural policies adopted in Algeria have largely failed, as have the programs intended to support the farming sector. This is evidenced by recurring crises such as the wheat and potato shortages, indicating that the substantial funds allocated to support farmers have not achieved their intended goals.
- The Agricultural and Rural Renewal Policy has contributed—albeit unevenly—to increasing the utilization of agricultural land, which could help boost agricultural production, self-sufficiency rates, and food security. However, this contribution remains very limited.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

- Since independence, Algeria has not been able to break its dependence on the hydrocarbons sector, which has kept agriculture as a secondary contributor to the country's Gross Domestic Product.
- Despite the efforts made, the actual implementation of plans and policies on the ground remains weak, mainly due to the failure to properlytitle consider economic and social realities. The approach remains approximate and lacks effective monitoring and follow-up mechanisms.
- Agricultural policies in Algeria do not stem from the actual realities on the ground, nor do they adequately consider human capital, which plays a crucial role in the success of any policy.

4. Recommendations:

- Support research institutions and universities to increase investment in agricultural research and development, aiming to develop new and improved technologies suited to Algeria’s climate and environmental conditions. This requires strengthening collaboration between the public and private sectors in the fields of research and innovation.
- Influence and diversify individual consumption patterns, which are currently heavily based on cereals, by promoting a more varied intake of other food groups.
- Adopt smart farming technologies, including artificial intelligence, to improve productivity and resource-use efficiency.
- Provide educational and training platforms for farmers to enable them to adopt and effectively use modern agricultural technologies.
- Establish strategic reserves of key food commodities to stabilize prices and mitigate the risks of food shortages, especially for staple goods-and modernize grain storage processes.
- Promote sustainable agricultural practices that consider environmental protection, such as organic farming and reduced use of chemical fertilizers and pesticides. This includes offering incentives to farmers who follow these practices and providing technical and financial support to develop these farming methods.
- Adopt global best practices in agricultural innovation, whether through advanced technologies or by partnering with countries that have successful experiences in the field.
- Enhance collaboration between the government and the private sector through strategic partnerships aimed at improving agricultural infrastructure and implementing modern technologies. These partnerships could include projects in irrigation, transportation, and storage.

5. References:

Abeda Al-Sultan, Y., & Khan, F. M. (n.d.). Comparison of Fuzzy Multiplication Operation on Triangular Fuzzy. *IOSR Journal of Mathematics, 12*(4), 35-41.
Aguilera, R. V., & Cuervo-Cazurra, A. (2009). Codes of good governance. *Corporate Governance: An International Review*, 17(3), 376-387.
Aguilera, R. V., & Jackson, G. (2003). The cross-national diversity of corporate governance: Dimensions and determinants. *Academy of Management Review*, 28(3), 447-465.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Ait-Amara, H. (2010). Agricultural policies and food security in Algeria: Challenges and prospects. *New Medit*, 9(1), 15-23.
Ali, M. Y., Sultana, A., & Khan, A. F. M. K. (2016). Comparison of fuzzy multiplication operation on triangular fuzzy number. *IOSR Journal of Mathematics*, *12*(4-I), 35-41.
Alston, J. M., & Pardey, P. G. (2014). Agriculture in the global economy. *Journal of Economic Perspectives*, 28(1), 121-146.
Alston, J. M., Andersen, M. A., James, J. S., & Pardey, P. G. (2009). *Persistence pays: US agricultural productivity growth and the benefits from public R&D spending*. Springer Science & Business Media.
Anderson, J. R., Feder, G., & Ganguly, S. (2010). The rise and fall of training and visit extension: An Asian mini-drama with an African epilogue. In *Changing roles of agricultural extension in Asian nations* (pp. 149-174). B.E. Swanson.
Anderson, K., Nelgen, S., & Strutt, A. (2013). *Agricultural trade reforms and poverty reduction in developing countries*. World Bank Publications.
Ataeian, S. M., & Darbandi, M. J. (2011). *Analysis of Quality of Experience by applying Fuzzy logic: A study on response time*. Master thesis
Barrett, C. B. (2010). Measuring food insecurity. *Science*, 327(5967), 825-828.
Barrett, C. B., & Bevis, L. E. (2015). The self-reinforcing feedback between low soil fertility and chronic poverty. *Nature Geoscience*, 8(12), 907-912.
