Data-Driven Management of Regional Food Security for Sustainable Development: A Case Study of Kazakhstan

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ABSTRACT

The purpose of the paper is to evaluate the possibility of implementing a food security management system in the Republic of Kazakhstan using the concept of data-driven decision-making in terms of achieving the principles of sustainable development. To achieve the goal set in the study, the authors use qualitative and statistical methods for processing the results obtained. Based on the analysis of internal and external factors, the authors determine indicators of food security in Kazakhstan for basic types of agricultural products/food in 2021, factors of influence on regional food security, and indicators of regional food security, which should be considered when making data-driven management decisions. A special external factor for Kazakhstan is the current geopolitical situation caused by the invasion of Russian troops in Ukraine. The study finds that in the process of managing regional food security, the use of the data-driven decision-making concept makes it possible to adequately assess the initial state of the problem and determine the optimal methods for its solution. The study identifies key internal and external factors influencing food security in the region and proposes a data-driven decision-making algorithm for managing food security. The results highlight the potential of this approach for improving food security management in the context of sustainable development.

1. INTRODUCTION

The provision of food and the well-being of the country's population depend on sustainable food security (FS) [1]. FS remains a global priority in the development strategy of modern countries. One of the most important tasks of the state is to ensure the national security of the country, i.e., its autonomy and independence from neighboring countries [2]. One of the main ways to ensure security is to provide improved access to safe and nutritious food and support FS. Based on the need to achieve the principles of sustainable development [3], which developed and developing countries are guided by, public policy should be aimed at ensuring FS, preserving the environment [4, 5], protecting territories from the degradation of water and land resources and destruction of biodiversity [6, 7], and motivating social institutions, business, and the population to care about the nutrition quality [8].

Researchers [9, 10] note that FS should be considered within each region, considering the regional characteristics of the territories, since each region differs from others by its inherent natural resources, material wealth, social living conditions, and economic and environmental situation [11]. Complementing this approach to understanding regional FS, researchers focus on the ability of the region to meet the needs of the population with food in volume, structure, quality, and caloric content corresponding to rational norms [12], based on the fullest use of the possibilities of regional production potential and the system of interregional relations following the territorial division of labor [13].

Summarizing the components of regional FS, it can be argued that among researchers, a structural and systematic approach is predominant, focused on understanding the food structure of the local demographic population, formed from interconnected subsystems according to functional, organizational, resource, and technological characteristics [14] and aimed at uninterrupted, sufficient, and high-quality satisfaction of the physiological needs of the population with basic foodstuffs from internal and international sources [15]. The formation of the product supply relies not only on regional and national resources but also on the use of imported goods [16].

Accordingly, any type of analysis, assessment program, and monitoring of FS management in a region requires an understanding of a set of relevant factors affecting the level of FS there.

It is not enough to limit oneself to creating a system of collected factors. One needs to apply it as much as possible in many situations. The most difficult task is to create a system

of assessment and forecasting, starting with the selection of indicators, until the final stage when enterprises can make decisions about creating a new product in the field of agriculture or the food industry, considering not only their business but also national interests aimed at reducing threats from the influence of certain factors [17]. However, how, using such an approach, can one assess the efficiency of working with the evaluation and forecasting system? In modern management practice, it is necessary to create special software that would help solve such problems. Such software should not proceed in obtaining data only by focusing on the HiPPO (Highest Paid Person's Opinion) approach in decision-making [18]. The main problem of HiPPO is that the manager cannot always be objective and know all features of a dynamically changing situation and indicators for each factor, including the expectations of both government agencies on the one hand and the population of the region on the other.

Thus, to solve this problem, it was necessary to create a theoretical and methodological system for managing regional FS in modern conditions.

The Republic of Kazakhstan was chosen as the object of this study, and Kazakh state bodies signed a memorandum of cooperation in the implementation of projects on the digital transformation of Kazakhstan, the transition to a platform model of digitalization, and the concept of Data-Driven Government [19]. Thus, purpose of the article was to assess the possibility of implementing an FS management system in Kazakhstan using the concept of data-driven decision-making (DDDM) in terms of achieving the principles of sustainable development.

