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Development of logistics infrastructure and supply chains of agri-food products in the Republic of Kazakhstan

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NORMATIVE REFERENCES

This dissertation references the following documents:

Concept for the Development of the Transport and Logistics Potential of the Republic of Kazakhstan until 2030.

DEFINITIONS

Cold Chain - A set of logistics operations that includes loading and unloading operations, order picking, processing, storage and transportation of products that require storage in a refrigerated environment.

Logistics Center (LC) - A material and technical complex consisting of a land plot with complex structures and specialized equipment designed to provide services for the delivery and processing of large quantities of goods.

Supply Chain (Product Chain) - A sequence of technological stages in the movement of products from the initial stage (raw materials or semi-finished products) to the production of finished goods and their delivery to the point of sale.

Wholesale Distribution Centers (WDCs) - These are warehouse complexes where products are delivered by producers and wholesale trading organizations. Goods are then distributed in smaller batches to customers through either the WDC's own or the customers' commodity distribution networks.

ABBREVIATIONS AND ACRONYMS

AIC	Agro-industrial complex
ALC AFP	Agro-logistics center Agri-food products
AFSC	Agri-food supply chains
CDN	Commodity distribution network
CA	Central Asia
DC	Distribution centers
EEU	Eurasian Economic Union
FCP	Frozen or chilled products
FP	Food products
FVP	Fruit and vegetable products
FSC	Food supply chains
FSC	Food supply chains
ITC	The International trade Centre
LI	Logistics infrastructure
LWDC	Logistics wholesale distribution centers
LDC	Logistics distribution centers
LPI	Logistics Performance Index
PPP	Public-private partnership
PSF	Personal subsidiary farming
PFP	Perishable food products
PG	Perishable goods
RLC	Regional logistics centers
SCM	Supply chain management
WFM	Wholesale food markets

INTRODUCTION

Relevance of the Research Topic. The development of the agro-food sector occupies a key place in the economic policy of the Republic of Kazakhstan, which is due to its contribution to GDP, significant export potential and strategic role in ensuring food security. However, the effective functioning of this sector is impossible without the development of modern logistics infrastructure and the construction of sustainable supply chains for agro-food products. The development of agricultural infrastructure plays an important role in increasing the investment attractiveness of the region and the efficiency of the economy. The process of its formation should take into account all factors, specifics, location of logistics infrastructure facilities and logistics service providers.

Currently, issues related to logistical support for agricultural enterprises remain highly relevant, but a comprehensive solution has not yet been achieved.

President of the Republic of Kazakhstan K.-J. Tokayev has set the task of accelerating the creation of modern storage and distribution infrastructure for agricultural products. In particular, he emphasized supporting businesses in constructing vegetable storage facilities, wholesale distribution centers, and rural service and distribution cooperatives. The President noted that approximately 60% of existing vegetable storage facilities are not equipped with modern refrigeration systems, and 30% of warehouse facilities have been in operation for more than 20 years, leading to significant product losses of up to 35–40% of the total harvested volume [1].

At present, logistics management in the country, particularly in the agro-industrial complex, is in its infancy.

At the same time, systemic issues persist in the logistics infrastructure and supply chains of agri-food products (AFSC) in Kazakhstan. These include regional and structural imbalances, weak coordination between supply chain participants, and insufficient access to quality logistics services. Collectively, these factors have a significant negative impact on the country's economic development, complicating efforts to achieve import substitution and build a competitive agro-industrial sector.

The formation of agri-food supply chains requires a highly efficient network of interconnections and economic relationships that enhance supply chain efficiency by developing new models and mechanisms that account for local characteristics, the level of logistics infrastructure development, and consumer mentality. Solving these issues will improve the efficiency and sustainability of logistics infrastructure and agri-food supply chains.

The Government of the Republic of Kazakhstan emphasizes the importance of developing logistics distribution centers to support sustainable regional economic growth. However, there is still a lack of clarity regarding the functioning mechanism and performance indicators of these centers. The fragmented nature of existing research, inadequate organizational and methodological support, and the absence of a systematic approach to designing logistics infrastructure, agri-food supply chains, and wholesale distribution centers highlight the significance of this dissertation study.