Bedrani, S. (2008). Agriculture and food security in Algeria: Challenges and policy responses. *Mediterranean Politics*, 13(3), 377-395.
Belkacem, N., & Mekhlouf, T. (2021). Agricultural transformation and rural development in Algeria: Assessment and future prospects. *Journal of North African Studies*, 26(4), 712-732.
Benissad, H. (1991). *Algeria: From socialism to market economy*. Westview Press.
Bessaoud, O. (2016). Agricultural and rural development policies in Algeria: Evolution and current challenges. *Options Méditerranéennes*, Serie B, 73, 123-142.
Bevir, M., & Rhodes, R. A. W. (2003). *Interpreting British governance*. Routledge.
Boudjenah, M. (2019). Institutional framework for food security governance in Algeria: Analysis and recommendations. *Food Policy*, 87, 101-115.
Brahimi, M. (2009). The agricultural revolution in Algeria: Achievements and limitations. *Review of African Political Economy*, 36(119), 95-112.
Byerlee, D., & Fischer, K. (2002). Accessing modern science: Policy and institutional options for agricultural biotechnology in developing countries. *World Development*, 30(6), 931-948.
Campbell, B. M., Vermeulen, S. J., Aggarwal, P. K., Corner-Dolloff, C., Girvetz, E., Loboguerrero, A. M., ... & Wollenberg, E. (2017). Reducing risks to food security from climate change. *Global Food Security*, 16, 34-43.
Capone, R., Bilali, H. E., Debs, P., Cardone, G., & Driouech, N. (2014). Food security and nutrition in the Mediterranean region: Analysis of the current situation. *New Medit*, 13(2), 2-12.
Clarke, T. (2007). *International corporate governance: A comparative approach*. Routledge.
Conceição, P., Levine, S., Lipton, M., & Warren-Rodríguez, A. (2016). Toward a food secure future: Ensuring food security for sustainable human development in Sub-Saharan Africa. *Food Policy*, 60, 1-9.
Diao, X., Hazell, P., & Thurlow, J. (2012). The role of agriculture in African development. *World Development*, 38(10), 1375-1383.
Donaldson, T., & Preston, L. E. (1995). The stakeholder theory of the corporation: Concepts, evidence, and implications. *Academy of Management Review*, 20(1), 65-91.
Drèze, J., & Sen, A. (1989). *Hunger and public action*. Oxford University Press.
Duflo, E., Kremer, M., & Robinson, J. (2008). How high are rates of return to fertilizer? Evidence from field experiments in Kenya. *American Economic Review*, 98(2), 482-488.
Evenson, R. E. (2001). Economic impacts of agricultural research and extension. *Handbook of Agricultural Economics*, 1, 573-628.
FAO. (2008). *An introduction to the basic concepts of food security*. Food and Agriculture Organization of the United Nations.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

FAO. (2013). *Climate-smart agriculture sourcebook*. Food and Agriculture Organization of the United Nations.
FAO. (2015). *Innovation in family farming*. Food and Agriculture Organization of the United Nations.
FAO. (2015). *the state of food and agricultural : innovations in agricultural.* ROMA.
FAO. (2015). *The state of food insecurity in the world 2015: Meeting the 2015 international hunger targets: Taking stock of uneven progress*. Food and Agriculture Organization of the United Nations.
FAO. (2018). *Regional overview of food security and nutrition in the Near East and North Africa 2017*. Food and Agriculture Organization of the United Nations.
FMI. (2004). *puplic private partnerhips the fiscal affairs devlopment.* New York.
Foster, A. D., & Rosenzweig, M. R. (2010). Microeconomics of technology adoption. *Annual Review of Economics*, 2(1), 395-424.
Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Cambridge University Press.
Fuglie, K. O. (2018). R&D capital, R&D spillovers, and productivity growth in world agriculture. *Applied Economic Perspectives and Policy*, 40(3), 421-444.
Gilbert, C. L., & Morgan, C. W. (2010). Food price volatility. *Philosophical Transactions of the Royal Society B*, 365(1554), 3023-3034.
Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., ... & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science*, 327(5967), 812-818.
Harbouze, R., Pellissier, J. P., Rolland, J. P., & Khechimi, W. (2019). *Report on agriculture in Algeria*. CIHEAM-IAMM.
Headey, D., & Fan, S. (2010). *Reflections on the global food crisis: How did it happen? How has it hurt? And how can we prevent the next one?* International Food Policy Research Institute.