This research addresses several critical gaps in the existing literature on food security in Kazakhstan. Firstly, it introduces the application of data-driven decision-making (DDDM) as a novel approach to managing food security, a topic that has not been extensively explored in the context of Kazakhstan. Secondly, it focuses on the regional nuances of food security within the country, acknowledging the unique challenges faced by different regions. This regional perspective is often missing in broader food security studies.

Moreover, this research bridges the gap between food security and sustainable development principles. While sustainability is widely recognized as crucial, there is a lack of practical guidance on integrating these principles into food security management, especially at the regional level.

The study includes an introduction, which substantiates the relevance of the study of regional FS management; a literary review devoted to internal and external factors affecting regional FS and the use of DDDM in the global practice as a possible approach to creating a tool for managing FS factors. The article includes the description of the materials and methods of the study and its results, including the determination of FS indicators in Kazakhstan for basic types of agricultural products/food in 2021, factors influencing regional FS, and regional FS indicators, which should be considered when making data-driven management decisions. The paper discusses the obtained results and presents a conclusion and a list of references.

2. LITERATURE REVIEW

2.1 Factor analysis

To build a theoretical and methodological system of regional FS management, it is necessary first to determine the factors that need to be considered for analysis.

Based on the purpose of the study, we decided to systematize the factors into internal and external ones. We identified the most significant internal factors. Their description is presented in no particular order since the focus of the study was not to build a universal ranking system for these factors.

1) **Economic factors and quality of life.** According to studies [20, 21], the sufficiency of calories and the diversity of the diet affect the quality of life. The quality of life directly depends on the level of household income and their purchasing power. Poverty, unemployment, fluctuations in food prices, and economic instability can exacerbate food insecurity.

2) **The level of development of agriculture and food industry.** Sustainable and efficient farming methods [22] and the ability to produce food, basic detergents, and sanitary products in sufficient quantities are crucial for FS. Modern agricultural technologies [23], breeding and genetic resources [24], feed bases and additives [25], agricultural machinery, efficient irrigation systems, and integrated pest control [26] can increase production and ensure a stable food supply.

3) **Population growth and urbanization.** If we consider this factor at the global level, it should be noted that according to the forecasts of the UN, by 2050 the world population will reach 9.7 billion people. Therefore, in general, the demand for food will increase globally. This will create an additional burden on countries with a high level of agricultural development. In regional management, it is necessary to consider the factor of population growth dynamics and the demographic situation to build FS more effectively [27]. The analysis of the demographic situation and migration flows allows one to predict the future of the labor market and the employed population, as well as the composition and number of other cohorts, since, based on the focus of the study, the development of the labor market affects the development of the agricultural sector and the food industry, as well as the related branches of the economy. Urbanization can affect FS by affecting the demand for food for the urban population, which, as a rule, participates less in the agricultural sector but consumes more food, thereby changing the system of food production, processing, and distribution.

4) **The level of health development and management of the sanitary situation.** The degree of influence of this factor depends on the level of regional management of sanitary situations and food quality and the development of healthcare, agriculture, and the food industry [28]. In the conditions of underdevelopment of these systems, diseases may become more frequent and threaten the life of a large number of the population of the whole country or a part of it.

5) **National and international trade.** The rules of international trade and participation in trade unions or agreements affect the FS. This factor has a strong influence on economic factors and the quality of life of the population [29]. The development of international trade and possible trade restrictions have an impact on the prices and availability of food [30]. Trade barriers, tariffs, agricultural subsidies, and duties are tools that regulate the food market in the country, lead to price volatility, and restrict access to food.

6) **Availability of the necessary infrastructure and environmental situation.** If regional infrastructure, including communications, transport, storage, and processing facilities, is poorly developed this can restrict access to markets and lead to difficulties in delivering goods to certain regions, resulting

in post-harvest losses that affect the availability and stability of food. Besides, an important characteristic is the amount of emissions, the state of the environment [31], and its assessment based on the criterion of the severity of environmental situations.

