

Research Paper: Foresight analysis of Sustainable Food Security in Rural Areas of East Azarbaijan Province

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ABSTRACT

Purpose: East Azerbaijan Province plays a pivotal role in Iran's food production, yet it still falls short of international food security benchmarks. Therefore, a foresight-based scientific approach is essential to design sustainable future scenarios. This study aims to examine the interrelationships of various factors affecting food security and to develop realistic future scenarios to guide rural policy and planning.

Methods: The study employed an impact analysis method and expert-based foresight techniques. A survey was conducted with 31 experts in the food industry, agriculture, and future studies from the University of Tabriz. A total of 58 influencing factors were identified across four dimensions and organized into a 58 × 58 cross-impact matrix to examine their mutual relationships and potential influence on the future of food security.

Results: The results showed that 54% of the factors influenced each other. Additionally, 33 possible states (ranging from optimal to sub-optimal) were designed for 11 key factors. Analysis revealed that 7,894 scenarios were weak and unreliable, while only 2 strong and 81 highly consistent scenarios were considered feasible for future planning.

Conclusion: Among the viable scenarios, "Effective Planning to Reduce Food Waste and Loss" was identified as a valuable and most consistent scenario. This suggests that policies targeting waste and loss reduction are critical for enhancing food security in the province.

1. Introduction

T

he right to food includes the responsibility to assist individuals who are unable to

care for themselves. Over the past two decades, scientific attention to food insecurity has considerably increased due to the rising frequency of natural disasters, price inflation, food shortages, and social unrest. Currently, over 2 billion people lack stable access to healthy, sufficient,

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and nutritious food (Cheraghi, 2022: 212). The instability of food systems is the main cause of food insecurity and malnutrition, as a well-functioning food system is the foundation of food security. To address food and nutrition challenges, food systems must undergo fundamental transformations to improve resource efficiency, equity, and transition towards sustainable diets. In other words, all components of food systems—including production, processing, and distribution—must be sustainable, resilient, and efficient (Capone et al., 2018: 176).

Food security is a key element of intellectual, psychological, and physical health, and the cornerstone of a developed society. However, food insecurity remains a serious issue, particularly in less-developed and developing countries (Gholizadeh et al., 2017: 57). It is widely acknowledged that food security is both a prerequisite for societal development and a key indicator of human health and social justice (Oghati et al., 2020: 200). Consequently, it is increasingly recognized as one of the essential dimensions of sustainable development, rural development, and agricultural policy—especially concerning vulnerable and marginalized populations (Azimi Dezfuli et al., 2019: 82).

The 2030 Sustainable Development Agenda introduces several goals linked to the socio-economic conditions of disadvantaged communities. These goals aim to promote sustainable economic growth, access to affordable and reliable energy, ensure sustainable water access and management, achieve food security, improve nutrition, and take actions to address climate change and its impacts (Cansino-Loeza et al., 2021: 1250).

Despite the implementation of numerous global, regional, and national programs aimed at improving nutrition and food security, there remain serious concerns about the ability of developing countries to achieve food security. Approximately 25% of their populations experience food insecurity, with rural communities being disproportionately affected (Boliko, 2019). Predictions of significant population growth in developing countries further increase the urgency of the issue (FAO, 2011). At the same time, it is anticipated that due to lifestyle changes, population growth, and political and social tensions, the quality of life for rural households will significantly decrease. Climate change and the exacerbation of drought crises have further intensified this issue (Keshavarz, 2020: 84). According to SOFI (2015), approximately 20% of the world's population is affected by hunger, and 795 million people still lack sufficient food for an active and healthy life.

The increasing population in rural areas, along with challenges such as climate change and resource management, has resulted in insufficient food production and a decline in the nutritional well-being of households. As a result, scholars are searching for a food system that ensures food security while preserving the environment for all individuals (Malekifard et al., 2021: 277). Meanwhile, UN projections suggest that the global population could exceed 8 billion by 2025 without a proportionate rise in food production, especially in countries experiencing high population pressure. The sharp rise in food prices since 2006 has significantly exacerbated global food insecurity; in 2007 alone, 75 million additional people were added to the global hunger count (Sarlio-Latheenkorva & Lahelma, 2008: 187).

Food Security always refers to the availability of sufficient food for all people to lead a healthy life. This definition is based on three components: food availability, accessibility, and sustainability (FAO, 2008). Achieving food security is a key priority in national development agendas, including in Iran, where it has been repeatedly emphasized in constitutional law, national development plans, and resistance economy policies. From a national development perspective, social justice and economic growth, ensuring adequate food, both in terms of quantity and quality of the dietary pattern and nutritional health of individuals, are the central and determining factor in the human-centered development process. Malnutrition is considered a major obstacle to economic growth and equitable development (Bayanati et al., 2022: 201).

According to the 2008 global food security map, Iran was categorized as one of the high-risk areas for food security (Seyed Hamzeh & Damari, 2017: 229). Therefore, food security and nutrition go beyond merely providing food; they are essential for ensuring the health of society and reducing poverty. Official documents, such as Article 3, Clause 12 of the Constitution and the 2025 National Vision, explicitly highlight the elimination of malnutrition and the attainment of food security as national priorities (Seyed Hamzeh & Damari, 2017: 229).

Furthermore, the assessment of food security in Iran indicates that, although the country is relatively favorable in terms of per capita food energy consumption, the unequal distribution of income and food across impoverished provinces have restricted food access in poorer rural regions (Bagherzadeh et al., 2016: 49). Nearly 75% of the food-insecure population lives in rural areas, demonstrating that food insecurity often coexists with income poverty.

Consequently, the National Nutrition and Food Security Document (2011-2019) strongly emphasizes the need to ensure food security. In this regard, policies and actions such as the formation of the Supreme Council for Health and Food Security, preparing and implementing necessary educational programs to improve nutrition knowledge and literacy, ensuring the availability of essential food items, and guaranteeing a proper market, as well as mandatory food fortification, have been emphasized to achieve food security goals in the country (Bagherzadeh et al., 2016: 49).

Due to population pressures, environmental stressors, and disruptions in supply-demand dynamics, food security has evolved into one of the most complex challenges of the 21st century (FAO, 2010). Assessing food security is similarly complex, as it spans multiple scales—from national and regional coverage to household and individual access (Nebie et al., 2021: 1).