Hirschman, A. O. (1958). *The strategy of economic development*. Yale University Press.
Indahingwati, A., Wajdi, N., & Susilo, E. K. (n.d.). Comparison Analysis of TOPSIS and Fuzzy Logic Methods On Fertilizer Selection. *International Journal of Engineering & Technology, 7*(1), 109-114.
Jensen, M. (2001). Value maximisation, stakeholder theory, and the corporate objective function. *European financial management*, *7*(3), 297-317.
Jouve, A. M., & Bellabed, N. (2020). Food security policies in North Africa: The case of Algeria and Tunisia. *Mediterranean Politics*, 25(2), 201-225.
Judge, W. Q., Gaur, A., & Muller-Kahle, M. I. (2008). Antecedents of shareholder activism in target firms: Evidence from anti-takeover, environmental, and social shareholder proposals. *Corporate Governance: An International Review*, 16(5), 408-423.
Just, R. E., & Zilberman, D. (1988). The effects of agricultural development policies on income distribution and technological change in agriculture. *Journal of Development Economics*, 28(2), 193-216.
Kaufmann, D., Kraay, A., & Zoido-Lobatón, P. (1999). *Governance matters* (World Bank Policy Research Working Paper No. 2196). World Bank.
Klerkx, L., & Rose, D. (2020). Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? *Global Food Security*, 24, 100347.
Klerkx, L., Van Mierlo, B., & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: Concepts, analysis and interventions. In *Farming systems research into the 21st century: The new dynamic* (pp. 457-483). Springer.
Kooiman, J. (2003). *Governing as governance*. Sage Publications.
Krueger, A. O., Schiff, M., & Valdés, A. (1991). *The political economy of agricultural pricing policy*. Johns Hopkins University Press.
Lamiri, A., Kacemi, M., & Abdelguerfi, A. (2023). Climate change and agricultural adaptation strategies in Algeria: Economic and policy implications. *Agricultural Systems*, 205, 103-118.
land, F. (2001). *basal committée guide ance on governance for bank.* suisse: bank international.
Lasram, A., & Dhehibi, B. (2019). Agricultural development policies in Algeria: Assessment and future directions. *New Medit*, 18(3), 45-62.
Lawless, R. I. (1984). Algeria: The contradictions of rapid industrialization. In *The Middle East: Oil, Conflict and Hope* (pp. 153-190). Croom Helm.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Lebrague, R. M., Chelil, A., & Meziane, T. (2019). Internal audit and its role in assuring an effective corporate governance implementation: A theoretical analysis. *Finance and Business Economies Review*, *3*(1), 210-221.
Lewis, W. A. (1954). Economic development with unlimited supplies of labour. *The Manchester School*, 22(2), 139-191.
Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., ... & Torquebiau, E. F. (2014). Climate-smart agriculture for food security. *Nature Climate Change*, 4(12), 1068-1072.
Lundvall, B. Å. (Ed.). (1992). *National systems of innovation: Towards a theory of innovation and interactive learning*. Pinter Publishers.
Malthus, T. R. (1798). *An essay on the principle of population*. J. Johnson.
Maxwell, S. (1996). Food security: A post-modern perspective. *Food Policy*, 21(2), 155-170.
Maxwell, S., & Smith, M. (1992). Household food security: A conceptual review. In S. Maxwell & T. R. Frankenberger (Eds.), *Household food security: Concepts, indicators, measurements* (pp. 1-72). UNICEF and IFAD.
Ministry of Agriculture and Rural Development. (2020). *National strategy for agricultural development and food security 2020-2030*. Government of Algeria.
Mohammadi, A., & Aryaeefar, h. (n.d.). Introducing a new method to expand TOPSIS decision making model to fuzzy TOPSIS. *Journal of Mathematics and Computer Science, 2*(1), 150-159.
Neelima, B. K., Ravi, K., & Patil, S. (2017). A Simplified Description of FUZZY TOPSIS Method for Multi Criteria Decision Making International Research. *Journal of Engineering and Technology*, 342-347.
OCED. (2016). *innovation : agricultural productivity and sustainability in the united states.* PARIS. Retrieved from https://doi.org/10.1787/24114278.
OECD. (2016). *Innovation, agricultural productivity and sustainability in the United States*. OECD Food and Agricultural Reviews, OECD Publishing.