7) Political stability and governance. FS is also influenced by political factors. Conflicts, corruption, underdeveloped social institutions, poor governance, and political instability can disrupt food production and distribution. In regions with a high level of state economy, this factor has a strong influence on economic factors and branches of economic activity [32].

8) Protecting citizens' rights and fighting against gender inequality. The protection of citizens' rights [17] has a significant impact on economic factors [33] and the political situation. Researchers note that women play a vital role in agriculture and the processing and food industries in many countries [34]. Researchers conclude that gender inequality restricts women's access to resources, services, and decision-making, thus affecting FS.

After analyzing internal factors, we studied scientific articles and reports, based on which we selected the factors affecting regional security. These factors are combined into the main groups.

1) Climate change. According to the reports of the Intergovernmental Panel on Climate Change (IPCC) [35] and separate studies in this area [36], global warming has a direct and indirect impact on the agricultural system, thereby affecting FS. Changes in temperature and precipitation patterns can affect yields, livestock health, and fish stocks [37] leading to instability of food supply.

2) Natural disasters. Such phenomena as floods, droughts, and pest invasions [26] can lead to significant losses of crops, livestock, and fish stocks, thereby affecting the availability of food [38].

3) Geopolitical stability on the continent and in the world. If a region is directly or indirectly affected by events such as military operations [39], trade and legal sanctions on partner countries, and possible sanctions against the region itself, this reduces the level of regional FS since it is necessary to change international policy and trade routes and look for new trade partners [40].

2.2 DDDM

According to Zelentsov [41], DDDM is a decision-making process using information based on big data. Research [42] shows that this type of decision-making has proved beneficial for any company, regardless of its size, business model, or industry, because it allows one to make more informed and accurate decisions quickly and efficiently.

In the scientific literature, DDDM, i.e., business decisions based on data [43], is opposed to approaches based on intuition or opinion since decision-making based on intuition is incomplete (i.e., less effective), outdated, and meaningless, as data analysis becomes more accessible due to easier and cheaper access to data, computing power, and analytical tools [44].

The main advantage of the data-based approach is the ability to measure the results of activities and, consequently, increase their economic efficiency. For example, in marketing, data has also begun to be used to monitor customer behavior patterns and to detect and respond to events such as customer outflow. The impact of using a data-based approach on company performance has been thoroughly studied [45]. It was found that data-driven companies are 5-6% more productive than non-data-driven companies, considering other variables [46].

Today, DDDM is combined with such concepts as big data, artificial intelligence (AI), data science (DS), and machine learning (ML) and is currently used not only in marketing but also in many areas of business, science, and public governance [47].

The use of this approach for making complex decisions affecting the national security of the region has not yet been described in detail in the scientific literature. This can be explained by the fact that resources for creating information systems capable of solving such problems have appeared relatively recently. In our study, we developed the foundations of a theoretical and methodological FS management system, the use of which will help in creating a database and software for responsible decision-makers.

The reviewed sources provide insights into the internal and external factors affecting food security. Internal factors, such as economic stability, agricultural development, and healthcare, reflect a region's self-reliance. External factors, including geopolitical stability and trade policies, highlight the interconnectedness of global food systems. Recognizing these influences is vital, but it complicates the decision-making process due to their complexity and often unpredictable nature.

Overall, the reviewed sources underscore the importance of adopting a holistic approach to food security management that incorporates DDDM, regional specificity, sustainable development, and consideration of both internal and external factors. While each approach has its merits, their effective integration remains a challenge, requiring multidisciplinary collaboration and robust data infrastructure.

3. MATERIALS AND METHODS

Due to the novelty of the phenomenon under study and the research nature of the goal, we chose a qualitative approach to research.

In this paper, we tried to answer the following research questions: (1) What factors of influence on regional FS should be considered when making management decisions based on data? And (2) What indicators of regional FS should be considered when making management decisions based on data concerning Kazakhstan?

To achieve the goal set in the study, we identified an indicative set of theoretical research methods: theoretical generalization to determine the theoretical foundations of DDDM, as well as structural and logical analysis and synthesis in establishing the current situation in the field of FS in Kazakhstan.