Given the existing research gap, it can be stated that although numerous studies have examined food security in urban and rural areas using diverse analytical tools, no research has specifically focused on foresight-based approaches to sustainable food security in rural areas of East Azerbaijan Province. This highlights the necessity and originality of the present study. East Azerbaijan Province—with its substantial agricultural, horticultural, and livestock capacities—is among Iran's major food production hubs and plays a vital role in national food security. However, despite better performance relative to many other provinces, the latest findings indicate that only 43% of households are food-secure, while 57% experience varying degrees of food insecurity. These figures remain far below global standards, where food insecurity rates in high-income countries typically fall below 10%. Additionally, rural households in East Azerbaijan exhibit greater food poverty than urban populations. Thus, while the province has strong agricultural potential, addressing food insecurity requires a scientific, foresight-based approach to develop sustainable future strategies. This study is dedicated to examining this issue and constructing realistic scenarios for the future of sustainable food security in rural East Azerbaijan.

2. Literature Review

Food security has been widely studied in Iran and globally, with research examining a range of economic, social, environmental, and policy-related determinants. National studies have investigated issues such as subsidy policies, socio-economic characteristics, agricultural resources, and rural-urban linkages, revealing their

complex short- and long-term implications for rural households. Meanwhile, international research has addressed broader themes, including class and religion, livelihood diversification, land and soil security, and integrated farming systems, highlighting pathways toward sustainable food systems. Together, these studies provide a valuable foundation for understanding food security dynamics, while highlighting the need for context-specific and future-oriented analyses.

Although previous studies—both in Iran and internationally—have identified various factors influencing rural food security, several significant research gaps remain:

Lack of foresight-oriented research on rural food security in Iran: Most domestic studies have been retrospective and descriptive in nature, with minimal use of forward-looking approaches such as scenario planning and strategic foresight.

Absence of a focused study on East Azerbaijan Province: None of the existing research has specifically analyzed the dynamics of sustainable food security in this province using a foresight methodology.

Limited integration of ecological, socio-economic, and institutional factors: Previous research has often examined a single dimension, whereas this study adopts a holistic framework that combines ecological, economic, social, and institutional variables to envision alternative futures for rural food security.

By addressing these gaps, the present study provides a comprehensive foresight analysis that can support policymakers and stakeholders in designing adaptive, sustainable strategies tailored to the specific context of East Azerbaijan's rural areas.

Various studies have been conducted on the topic of food security among rural households, focusing on the factors influencing their food security status. These studies primarily aim to identify and analyze the effects of price and input subsidies, social capital, non-agricultural livelihoods, climate change, and supportive institutions. Specifically:

Price and Input Subsidies: Some studies show that agricultural subsidies can improve food security in the short term but create dependency and inefficiency in the long term, emphasizing the need for targeted and diversified support tools.

Table 1. National and International Research Background

	Key Findings	Research Topic	Authors (Year)
National studies	Negative price subsidies and positive input subsidies have a short-term positive effect on the food security of rural households, but a negative long-term effect.	Price and input subsidies in the agricultural sector	Mehrabi Bashar Abadi & Mousavi Mohammadi (2010)
	Malaysia, Iran, and Thailand rank first to third in terms of food security.	Food security in countries	Bakhshi et al. (2011)
	Income, employment rate, ownership of agricultural machinery, and wheat yield have an impact on the food security of rural households.	Factors affecting food security of rural households	Asgharian et al. (2013)
	A significant relationship was observed between income, father's occupation, mother's education level, and household size with food security.	Relationship between socio-economic status and food security	Rostami et al. (2014)
	Household size and the number of educated and literate household heads have a negative effect on food security. University education improves awareness of food quality.	Variables affecting food security in urban and rural models	Pakravan et al. (2015)
	The food security status of individuals is weak. Attention to the "Islamic-Iranian model of rural food security" is essential.	Food security status in rural areas	Behrozeh & Shahvali (2016)
	Weak agricultural support systems, increasing food prices, climate change, and underdevelopment of rural communities are major challenges to food security in rural areas.	Challenges of food security in rural communities	Savari and Ghanyan (2019)
	Components of social capital (trust, cohesion, participation) have a positive and significant impact on the food security of households.	The impact of social capital on food security in rural households	Savari et al. (2021)
International studies	52 factors affecting sustainable food security were identified, and the variable distribution in the study area is unstable.	Rural-urban linkages for sustainable food security	Shafiei Sabet & Mirvahidi (2022)
	Adapting rural food systems to various driving factors is essential to strengthening food security.	Food security for the poor	Graf et al. (2014)
	Small farms have greater crop diversity and higher self-consumption in food products.	Crop diversity in small farms	Alexandri et al. (2015)
	There is a conflict between promoting innovations for sustainable food production and concerns about losing agroecological principles.	The paradox of ecological agriculture flow	Pant (2016)
	Sustainable food security is only achievable by guaranteeing land security.	Food insecurity in Thailand	Charoenrathana & Shinohara (2018)
	Socio-economic changes in Myanmar's villages have affected food security patterns and dietary quality.	Non-agricultural livelihoods and food security	Pritchard et al. (2019)
	Soil security and food security are interrelated and require approaches that consider this relationship.	Soil security and food security relationship	Pozza & Field (2020)
	Integrated crop-livestock systems can provide sustainable food security and resilience to climate change.	Integrated crop-livestock systems	Sakaran et al. (2021)



Social Capital: Other research emphasizes social capital, demonstrating that components such as social trust, cohesion, and collective participation can facilitate improvements in food security within rural communities.

Non-agricultural livelihoods: Engagement in non-agricultural activities has also been identified as an impor-

tant factor in strengthening food security. Participation in non-agricultural activities and the resulting income enhance food security and reduce poverty in rural areas.

Climate Change and Environmental Challenges: Some studies have identified challenges such as climate

change, rising food prices, and inadequate support systems as significant factors affecting food security.

Land and Resource Security: research indicates that achieving sustainable food security is only possible by ensuring land security and the legal rights of farmers.

Despite extensive studies, several persistent research gaps remain:

Lack of Long-Term Aspects of Food Security: Many studies have explored the short-term effects of agricultural and input subsidies, but further research is needed to analyze the long-term implications and sustainability of these policies in ensuring food security.

Limited evaluation of Modern Technologies: While some research highlights improvements in agricultural performance through modern technologies, more studies are required to evaluate their precise role in enhancing food security at the household level in rural areas.

Insufficient analysis of Migration and Socio-Economic Change: Although migration and socio-economic changes have been partially explored, a more detailed analysis of migration's effects on food security and strategies for managing these changes is still needed.

Need for Comparative Studies: A Few studies in Malaysia and Thailand have compared food security statuses across countries. However, cross-country or cross-regional analyses are still scarce in Iran.

Lack of Alternative Food Security Models: More research is needed on alternative food security models, such as sustainable agriculture and integrated crop-livestock systems, to determine how these approaches can serve as practical solutions for rural communities.

Collectively, these gaps reveal significant opportunities for further academic inquiry and emphasize the need for context-specific foresight studies to guide policy and improve rural food security across Iran.