The degree of scientific elaboration of the problem. The issues of forming logistics infrastructure have been studied by foreign researchers such as Abrahamsson M., Bowersox D., Closs D., Cooper B., Kihlén T., and Sandberg E., as well as by domestic researchers including Abzhapbarova A.Zh., Dzhamalova G.G., Khadzhieva G.U., Imasheva G.M., Izteleuova M.S., Sabden O.S., Zhumataeva B.A., and Zhanbirov Zh.G., among others. Significant contributions to the development of the theory and methodology of logistics infrastructure development, supply chain management, and the advancement of the commodity distribution system in Kazakhstan's food market have been made by domestic scholars Raimbekov Zh.S. and Syzdykbaeva B.U.

The development of logistics infrastructure for enterprises, including agricultural ones, has been explored by Aisner L.Y., Ahumada O., Bikmetov R.R., Costa Y., Carvajal J., Grigoryan A.N., Kosova A., Kokov A.C., Kurbatova S.M., Nosov A.L., Petrova I.V., Sarache W., Shvalov P.G., Villalobos J., Vlasov V.A., Varava A.V., and others.

The authors generally agree that logistics infrastructure plans, coordinates, and regulates information and material flows at both the enterprise and regional levels. It serves as a mechanism that ensures the interconnection of economic processes within an enterprise's operations.

The theoretical and methodological aspects of creating and developing logistics infrastructure have been reflected in the works of scholars from CIS countries, including D.S. Bukharov, M.P. Bolodurina, V.A. Gudkov, A.M. Gadzhinsky, A.V. Dmitriev, S.B. Karnaukhov, N.P. Karpova, V.S. Lukinsky, S.Yu. Maksimova, A.I. Mishurova, I.Yu. Miretsky, P.V. Popov, and others.

The modeling aimed at enhancing the resilience of agri-food supply chains has been carried out by Akram H., Akhtar S., Ahmad A., Anwar I., Atzhanova A.N., Bekmurzaev I.D., Christopher M., Centobelli P., Cerchione R., Ertz M., Hammoudi A., Kendi S., Kondratenko S.A., Mukwarami S., Nkwaira C., Nemasipova A.N., Sarbaev S.Sh., Straube F., Simulation D.J., Serba V.Ya., Simakova Z.L., Saengsathien A., Sidorenko Yu.A., Sulaiman M., Ross D.F., Radjef M.S., Tursynbaev E.E., Tromp S.O., van der Poll H.M., Van Der Vorst J.G., Van Der Zee, Volkova A.A., Wiederer C., and Zhailaubek E.E., among others.

However, in many studies, the resilience of supply chains has predominantly been examined in the context of developed countries, with less focus on developing nations. The results suggest that organizations should work on aggregating agricultural products and integrating farmers into the market to establish efficient and sustainable supply chains.

Research on building intelligent cold chain logistics systems based on the pervasive 5G Internet of Things (IoT) and the role of information and communication technologies (ICT) in logistics services has been conducted by Akhmetkalieva S., Abdullaev S., Alpeisov A., Abdullaeva A., Baimukhanbetova E., Moldabekova A., Seidametova Zh., and Zhidebekkyzy A. These studies have significant practical value for improving the efficiency of the entire cold chain logistics system for fresh agricultural products.

In their works, Akhmetova Z.B., Chen Y.J., Chen X.J., Chepurnoy M., Ergobek D.K., Feng Y.Q., Geoffrion A.M., Gorlova E.E., Kaygorodtsev A.A., Kopylova O.A., Liu Y.K., Li Y., Lu C., Morris J., Momynkulova Sh., Musa K.A., Ozerova M.G., Rakhmangulov A.N., Wang Y., Wang P., Webster S., Ydyrys S.S., Zhang X.B., and others have explored the issues and prospects of developing wholesale distribution logistics centers, improving sales systems, and forming regional markets.

Thanks to a comprehensive review of scientific research on this topic, the work proposed new approaches to organizational and methodological support for the creation of logistics centers. While numerous studies address various aspects of this topic, there remain notable deficiencies in methodological frameworks and a lack of contemporary approaches grounded in scientifically validated criteria for assessing logistics center performance.

Furthermore, most existing research tends to focus on logistics infrastructure at the enterprise level or in the context of national transportation systems and regional development. However, the evolution of logistics infrastructure across different economic tiers, framed within the concept of "modern network and digital logistics" propelled by globalization, internationalization, and digital technologies, remains insufficiently explored—thereby emphasizing the need for further investigation.