Following the purpose of the study, at the first stage, we carried out a selection of regulatory legal acts using the Adilet information storage and retrieval system (ISRS) and analytical and statistical data provided by the Eurasian Development Bank (EDB) [4, 5]. We performed a selection of scientific sources from Web of Science and Scopus using the keywords "food security", "data-driven", "agricultural sector", "agro-industrial complex" (AIC), and "regional security" with a limit on the date of publication (not older than 10 years).

At the second stage, an expert survey was conducted. Emails with an offer to participate in the survey were sent to 74 experts from Kazakhstan. The selection criterion for the expert pool was professional experience in government

organizations responsible for the regulation of FS in Kazakhstan; research experience in the field of FS and agricultural economics with the availability of publications on this topic over the past 5 years; practical experience in the agricultural and food industry. 69 people agreed to take part in the survey, after which they were sent emails with the research questions. In the emails, they were asked to substantiate their answers.

After receiving the expert responses, we sent the experts a second email, in which it was proposed, depending on the level of significance of the factors influencing the regional FS and the indicators of the regional FS, to arrange them by assigning points. After that, their rank was determined according to the scores given by the experts.

For a more objective analysis of the data obtained in the expert survey, the degree of consistency of expert opinions with mathematical processing of the results was measured using the Kendall concordance coefficient (W) [45]. Further, the information obtained during the expert survey was processed to determine the indicator weight, the final values of which determined the significance of a particular indicator.

4. RESULTS

4.1 Analysis of the current situation in Kazakhstan

In Kazakhstan, FS is recognized as a component of economic security and assumes the ability of the state to ensure physical and economic accessibility for the population of high-quality and safe food products sufficient to meet physiological consumption standards and demographic growth. Food independence is not directly included in the definition of the country's FS but it is considered a key condition for achieving economic security [16]. Food independence is considered insufficient if the annual production of basic food products is less than 80% of the annual needs of the population following the physiological consumption norms [13].

In the aspect of food sufficiency, the main indicators of the FS state in Kazakhstan are:
- self-sufficiency in basic agricultural products (the ratio of internal production to internal consumption);
- the ratio between the actual indicators of the average per capita consumption of basic foodstuffs and the accepted standards (rational norms) (Table 1).

According to Table 1, insufficient levels of self-sufficiency in Kazakhstan were observed only for sugar, fruit, and berries. For some types of food (dairy and meat products, eggs, fruit and berries, vegetables, and bread products), the average per capita consumption in Kazakhstan remains below the accepted standards. For certain products (primarily sugar, bread products, and vegetables) the actual levels of per capita consumption in Kazakhstan significantly exceed the established rational norms.

In terms of the economic availability of food, the situation is less optimistic. The share of food expenditures in the total consumer spending of the population in Eurasian Economic Union (EAEU) countries exceeds 30% (even though the actual level of consumption of certain types of food is lower than the accepted rational norms).

According to estimates [48], in 2018, the share of households with consumer spending below the level corresponding to the cost of a food basket built according to rational norms was 70-75% in Kazakhstan. This indicates insufficient purchasing power of disposable incomes of the population and insufficient economic availability of food in the required volumes and variety. Kazakhstan is completely dependent on imported sunflower seed material [49]. Thus, the achievement of high self-sufficiency in sunflower oil is conditional if we exclude the import component in the production chain.

4.2 Survey results

The results of the expert survey allowed us to determine which factors of influence on the regional FS should be considered when making data-driven management decisions (Table 2).

As a result of the expert survey, we identified the regional FS indicators, which should be considered when making data-driven management decisions (Table 3).

4.3 Development of an algorithm for managerial decision-making

The analysis of the results of the expert survey made it possible to develop an algorithm for making managerial decisions in the field of regional FS based on DDDM (Figure 1).