Osborne, D., & Gaebler, T. (1992). *Reinventing government: How the entrepreneurial spirit is transforming the public sector*. Addison-Wesley.
Pardey, P. G., Alston, J. M., & Chan-Kang, C. (2016). *Agricultural production, productivity and R&D over the past half century: An emerging new world order*. InSTePP Working Paper. University of Minnesota.
Peters, B. G., & Pierre, J. (1998). Governance without government? Rethinking public administration. *Journal of Public Administration Research and Theory*, 8(2), 223-243.
Pierre, J., & Peters, B. G. (2000). *Governance, politics and the state*. Macmillan.
Pinstrup-Andersen, P. (2009). Food security: Definition and measurement. *Food Security*, 1(1), 5-7.
Pinstrup-Andersen, P., & Watson, D. D. (2011). *Food policy for developing countries: The role of government in global, national, and local food systems*. Cornell University Press.
Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., ... & Wratten, S. (2018). Global assessment of agricultural system redesign for sustainable intensification. *Nature Sustainability*, 1(8), 441-446.
Rhodes, R. A. W. (1997). *Understanding governance: Policy networks, governance, reflexivity and accountability*. Open University Press.
Ricardo, D. (1817). *On the principles of political economy and taxation*. John Murray.
Roberts, H. (2003). *The battlefield: Algeria 1988-2002*. Verso Books.
Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5, Part 2), S71-S102.
Ruttan, V. W. (2001). *Technology, growth, and development: An induced innovation perspective*. Oxford University Press.
Sameh, F. (2000). *concepts of scientific foundations of knowledge International Center for Future and Strategic Studies.* CAIRO.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Schneider, U. A., Havlík, P., Schmid, E., Valin, H., Mosnier, A., Obersteiner, M., ... & Fritz, S. (2011). Impacts of population growth, economic development, and technical change on global food production and consumption. *Agricultural Systems*, 104(2), 204-215.
Sen, A. (1981). *Poverty and famines: An essay on entitlement and deprivation*. Oxford University Press.
Sen, A. (1999). *Development as freedom*. Oxford University Press.
Smith, L. C., & Haddad, L. (2015). Reducing child undernutrition: Past drivers and priorities for the post-MDG era. *World Development*, 68, 180-204.
Stoker, G. (1998). Governance as theory: Five propositions. *International Social Science Journal*, 50(155), 17-28.
Sunding, D., & Zilberman, D. (2001). The agricultural innovation process: Research and technology adoption in a changing agricultural sector. *Handbook of Agricultural Economics*, 1, 207-261.
Sutton, K. (1982). Algeria's socialist villages: A reassessment. *The Journal of Modern African Studies*, 20(2), 223-248.
Thirtle, C., Lin, L., & Piesse, J. (2003). The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America. *World Development*, 31(12), 1959-1975.
Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, 108(50), 20260-20264.
Timmer, C. P. (2000). The macro dimensions of food security: Economic growth, equitable distribution, and food price stability. *Food Policy*, 25(3), 283-295.
Timmer, C. P., Falcon, W. P., & Pearson, S. R. (1983). *Food policy analysis*. Johns Hopkins University Press.
Trendov, N. M., Varas, S., & Zeng, M. (2019). *Digital technologies in agriculture and rural areas: Status report*. Food and Agriculture Organization of the United Nations.
United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. United Nations General Assembly.
Vahdani, B., Mousavi, S., & Tavakkoli-Moghaddam, R. (s.d.). Group decision making based on novel fuzzy modified TOPSIS method. *(35)*, 4257–4269. Applied Mathematical Modeling.
Watts, M., & Bohle, H. G. (1993). The space of vulnerability: The causal structure of hunger and famine. *Progress in Human Geography*, 17(1), 43-67.
Webb, P., Coates, J., Frongillo, E. A., Rogers, B. L., Swindale, A., & Bilinsky, P. (2006). Measuring household food insecurity: Why it's so important and yet so difficult to do. *The Journal of Nutrition*, 136(5), 1404S-1408S.
Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming–a review. *Agricultural Systems*, 153, 69-80.
World Bank. (1986). *World development report 1986*. Oxford University Press.
World Bank. (1992). *Governance and development*. World Bank Publications.
World Bank. (2012). *Agricultural innovation systems: An investment sourcebook*. World Bank Publications.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)