Food insecurity, the absence of sufficient, safe, and desirable food, may arise from limited availability, low purchasing power, or inadequate household practices. According to WHO standards, it can be quantified when caloric intake falls below 80% of the average requirement (Farzana et al., 2017: 9). Cornell University researchers describe it as the inability to secure adequate food in both quality and quantity (Foroutanfar, 2015: 26). Beyond its nutritional consequences, food insecurity

negatively affects social and psychological well-being, making the assurance of food security a fundamental objective of socio-economic development policies (Ali Mardani et al., 2014: 64). Broader economic and social frameworks—through their influence on prices, wages, and employment—play a decisive role in household access to food (Dastgiri et al., 2006: 21).

The concept of food security gained global prominence following the early-1970s global food crisis, which framed it as an essential component of national security priorities (Rahbar & Mobini Dehkordi, 2004: 4). The 1996 World Food Summit defined it as a state where all individuals have continuous physical and economic access to adequate, safe, and nutritious food for a healthy and active life (Rezvani & Sanaei Moghadam, 2019: 43).

Scientifically, food security represents a structured approach to resolving nutritional challenges and is inherently multidimensional, with over 450 identified indicators (Ghadiri Masoom et al., 2015: 71; Bayanati et al., 2022: 201). Historically focused on large-scale food supply, the definition shifted in the late 20th century toward household and individual access (Ziaei et al., 2013: 84). Achieving genuine food security requires coordinated, sustainable action from all societal sectors in production, consumption, and oversight of the food system (Zhou, 2010).

Within the broader field of futures studies, foresight has emerged as a foundational concept, often used interchangeably with futures research, although terminological differences exist between European and American scholarly traditions (Saberfard, 2013: 2). Futures studies gained institutional significance in the 1960s, when numerous foresight organizations emerged globally (Arcade et al., 2003). Foresight is widely defined as a systematic, participatory process for collecting forward-looking information, formulating medium- to long-term visions, and guiding present decisions toward collective action (Omidi Shahabadi et al., 2019: 95; Bell, 2016). Scholars have proposed various models for structuring foresight activities—including frameworks by Martin, Voros, Miles, Saritas, Horte, and Rieger—that can be adapted to diverse thematic fields.

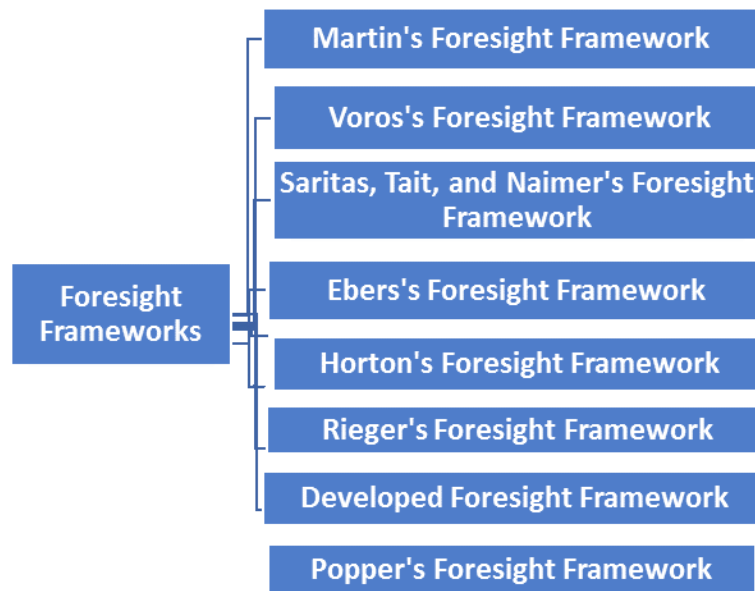


Figure 1. Foresight Framework and Its Stages. Source: Darabi, 2016: 34



So far, the topic of food has received relatively little attention in the field of futures studies. There are many reasons. This neglect is largely attributed to the multidimensional complexity of food-related issues, urban and disciplinary biases, cultural diversity, fear, and even personal perceptions regarding food. Given the importance of food security and the future of food, it is necessary to integrate these issues more systematically into futures studies. Food is inherently interdisciplinary; it is both a cultural heritage asset, a connector across ecosystem components, and for many global corporations, a highly valuable commercial commodity. Food also serves as a marker of geographical identity, distinguishing one region from another (Swinnen & Vandeveld, 2018). Environmental issues that threaten food security are other problems associated with studying food. Each of these issues has its own complexities. This has led to either a lack of attention to the nutrition of future generations or a mere focus on food shortages based on statistics and numbers (Petrick, 2011).

One reason for not considering food in futures studies is the urban bias. The attractions of urban life have led people to leave agricultural life and move to cities. Professional specialization has further marginalized food-related topics in foresight studies; when food appears in the limited literature of futures studies, it is often in relation to biotechnology, while agriculture and food production—especially in rural areas—are undervalued (Hurley, 2008). In contrast to the unsettling scenarios proposed for the future of food, there have been positive movements worldwide related to food. These include the production of organic foods, familiarizing people with

traditional foods, and renewed interest in sustainability and food security at universities worldwide. Academic institutions offer a variety of programs and courses on sustainability and food security. Futures researchers can use these programs to explore diverse food futures (Swinnen, 2015).

The growing demand for organic products is increasing. Organic farming not only ensures that future generations benefit from a healthy environment but also secures the interests of farmers and food producers. At the same time, the revitalization of traditional foods has strengthened linkages between producers and consumers, improving food quality and preserving food diversity (FAO, 2011).

In summary, the issue of food security has been less emphasized in futures studies largely due to its complexity and the dominance of urban-industrial perspectives. Environmental threats, pollution, the devaluation of agriculture, and the shift to urban living are major challenges in the field of food security. Positive developments in food security include the growing interest in organic products, producer-consumer relationships, and the growing academic awareness of food-related issues provide new opportunities for research and action. Importantly, global hunger is not solely a problem of food shortage, but rather one of inequity and inadequate governance. Hunger in the world is not due to a lack of food, but rather a lack of democracy in people's lives. It is unacceptable that people around the world suffer from severe and chronic hunger, and future researchers must think of solutions to address this problem. By examining

past trends, the futures research community can create a future where food production and provision are seen as important and valuable activities. Communities and regions with food security can produce local, healthy food that is accessible to all without the need for complex transportation systems, among other things, and this is one of the goals we should strive for (Hurley, 2008). The conceptual model of the research is shown in the following figure.

3. Methodology

In this study, a semi-structured and researcher-developed questionnaire was used rather than a fully standardized international instrument. The questionnaire was constructed based on a comprehensive review of national and international literature on food security, including FAO and WHO guidelines, as well as prior validated instruments from related studies. Although global tools such as the Household Food Insecurity Access Scale (HFIAS) and FAO’s Food Insecurity Experience Scale (FIES) were reviewed during the design phase, they were adapted to the socio-economic and cultural context of Iran thereby enhancing the relevance and local applicability of the instrument.