At the first stage, the systematization of operational information (data) on the level of FS is carried out. It is necessary to collect information, which includes economic factors and quality of life, population growth in the country and urbanization of territories, the level of development of health care, and management of the sanitary situation in the region. When assessing Kazakhstan, we included in these factors such characteristics as the number and composition of the population; the gender and age composition of the population; the population in cities, urban districts, and districts of the region; general indicators of population reproduction, etc.; characteristics of the standard of living of the population: its monetary income, the subsistence minimum, the average monthly nominal accrued wages, purchasing power, the average per capita monetary income of the population, the composition of final consumption expenditures of households of different socio-economic categories; the level of food consumption; the health status of the population; the level of food prices; food production. Besides, it is appropriate to include in this group the food ration of the population, as well as regional food supplies.

Table 1. FS indicators in Kazakhstan for basic types of agricultural products/food in 2021 [4]

Basic Types of Agricultural Products/Food	Level of Self-Sufficiency*	Actual and Normative Indicators of Average Per Capita Consumption, kg Per Person Per Year
Grain/bread and grain processing products	125	99.2 (109)
Potatoes	104	107.4 (100)
Vegetables and melons	108	230.6 (149)
Fruit and berries	38	48.7 (132)

Meat and meat products recalculated as meat	82	78.7 (78.4)
Fish and fish products	-	15.1 (14.0)
Milk and dairy products recalculated as milk	93	247.0 (301)
Eggs	100	228.7 (265) (units per year)
Sugar	8	26.5 (17.0)
Vegetable oils	91	21.1 (12.0)

Note: *the ratio of physical volumes of internal production to physical volumes of internal consumption in Kazakhstan.

Table 2. Factors of influence on the regional FS

Factors of Influence	Rank	Weight
Internal factors		
Average daily caloric content of one person's diet (kcal)	1	0.24
Average selling prices of livestock and poultry (tenge/t)	2	0.18
Average selling prices of grain and leguminous crops (tenge/t)	3	0.14
Agricultural production volume index (%)	4	0.11
Environmental friendliness of AIC production (points)	5-6	0.08
Consumption of high-quality water (points)	5-6	0.08
Area of agricultural land (thousand ha)	7	0.06
Average monthly nominal salary (tenge)	8-9	0.04
Population with a monthly average per capita income below the subsistence minimum (thousand people)	8-9	0.04
Unemployment rate (%)	10	0.02
Total population of the region (thousand people)	11	0.01
External factors		
Level of geopolitical stability	1	0.33
Imports of agricultural products (million USD)	2	0.26
Force majeure	3	0.18
Natural and climatic conditions	4	0.13
Agricultural exports (million USD)	5	0.10

Note: Compiled based on the expert survey; the value of the concordance coefficient W=0.74 (p<0.01), which indicates a strong consistency of expert opinions.

Table 3. Regional FS indicators that should be considered when making data-driven management decisions

Regional FS Indicators	Rank	Weight
Energy value of food consumed in the households of the region, kcal	1	0.24
Production (in farms of all categories) of the most important food products, thousand tons	2	0.18
Production of the most important food products per person, kg	3	0.14
Consumption of the most important food products per person per year, kg	4	0.14
Dynamics of grain production and changes in their reserves in the state resources of Kazakhstan	5	0.12
The structure of total household expenditures of the region's population (total costs, consumer costs, including food costs, and non-consumer costs)	6	0.08
Differentiation of the cost of food by social groups	7	0.06
Capacity of the Kazakh regional food market, thousand t	8	0.04

Note: Compiled based on an expert survey; the value of the concordance coefficient W=0.71 (p<0.01), which indicates a strong consistency of expert opinions.
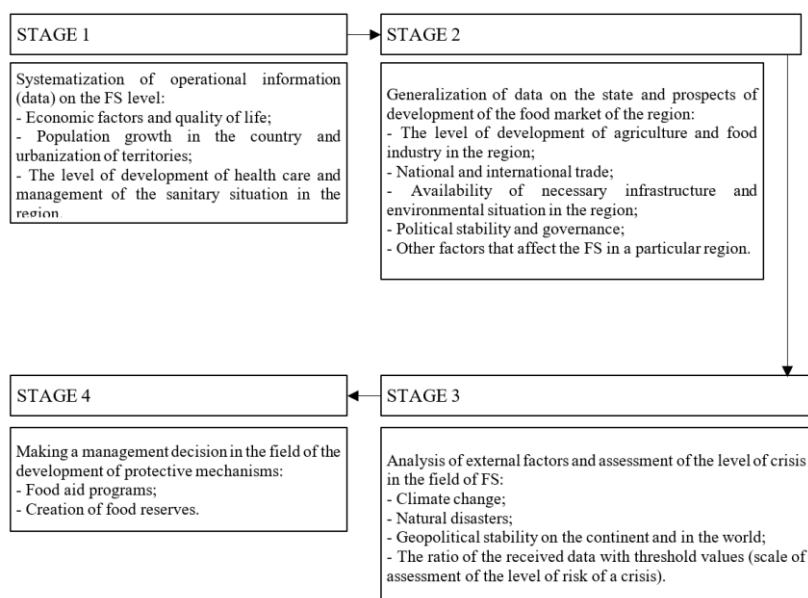