The purpose of the dissertation research is to develop recommendations and an organizational and economic mechanism for the development of logistics infrastructure and sustainable supply chains of agri-food products to increase the competitiveness of the economy of Kazakhstan in the domestic and international markets.

The implementation of this goal necessitated the need to solve the following problems:

1. Conduct a theoretical analysis of the formation of logistics infrastructure, examining its role and the specific features of the functioning of agri-food supply chains.

2. Analyze international experience in the formation and development of agri-food supply chains and their logistics infrastructure, and develop a methodology for their study.

3. Assess the current state of logistics infrastructure and established supply chains for perishable products, identifying factors that influence their development.

4. To develop recommendations for the development of logistics infrastructure facilities in the regions and to propose effective supply chains for agricultural products to increase the country's competitiveness and reduce transportation costs;

5. Justify a prospective model and organizational-economic mechanism for the functioning of logistics infrastructure and supply chains, using logistics wholesale distribution centers as an example, develop a model of the LWDC of agro-food products based on the mechanism of public-private partnership;

6. To propose methodological solutions for the formation of logistics wholesale distribution centers for agricultural products and to conduct an assessment of the economic efficiency of their operation

The object of the study is the logistics infrastructure and supply chain of agri-food products.

The subject of the study is the organizational and economic relations that arise during the formation and functioning of logistics infrastructure facilities and supply chains of agri-food products.

The theoretical and methodological foundations of this research draw upon the works of both international and domestic scholars examining the development of logistics infrastructure at the regional level and supply chain management in the agri-food sector.

The dissertation employs a variety of general scientific methods (comparative, systematic, and statistical analyses) and applied techniques (indicator standardization, cluster analysis, regression analysis, factor analysis, center-of-gravity methods, regional ranking, and forecasting).

The empirical basis of the study comprises legislative and regulatory documents of the Republic of Kazakhstan, statistical data from the Bureau of National Statistics under the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, as well as information from periodical publications, and research conducted by the author personally.

Main provisions submitted for defense. In the course of the study, new provisions, conclusions and recommendations were formulated, the most significant of which are the following:

1. Systematization and clarification of the elements and structure of logistics infrastructure, leading to the development of a structural model of transport and logistics infrastructure and a classification of logistics infrastructure in the context of building effective and sustainable supply chains.

2. A methodological approach to the formation and development of logistics infrastructure and agri-food supply chains.

3. Scientifically substantiated proposals for prioritizing the development of logistics infrastructure and agri-food supply chains, along with measures for their implementation.

4. A model and organizational-economic mechanism for the functioning of logistics infrastructure for agri-food products.

Scientific Novelty of the Key Provisions of the Dissertation Research:

1. Based on the study of the formation and development processes of logistics infrastructure, distinctions in the concepts of logistics infrastructure and its core characteristics were identified.

2. Methodological approaches to the formation and development of logistics infrastructure and agri-food supply chains were developed based on the analysis of international experience.

3. Factors influencing the formation of effective logistics infrastructure and agri-food supply chains were identified, and the efficiency of their functioning was evaluated.

4. Scientific-practical recommendations and organizational-economic measures were developed in order to form logistics infrastructure and sustainable supply chains connecting small-scale agricultural producers to major regional consumers. This was achieved through an analysis of the agri-food market, organizational-economic issues in the development of logistics infrastructure, and the logistics services provided.

5. An organizational and economic mechanism for the functioning of the logistics infrastructure and efficient supply chains for products and a model for the formation of the LWDC based on the mechanism of public-private partnership, combining into one chain all logistics, production and technological processes, as well as the marketing and sale of agricultural products, have been developed.

6. Methodological solutions were proposed and tested for the formation of logistics wholesale distribution centers for the storage, distribution, and trade of agri-food products. Unlike existing centers, these solutions are based on the calculation of an integral indicator, determination of optimal placement, service zones, and the number of centers required in the regions, thereby justifying their locations, increasing the efficiency of production and sales of products. Based on economic efficiency indicators, including the discounted payback period (DPP), the built-in rate of return and the profitability ratio, an assessment of the project for the creation of the wholesale distribution center was carried out. The economic efficiency from the creation of the wholesale distribution center will be expressed in a decrease in losses and expenses in the distribution system, an increase in the efficiency of the supply system, an increase in tax revenues, an increase in the income of producers and an expansion of consumer choice.