Regarding calorie intake, a standardized classification system aligned with FAO dietary energy requirement thresholds was adopted. Specifically, daily per capita calorie intake levels were categorized into severe deficit (<1,800 kcal), moderate deficit (1,800–2,100 kcal), and adequate intake (>2,100 kcal), based on both national dietary guidelines and FAO’s minimum dietary energy requirements. This dual reference allowed the study to

benchmark local findings against global nutritional standards while maintaining local applicability.

After determining the research focus and spatiotemporal boundaries, the key drivers and major trends in food security were identified through a systematic review of domestic and international articles, reports, and policy documents. Sub-variables related to each driver were also determined. Following validation of the driver list, a cross-impact matrix was designed, in which rows represent influencing variables and columns represent variables being influenced. This matrix enabled the identification of interdependencies and directionality between drivers, thereby providing the foundation for scenario-based modeling.

To assess the level of influence and vulnerability of the drivers, a survey was conducted among 31 experts specializing in food industries and agricultural planning. To calculate the validity of the questionnaire, both content and face validity methods were employed, and opinions from experts in various fields were consulted. Additionally, to measure the reliability of the questionnaire, pre-tests were conducted among the experts, and after necessary adjustments, the final version of the questionnaire was approved.

For data analysis, the collected responses were processed using Scenario Wizard software, which is specifically designed for futures analysis, cross-impact assessments, and scenario simulation. In this study, the software was used to model and generate multiple food security scenarios for rural areas of East Azerbaijan Province for the year 2033, enabling the identification of plausible and high-consistency future pathways.

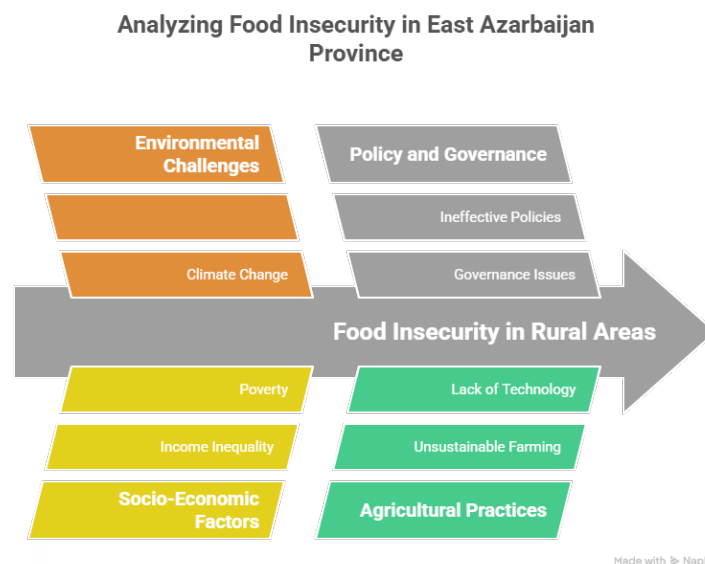


Figure 2. Conceptual research model

4. Findings

The results obtained from the bibliographic review, used to identify potential future scenarios for ensuring sustainable food security in rural areas of East Azerbaijan Province, were presented to respondents through a researcher-made questionnaire comprising both latent and observed variables. This section of the statistical analysis examines the distribution of the sample based on demographic variables such as gender, marital status, service history, and education level. [Tables 2](#) shows the demographic findings of the study, including gender, age, and education level, along with their corresponding statistical charts.

The results show that 80% of the respondents were male, and 20% female. 2% were below 25 years old, 10% were between 25 and 30 years old, 16% were between 30 and 35 years old, 19% were between 35 and 40 years old, and 48% were over 40 years old. According to the data collected, 100% of the participants in the study hold a doctoral degree.

Foresight studies typically begin with the identification of key variables that significantly shape the future of a subject. Accurate prediction involves recognizing current trends and issues as well as potential future events and then introducing them to prepare for various scenarios. Accordingly, the foresight of food security follows this logic, and this section aims to identify the primary factors influencing the future trends of food security in rural areas of East Azerbaijan province. After identify-

ing the key determinants, scenario design was conducted to highlight desirable and high-consistency future pathways.

A total of 58 factors were extracted across the economic, social, natural, and political management domains. In the second stage, these factors were entered into a cross-impact matrix to determine the level and magnitude of their influence on each other and on the future trend of food security in rural areas. The number of identified variables (N) forms an $N \times N$ matrix. The influence level ranges from zero to three, where zero indicates no effect, one indicates weak influence, two indicates moderate influence, and three indicates strong influence. After determining the level of influence of the factors, the matrix was entered into the Micmac software to extract the key factors. The matrix dimensions was 58×58 , and the matrix density was 53.89%, indicating that over 54% of the factors influenced each other. Among 1813 potential interactions, 1551 were scored zero, 643 were scored one, 611 were scored two, and 559 were scored three. The general characteristics of the output matrix from Micmac are shown in [Table 4](#).

MICMAC Software provides two types of graphs and analysis:

1. Direct Impacts
2. Indirect Impacts

Table 2. Distribution of Sample Group Frequency

Indicator	Frequency	Percentage (%)
Gender		
Male	25	80
Female	6	20
Total	31	100
Age		
25 years and below	2	6
25-30 years	3	10
30-35 years	5	16
35-40 years	6	19
40 years and above	15	48
Total	31	100
Education Level		
PhD	31	100
Total	31	100

Table 3. Characteristics of Direct Effects Matrix

Index	Value
Matrix Dimensions	58
Number of Repetitions	2
Number of Zeros	1,551
Number of Ones	643
Number of Twos	611
Number of Threes	559
Total	1,813
Percentage of Filled Cells	53.89%

Source: Research Findings, 2024.