Figure 1. An algorithm for making managerial decisions in the field of regional FS based on DDDM

In the second stage, data on the state and prospects of development of the food market of the region are summarized. The timely use of the obtained information makes it possible to identify signs of an impending food crisis. At this stage, it is important to take into account the level of development of agriculture and the food industry in the region and the availability of the necessary infrastructure, national and international trade. This, in turn, makes it possible for regional authorities to use the developed protective measures, including the creation of an optimal food reserve in case of an emergency, taking into account scientifically-based consumption standards; conducting a comprehensive study of the socio-economic condition of citizens to identify the most lacking groups of the population, priority assistance to them in case of crisis, etc. This may also include information on the number of enterprises producing food; the ratio of prices for local and imported food products; the ratio of food consumption by urban and rural populations, including in the context of individual urban entities; assessment of physical and institutional infrastructure, the political situation and other internal factors. Such a system makes it possible to increase the effectiveness of measures to ensure safety.

In the third stage, the identification and assessment of the level of crisis in the field of FS is carried out based on the analysis of selected regional FS indicators and the influence of external factors on them. It is necessary to assess external factors that are practically impossible to control, but their occurrence significantly affects Regional FS (the geopolitical situation, natural disasters, and climate change). After obtaining the values of the indicators listed above, when comparing them with the threshold values, it is recommended to use the appropriate scale for assessing the level of crisis risk (for example, high, low, or medium).

In the fourth stage, management decisions are made to eliminate or reduce the negative impact of a crisis, if any. In case of a possible food shortage, it is appropriate to use such protective mechanisms as food aid programs and the creation of food reserves.

5. RESULTS AND DISCUSSION

The demand for food is growing at a higher rate than its production. Therefore, there are constant discussions in the scientific literature about the possibilities of FS development [36, 50]. As the results of the study have shown, in the context of achieving the principles of sustainable development, FS, first of all, is the access of all people to sufficient, safe, and nutritious food at any time to meet their nutritional needs for an active and healthy life. The development of FS depends on various factors. The results of the study have confirmed that to effectively manage FS, it is necessary to take into account several elements, from agricultural practices to global trade policies specific to this region. Regional features are quite diverse, which allows us to assess the importance of factors affecting FS in different ways. For example, households in Ghana are characterized by a low level of food consumption due to factors such as low level of education, employment status, and location of the household (i.e., in rural areas or the city) [51].

The more factors affect regional FS, the more opportunities there are for the development of FS, on the one hand, and on the other hand, the more difficult it is to manage it, which explains the need to create special tools that would increase the effectiveness of FS management.

Therefore, with our study, we fully confirmed the effectiveness of the assumption, together with other researchers, that when analyzing significant factors influencing regional FS, it is necessary to form two groups of factors (for the results of this study, see Table 2): internal and external.

The analysis of regional peculiarities of external and internal factors and the interpretation of the results of the expert survey affecting the FS of Kazakhstan allowed us to draw theoretical and practical conclusions from the results of our study.

Several points were noted as theoretical ones. When making management decisions in the field of food safety in Kazakhstan, special attention should be paid to the factors reflecting the sufficiency of consumption of certain foods as having the greatest weight, and not to what characterizes the number of people below the poverty line, because such groups are in the greatest food danger, which is confirmed by the results of the study [12].

The external factors either cannot be influenced (like natural and climatic conditions) or can be influenced only at the state level, which is confirmed by the results of the study [14]. In particular, the main external factor in ensuring the FS of Kazakhstan is the presence of geopolitical risks. The economy of Kazakhstan as a participant of the integration association of the EAEU, in connection with Russia's war in Ukraine, suffered from rising prices for raw materials, failures in logistics chains, high volatility of the cost of agricultural products, and the availability of inventory resources. Therefore, to reduce the influence of the factor of geopolitical risks, it is necessary to expand partnerships at the state level in a multipolar world, pursuing a policy of multi-vector integration [50].

Analyzing the regional FS indicators proposed by experts, which should be considered when making data-driven management decisions (Table 3), it should be noted that regional FS is guaranteed when, in addition to increasing food production, the nutrient balance in the food improves, and so does its quality, that is, energy value and nutrient content. Among the indicators of FS, this indicator is intentionally placed at the top.

An important indicator of regional FS is the inclusion of the main types of food into the human diet. In the FS of Kazakhstan and its regions, the sufficiency of grain reserves in state resources is important, which is defined as the ratio between the volumes of edible grain in the state food reserve and the volume of internal consumption of bread and bread products by the population recalculated as grain [52].

Besides, an important role in regional FS is played by the indicator of economic availability of food, defined as the share of total food costs in the total household expenditures, including in urban settlements and rural areas. A significant share of these costs belongs to consumer total expenditures on food products.

The level of food satisfaction of the population and regional FS depends not only on the physical needs of population groups but also on their purchase power [53]. A priority indicator of regional FSs is the differentiation of the cost of food by social groups, which is tracked in dynamics.

Experts have noted that the safety of regions is guaranteed when food production increases, the food quality, and balance of nutrients improves, when ensuring the necessary accessibility of each person to food resources is a priority in

filling the capacity of the Kazakh regional market of certain important products and tends to grow. The capacity of the internal regional market of individual goods is tracked in dynamics and is determined in physical terms as the product of consumption of a certain product and the average annual population of the region.

As practical conclusions, we identified the following provisions. Monitoring of the selected inductors will greatly contribute not only to the creation of a food crisis prevention system but also to the sustainable food supply of the region. To increase the level of efficiency of FS management in Kazakhstan, we developed an algorithm for making managerial decisions in the field of regional FS based on DDDM.

A feature of the decision-making system for managing regional FS is the ability of this system to predict the state of the regional FS and, through fluctuations in factors, determine the possibilities of influencing it. An important tool for improving the level of FS is to provide correct data on cases in the field of ensuring FS to decision-makers, allowing them to make decisions based on the provided data. The management of the regional FS using DDDM allows one to determine its state in the future, which in turn is the basis for creating a database and software [54] that helps to determine the management strategy and make operational decisions.

6. CONCLUSIONS

FS management includes addressing negative impacts through interventions such as developing climate-resilient farming practices, implementing effective population control measures, investing in sustainable agricultural technologies, strengthening political stability, reviewing global trade policies, implementing anti-poverty programs, strengthening infrastructure, and promoting gender equality. The highlighted variety of factors makes it possible to evaluate the implementation of the FS management system in Kazakhstan using DDDM. DDDM will allow for creating tools for making managerial decisions and reducing risks in FS in the context of the principles of sustainable development.

Research contributes to the growing body of knowledge on food security management and sustainable development by highlighting the complexity of factors influencing regional food security in Kazakhstan. By recognizing these factors and their interplay, policymakers and stakeholders can develop more effective strategies and policies to ensure food security, promote sustainable agriculture, and work towards broader sustainable development goals.

The limitations of the study include the quantitative limitations of the expert pool, which does not allow the conclusions of the study to be fully generalized.

Future research in the realm of food security management and sustainable development should prioritize regional-specific investigations, enabling a nuanced understanding of the diverse challenges faced by different areas within Kazakhstan. Additionally, research into climate-resilient agricultural practices can enhance food production systems' adaptability to environmental changes.

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