**Table 4.** Shows the direct impacts of variables on each other

N°	Variables	Row Total	Column Total
1	Diversification and sustainability of income in rural areas to prevent food insecurity	36	84
2	Expansion and strengthening of non-agricultural income sources (services, tourism, industry, etc.) and better access to healthy and quality food for rural people	67	43
3	Expansion and strengthening of agricultural income for better access to healthy and quality food	29	73
4	Increasing the participation of rural people in food security matters at the village level	88	68
5	Increasing crop yields by providing high-yielding seeds through breeding and focusing more on orphan (green) crops	140	27
6	Increasing animal protein production (milk and meat) per unit area through sustainable management	125	53
7	Increasing fishery production by simultaneously improving feed, land, water, and energy efficiency	134	42
8	Encouraging fish and poultry farming to reduce red meat consumption	73	70
9	Reducing agricultural product waste during production and post-production stages	80	32
10	Increasing investment in agricultural productivity, especially in crop production and grain production	16	11
11	Promoting correct consumption patterns in society	22	47
12	Encouraging investment in the creation of agro-industries and food processing in rural areas in both small and large scales	148	20
13	Preventing the sale of movable and immovable assets by rural people and efforts to preserve their assets	40	97
14	Increasing security in rural areas and encouraging investment and more production	63	14
15	Increasing social support actions by the public in the form of food security aid packages	28	55
16	Adopting strategies to eliminate chronic hunger and food insecurity in villages	33	65
17	Changing food patterns, including reducing calorie consumption, especially in obese individuals	136	51
18	Reducing red meat consumption and replacing it with fish, poultry, and legumes	32	64
19	Reducing the use of food products for bioenergy production	17	17
20	Increasing crop production through soil and water management techniques	134	79
21	Preferential consumption of cheaper, less nutritious foods	50	58
22	Reducing the number of meals for male household members	23	76
23	Skipping one meal per week	30	59
24	Increasing investment in agricultural research and technology development, along with environmental progress	93	55
25	Planning to address concerns about shortages of basic food products needed by rural households (milk, pasta, rice, vegetables, etc.)	116	62
26	Reducing food waste from farm to consumer and by consumers themselves	84	58

Table 4. Shows the direct impacts of variables on each other

N°	Variables	Row Total	Column Total
27	Developing active social and civil society institutions in rural areas for sustainable food security	41	60
28	Increasing cohesion and solidarity in rural areas to enhance food security	31	70
29	Close and intimate social ties and increasing food security	115	93
30	Increasing nutritional knowledge and awareness, and adopting proper dietary patterns at individual and household levels	70	85
31	Conducting nutrition and food health training programs in villages, separated by gender	84	98
32	Easy access to nutrition experts to avoid food insecurity	16	72
33	Increasing rural households' access to nutritional and health information sources	21	95
34	Reducing the distance between rural people and urban or rural food supply centers	70	84
35	Facilitating quick and easy access to surface and groundwater resources for household consumption	77	79
36	Improving the quality of transportation and communication infrastructure for food supply in rural areas	16	47
37	Considering elevation classes in ensuring food security for rural populations	20	106
38	Preserving natural resources, environment, and climate sustainability	22	81
39	Protecting soil and water for growing important food crops	131	64
40	Preventing environmental degradation by livestock and farmers	72	53
41	Avoiding overuse of existing lands and pastures in rural areas	79	74
42	Using integrated pest management more and reducing herbicide use for weed control	16	56
43	Considering cover crops and mechanical weed control	21	79
44	Planning for combating wheat diseases and related pests	132	85
45	Eliminating monocropping and adopting mixed or multi-cropping practices	22	48
46	Ensuring agricultural products to increase farmers' economic capacity and improve nutritional status	121	108
47	Developing and expanding food product markets to increase rural access to healthy and quality food	72	65
48	Making appropriate decisions for each village based on local conditions and developing strategies to support agriculture and food production	79	62
49	Transferring and disseminating technology suitable for rural food needs and creating appropriate legal frameworks for market-oriented solutions	15	92
50	Improving and strengthening infrastructure for food transportation and distribution in rural areas	22	66
51	Monitoring the spatial distribution of food products in villages	14	104
52	Special monitoring of agricultural product storage	22	60
53	Preventing price fluctuations and stabilizing food prices	105	68
54	Guaranteeing prices for agricultural and livestock products	22	59
55	Increasing agricultural production subsidies at different stages	126	49
56	Special government support for food and livestock producers	15	0
57	Support for processing livestock, horticultural, and agricultural products in rural areas	22	0
58	Increased support from welfare institutions for rural residents, including Imam Khomeini Relief Committee, Welfare Organization, Social Security Organization, etc.	14	0

Source: Research Findings, 2024.



In the structural analysis matrix, the row sum of each variable represents its level of influence, while the column sum reflects its level of dependence or responsiveness.

Bidirectional variables, which have high influence and high responsiveness, will trigger reactions from other variables within the system. These variables can be di-

vided into two categories: risk variables and target variables. Out of the 58 initial factors influencing the future trend of rural food security planning, 11 factors from the economic, social, cultural, macro, managerial, and political groups are considered bidirectional variables. Figure 3 shows the position of the bidirectional variables on the scatter plot of variables.

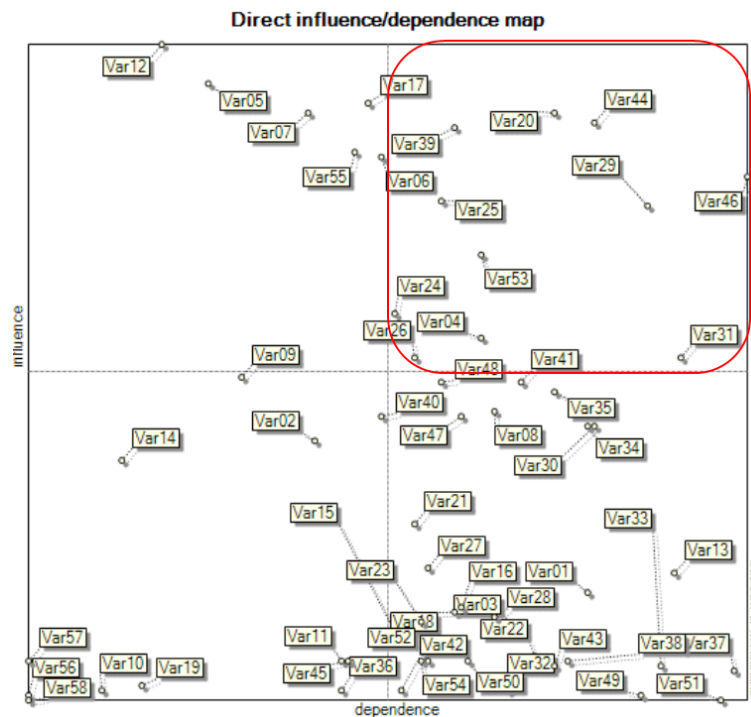


Figure 3. Position of bidirectional variables on the scatter plot of variables. Source: Research findings, 2024



Following the identification of variable positions in the influence–dependence map and the classification of system stability and instability and variable types, the direct impacts of the variables were analyzed. Figure 4 illustrates the direct impacts of the variables on each other (from very weak to very strong impacts)

From a total of 58 initial influencing factors, 11 factors were identified as the key driving forces shaping the system’s future. Notably, these key drivers consistently

emerged in both direct and indirect impact assessment methods, demonstrating their central role in shaping the system’s trajectory. The presence of these factors in both methods highlights their robustness and importance, suggesting that any strategic planning for the system’s future must address them directly. Accordingly, Table 6 presents the list of key influential variables that should form the foundation of future foresight and decision-making frameworks for rural food security.

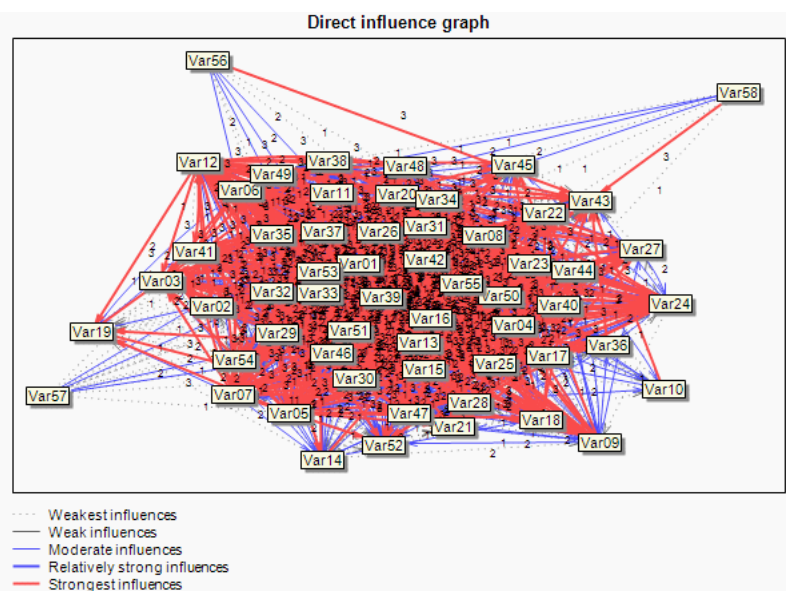


Figure 4. Direct impacts of variables on each other (from very weak to very strong impacts). Source: Research Findings, 2024



Table 5. Key Factors Influencing the Future of Sustainable Food Security in Rural Areas of East Azarbaijan Province

Row	Variable	Code	Dimension
1	Creation of diverse and sustainable income in rural areas to prevent food insecurity	Var 01	Economic
2	Increase in crop production in agricultural lands through soil and water management techniques	Var 20	Economic
3	Increased investment in agricultural research and technology development for sustainable food security	Var 24	Economic
4	Large-scale planning to address concerns about the shortage of essential food products needed by rural households (milk, pasta, rice, vegetables, etc.)	Var 25	Economic
5	Reducing food waste between farm production and consumption, as well as by consumers	Var 26	Social
6	Close and strong social bonds in rural areas and increasing food security	Var 29	Social
7	Conducting training courses related to nutrition and food health at the village level, divided by gender	Var 31	Social
8	Protection of soil and water for the cultivation of important food crops	Var 39	Natural
9	Large-scale planning to combat diseases in crops (especially wheat) and related pests	Var 44	Natural
10	Ensuring agricultural products to increase farmers' economic capacity and improve nutritional status	Var 46	Political and Managerial
11	Large-scale planning to prevent fluctuations in food prices and stabilize them	Var 53	Political and Managerial

Source: Research Findings, 2024.



Based on the possible future scenarios, a total of 33 different scenarios has been developed for 11 key driving factors. These scenarios span a spectrum ranging from favorable to unfavorable conditions, with each factor having three possible scenarios. Table 2 shows the key factors and their related possible scenarios for food security in the rural areas across the districts of East Azerbaijan Province.

Based on the potential future scenarios for ensuring sustainable food security in rural areas across East Azerbaijan Province, a total of 33 scenarios were identified for 11 key driving factors. These scenarios were categorized into three spectrums: desirable, neutral, and undesirable.

Following expert validation through the Delphi method, the processed data enabled the use of Scenario Wizard software for scenario extraction and classification. This facilitated the identification of: High-compatibility (strong) scenarios; Moderately probable scenarios, and Low-compatibility (weak) scenarios.

Table 4 presents the project information for drafting scenarios to ensure sustainable food security in the rural areas of East Azerbaijan Province.

The inherent capability of the Scenario Wizard software allows for the reduction of a vast scenario space from millions of scenarios to only a few with a high probab-

ity of occurrence. Based on the analysis, two scenarios with the highest probability of occurrence were identified. However, despite their statistical prominence, these scenarios were excluded from consideration as favorable or desirable scenarios due to their impractical nature and unrealistic outcomes.

Similarly, the software generated 7,894 weak scenarios, which were classified as illogical and unreliable, and therefore unsuitable for policy or strategic planning purposes.

Therefore, what seems reasonable is to select a scenario with compatibility or a scenario with high compatibility from among the strong scenarios (2 scenarios) and weak scenarios (7,894 scenarios). According to the results, 81 scenarios with high compatibility were identified. The "one distance" in a scenario with compatibility essentially extends the range of strong scenarios by one unit toward the weak scenarios. Figure 2 illustrates how scenarios with compatibility are selected from among the multitude of scenarios

As a result, based on the above figure and the outcomes obtained from the Scenario Wizard method, 81 highly compatible scenarios were selected. Since each of the key driving factors has 3 potential scenarios, each scenario was categorized into three types: desirable, static, and critical. The scenarios are discussed in detail below.

Table 6. Key Factors and Potential Scenarios Related to Sustainable Food Security in Rural Areas of East Azerbaijan Province

Key Driving Factors	Desirability Level	Uncertainties	Code
A: Creating diverse and sustainable income in rural areas to prevent food insecurity	Desirable	Coherent and effective planning for creating diverse and sustainable income in rural areas to prevent food insecurity	A1
	Neutral/Static	Insufficient attention to creating diverse and sustainable income in rural areas to prevent food insecurity	A2
	Undesirable	Ignoring the need to create diverse and sustainable income in rural areas to prevent food insecurity	A3
B: Increasing agricultural productivity through soil and water management methods	Desirable	Increasing agricultural productivity through soil and water management in line with rural development	B1
	Neutral/Static	Limited focus on improving agricultural productivity through soil and water management in planning processes	B2
	Undesirable	Decreased agricultural productivity due to improper soil and water management practices	B3
C: Increasing investment in agricultural research and technology development for sustainable food security	Desirable	Implementation of various programs to increase investment in agricultural research and technology development for sustainable food security	C1
	Neutral/Static	Insufficient attention to investment in agricultural research and technology development for sustainable food security	C2
	Undesirable	Neglecting the importance of investment in agricultural research and technology development for sustainable food security	C3
D: Macro-planning to address concerns about shortages of essential food products for rural households (milk, pasta, rice, vegetables, etc.)	Desirable	Macro-planning to address concerns about shortages of essential food products for rural households	D1
	Neutral/Static	Continuation of the current situation	D2
	Undesirable	Insufficient attention to macro-planning for addressing shortages of essential food products for rural households	D3
E: Reducing food waste and loss from farm to consumption and by consumers	Desirable	Coherent and effective planning to reduce food waste and loss from farm to consumption and by consumers	E1
	Neutral/Static	Insufficient attention to reducing food waste and loss from farm to consumption, and by consumers	E2
	Undesirable	Neglecting efforts to reduce food waste and loss from farm to consumption and by consumers	E3
F: Promoting close and harmonious social ties in rural areas to enhance food security	Desirable	Designing and implementing effective policies to promote close and harmonious social ties in rural areas to enhance food security	F1
	Neutral/Static	Continuation of current policies and trends	F2
	Undesirable	Lack of specific policies to promote close and harmonious social ties in rural areas to enhance food security	F3
G: Conducting nutrition and food health education programs in rural areas for men and women	Desirable	Effective management of nutrition and food health education programs in rural areas for men and women	G1
	Neutral/Static	Continuation of the current situation	G2
	Undesirable	Ineffective management of nutrition and food health education programs in rural areas for men and women	G3
H: Soil and water conservation for cultivating essential food crops	Desirable	Regional balance policies for soil and water conservation to cultivate essential food crops	H1
	Neutral/Static	Continuation of the current situation with a gradual decline in soil and water conservation	H2
	Undesirable	Ineffective development plans for soil and water conservation for essential food crops	H3

Table 6. Key Factors and Potential Scenarios Related to Sustainable Food Security in Rural Areas of East Azerbaijan Province

Key Driving Factors	Desirability Level	Uncertainties	Code
I: Planning to combat grain diseases (especially wheat) and related pests	Desirable	Agricultural development aligned with planning to combat grain diseases (especially wheat) and related pests	I1
	Neutral/Static	Continuation of the current situation	I2
	Undesirable	Insufficient attention to planning for combating grain diseases (especially wheat) and related pests	I3
J: Ensuring agricultural products to enhance farmers' economic stability and nutritional improvement	Desirable	Special attention to ensuring agricultural products to enhance farmers' economic stability and nutritional improvement	J1
	Neutral/Static	Continuation of the current situation	J2
	Undesirable	Neglecting the issue of insuring agricultural products to enhance farmers' economic stability and nutritional improvement	J3
K: Macro-planning to stabilize food prices and prevent price fluctuations	Desirable	Designing and implementing policies and macro-plans to stabilize food prices and prevent price fluctuations	K1
	Neutral/Static	Continuation of the current situation	K2
	Undesirable	Neglecting macro-planning for stabilizing food prices and preventing fluctuations	K3

Source: Research Findings, 2023.



Table 7. Project Information for Drafting Scenarios to Ensure Sustainable Food Security in Rural Areas of East Azerbaijan Province

Type and Number of Scenarios	Strong: 2 Weak: 7,894 High compatibility: 81
Number of Descriptors	11
Total Number of Types (Potential States)	33
Number of Descriptors with 3 Potential States	33
Total Configurations	177,147
Judgments	- 29 out of 110 judgment sections (26.36%) are empty. - The matrix contains 990 judgment cells. - 42 cells (4.24%) contain judgments for interactions scored as (-3). - 75 cells (7.58%) contain judgments for interactions scored as (-2). - 106 cells (10.71%) contain judgments for interactions scored as (-1). - 515 cells (52.02%) contain judgments for interactions scored as (0). - 150 cells (15.15%) contain judgments for interactions scored as (1). - 67 cells (6.77%) contain judgments for interactions scored as (2). - 35 cells (3.54%) contain judgments for interactions scored as (3).
Project Reliability	- This project includes no independent scenarios. - This project includes no inactive scenarios

Source: Research Findings, 2023.

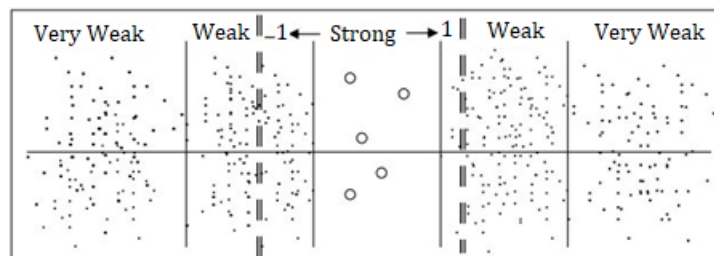


Figure 5. The method of selecting scenarios with compatibility from a set of scenarios



Table 8. Status of strong scenarios with high probability

Scenario No. 1	Scenario No. 2
Creating diverse and sustainable incomes in rural areas to prevent food insecurity: Cohesive and efficient planning for creating diverse and sustainable incomes in rural areas to prevent food insecurity.	Creating diverse and sustainable incomes in rural areas to prevent food insecurity: Lack of adequate attention to creating diverse and sustainable incomes in rural areas to prevent food insecurity
Increasing crop production on agricultural lands through soil and water management methods: Increasing crop production on agricultural lands through soil and water management methods for rural development.	
Increasing investment in agricultural research and technology development for sustainable food security: Implementation of various programs and plans to increase investment in agricultural research and technology development for sustainable food security.	Increasing investment in agricultural research and technology development for sustainable food security: Lack of attention to increasing investment in agricultural research and technology development for sustainable food security.
Macro planning to address concerns about the shortage of essential food products for rural households (milk, pasta, rice, vegetables, etc.): Macro planning to address concerns about the shortage of essential food products for rural households (milk, pasta, rice, vegetables, etc.).	Macro planning to address concerns about the shortage of essential food products for rural households (milk, pasta, rice, vegetables, etc.): Continuation of the current situation.
Reducing food waste and loss from farm to consumption, including by consumers: Cohesive and efficient planning to reduce food waste and loss from farm to consumption, including by consumers.	Reducing food waste and loss from farm to consumption, including by consumers: Lack of attention to reducing food waste and loss from farm to consumption, including by consumers.
Close and intimate social relations in villages and increased food security: Designing and implementing favorable policies to foster close and intimate social relations in villages and increase food security.	
Conducting nutrition and food health training courses in rural areas, separated by gender: Inefficient management of conducting nutrition and food health training courses in rural areas, separated by gender.	
Soil and water conservation for growing important food crops: Implementing balanced regional policies for soil and water conservation to grow important food crops.	Soil and water conservation for growing important food crops: Continuation of the current situation and gradual reduction in soil and water conservation efforts for growing important food crops
Planning to combat diseases in cereals (especially wheat) and related pests: Development and management of agriculture in line with planning to combat diseases in cereals (especially wheat) and related pests	
Insuring agricultural products to increase farmers' economic capacity and improve nutrition and food status: Special attention to insuring agricultural products to enhance farmers' economic capacity and improve nutrition and food status.	
Macro planning to prevent fluctuations in food prices and stabilize them: Designing policies and strategies for macro planning to prevent fluctuations in food prices and stabilize them.	Macro planning to prevent fluctuations in food prices and stabilize them: Lack of macro planning to prevent fluctuations in food prices and stabilize them.

Source: Research Findings, 2023.



Generally, the assumptions of a stable scenario are supported unequally. The level of stability can be expressed as the “stability amount.” This method measures the difference between the impact score of the assumption and the impact score of the best alternative assumption. In the list below, the key factors are ranked in order of robustness:

The elements of the reported scenario form a complete set of mutually supportive assumptions; therefore, the scenario can be evaluated as internally consistent.

5. Discussion

Foresight research often begins by identifying key variables that significantly impact the future of the subject. A good forecast involves identifying current trends, issues, and potential events, then introducing them to prepare for various scenarios. In this context, food security foresight is no exception. In this section, an attempt is made to identify the primary factors affecting the future trends of food security in rural areas of East Azerbaijan prov-

ince. Key factors affecting the future of the system are extracted, and then scenario writing and the identification of desirable scenarios for the future are conducted.

A total of 58 influencing factors were identified in the economic, social, natural, and political-management dimensions. In the next step, these factors were entered into a cross-impact matrix to determine the extent and degree of their mutual influence on the future of food security. The identified variables, N, should form an N×N matrix. The degree of influence ranges from 0 to 3, where 0 represents no influence, 1 represents weak influence, 2 represents medium influence, and 3 represents strong influence. After determining the degree of influence, the matrix was input into the MICMAC software. The matrix dimensions are 58×58, with a matrix fill degree of 53.89%, indicating that over 54% of the factors influence each other. Out of the 1813 possible relationships in the matrix, 1551 have a value of zero, 643 have a value of one, 611 have a value of two, and 557 have a value of three.

Table 9. Stability and Robustness of Assumptions

Compatibility Value	Key Factor	Assumption
12	Coordinated and efficient planning to reduce food waste between farms and consumers, as well as by consumers	Reducing food waste between farms and consumers, as well as by consumers themselves
9	Implementation of various programs and plans to increase investment in agricultural research and technology development for sustainable food security	Reducing food waste between farms and consumers, as well as by consumers themselves
7	Special focus on ensuring agricultural products to increase farmers' economic capacity and improve nutritional and food security	Insuring agricultural products to increase the economic capacity of farmers and improve nutritional and food security
5	Coordinated and efficient planning to create diversified and sustainable incomes in rural areas to prevent food insecurity	Creating diversified and sustainable incomes in rural areas to prevent food insecurity
5	Increasing crop production in agricultural lands through soil and water management techniques for rural development	Increasing crop production in agricultural lands through soil and water management techniques
5	Designing and implementing policies to strengthen close and intimate social ties in rural areas and increase food security	Strengthening close and intimate social ties in rural areas and increasing food security
4	Macro-level planning to address concerns about the shortage of essential food products needed by rural households (milk, pasta, rice, vegetables, etc.)	Macro-level planning to address concerns about the shortage of essential food products needed by rural households (milk, pasta, rice, vegetables, etc.)
4	Implementing balanced regional policies for the protection of soil and water for the cultivation of important food crops	Protecting soil and water for the cultivation of important food crops
4	Designing policies and macro-level planning to prevent fluctuations in food prices and stabilize them	Macro-level planning to prevent fluctuations in food prices and stabilize them
3	Ineffective management of training courses related to nutrition and food health in rural areas, separately for men and women	Conducting training courses related to nutrition and food health in rural areas, separately for men and women
3	Development and management of agriculture in line with planning to combat diseases in grains (especially wheat) and related pests	Planning to combat diseases in grains (especially wheat) and related pests

Source: Research Findings, 2023.



In this study, the scatter plot showed that most variables exhibited intermediate levels of influence and dependence, clustering around the diagonal axis. This indicates that the system is unstable, and its future is highly sensitive to small changes within multiple variables. Such instability typically requires adaptive and flexible policy strategies, as the dynamics of the system may change rapidly over time.

Two scenarios with a high probability of occurrence, due to their impracticality and unexpected results, are not considered as optimal scenarios and cannot be used as desirable scenarios. The results of the weak scenarios show 7894 scenarios, and due to the weak nature and illogicality of these scenarios, they are not considered desirable either and cannot be relied upon. Therefore, it seems reasonable to consider scenarios with high consistency or those with high compatibility based on the results, where 81 such scenarios are identified. The one-unit distance in the scenario with high consistency reflects the expansion of the strong scenarios towards weak scenarios.

The findings of this study are consistent with results from both domestic and international research: Iranian studies such as those by [Asgharian et al. \(2013\)](#) and [Ros-tami et al. \(2014\)](#) have confirmed the role of economic and social variables—such as income, employment, education level, and household size—in determining food security, which are also reflected in the present findings. Furthermore, the challenges highlighted by [Savari and Ghanian \(2019\)](#) regarding weak agricultural support systems and climate change align closely with the systemic instability identified in this study. Similarly, [Shafiei Sabet and Mirvahidi \(2022\)](#) emphasized the uneven distribution of factors affecting food security, a pattern echoed in the spatial dispersion analysis of the present research.

At the international level, studies such as [Pritchard et al. \(2019\)](#) have emphasized non-agricultural activities and socio-economic transition as key to food security—elements considered in the development of future scenarios and the evaluation of key drivers in the current research. Moreover, the importance of crop diversification and integrated crop–livestock systems for sustaining

food security, as discussed by Sakaran et al. (2021), is consistent with the environmental and managerial factors emphasized in this research.

The following are identified as robust scenarios:

Coordinated and efficient planning to reduce food waste between farms and consumers, as well as by consumers themselves.

Implementing various programs and plans to increase investment in agricultural research and technology development for sustainable food security.

Special focus on ensuring agricultural products increase the economic capacity of farmers and improve nutritional and food security.

Coordinated and efficient planning to create diversified and sustainable incomes in rural areas to prevent food insecurity.

Increasing crop production in agricultural lands through soil and water management techniques for rural development.

Designing and implementing favorable policies to strengthen close and intimate social ties in rural areas and increase food security.

Macro-level planning to address concerns about the shortage of essential food products needed by rural households (milk, pasta, rice, vegetables, etc.).

Implementing balanced regional policies to protect soil and water for the cultivation of important food crops.

Designing policies and executive strategies to prevent fluctuations in food prices and stabilize them.

Ineffective management of conducting training courses related to nutrition and food health in rural areas, separately for men and women.

Development and management of agriculture in line with planning to combat diseases in grains (especially wheat) and related pests.

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Conflict of Interest

The authors declared no conflicts of interest.

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