Theoretical and practical relevance of the research. The results obtained by the author and the developed methodological approaches have the potential for further development of theoretical and applied research in the current field and the development of industrial employment and the supply chain of agro-food products. They have scientific and practical value for government agencies and research organizations involved in the development of the agro-industrial complex.

The proposed methodological support allows us to put in order the mechanisms of the LWDC. This will ensure the optimization of supply chains, a reduction in the scale of costs and product losses, which plays a key role in increasing the competitiveness of the agro-food sector.

The practical innovativeness of the dissertation is determined by the fact that the measures developed within the framework of the study allow us to increase the efficiency of alternative employment and create sustainable supply chains of agro-food products. The proposed methodological solutions for the formation of the LWDC of agro-food products can be used in the activities of government bodies in developing strategies for the economic development of agriculture, regulating agro-food markets, implementing import substitution policies; as well as in economic and production activities, agricultural agriculture, food industry, wholesale trade, in order to ensure a good system of marketing of agricultural products and increase the efficiency of their effectiveness.

A number of provisions and conclusions developed within the framework of dissertations can be used in the educational process of higher educational institutions in economic educational programs.

Testing and implementation of research results. The results of the dissertation research were covered at international conferences, including: The IIER International Conference on Social Science and Economics (London, 2024), International scientific and practical conference «New reality: economics,

management, social communications» (Novosibirsk, Novosibirsk State Pedagogical University, 2023), X ISPC «Current innovation and investment mechanisms for the development of the national economy in the minds of European integration» (Poltava Polytechnic named after Yuri Kondratyuk, 2023).

In addition, the results of the study were reported at international scientific and practical conferences, in particular: VIII RSPC «Integration of education-science-business: problems and prospects» (Ust-Kamenogorsk, S.Amanzholov East Kazakhstan State University, 2022), ISPC «Uvaliyev Readings: Actual Problems of Science and Education in the Context of Modern Challenges» (Ust-Kamenogorsk, S. Amanzholov East Kazakhstan State University, 2022), IX ISPC «Integration of education-science-business: problems and prospects» (Ust-Kamenogorsk, S. Amanzholov East Kazakhstan State University, 2023), XVIII ISPC «Ǵylym jáne bilim» (Astana, L.N. Gumilyov Eurasian National University, 2023), ISPC «Development of digitalization and formation of the institutional environment of e-commerce: trends, problems and solutions» (Astana, L.N. Gumilyov Eurasian National University, 2024).

The materials of the electronic book "Scientific project "Development of the transport and logistics system of Kazakhstan" were used in the educational process at the Sarsen Amanzholov East Kazakhstan State University, Kokshetau University named after Sh. Ualikhanov. Individual recommendations of the applicant were used in the activities of of LLP "New Silk Road" and LLP "SMART Trade Solutions," which is confirmed by the relevant acts on the implementation of scientific research results (Appendix A).

The results of the dissertation research were reflected in the applied research in priority areas for the state, in the project within the framework of grant funding from the Ministry of Higher Education of the Republic of Kazakhstan "AP19677634 Development of logistics infrastructure and sustainable supply chains of perishable food products in Kazakhstan (2023 - 2025)" (Appendix B).

Publications. The results of the scientific research have been published in 4 articles in journals indexed in the Scopus database, including 3 articles in the Web of Science Core Collection database, 5 articles in journals recommended by the Committee for Control in Education and Science of the Republic of Kazakhstan (CCES RK), and 8 articles presented at international conferences. Additionally, 1 copyright certificate from the Ministry of Justice of the Republic of Kazakhstan was obtained, registered in the State Register of Rights to Copyright-Protected Objects under № 42478 dated January 30, 2024. (Appendix C).

Structure of the work. The dissertation contains an introduction, three sections, a conclusion, as well as a list of references, contains 20 tables, 28 figures, 7 appendices.

1 THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF TRANSPORT AND LOGISTICS INFRASTRUCTURE AND ITS ROLE IN THE FORMATION OF SUPPLY CHAINS

1.1 Logistics infrastructure and its role in supply chains

Logistics infrastructure is a set of objects necessary for the implementation of the enterprise's activities to form, promote the flow of materials and minimize the costs of the enterprise and customers while satisfying customer requirements and complying with all necessary requirements and quality standards when performing these functions. The presence of a developed infrastructure is a prerequisite for the effective functioning of the logistics system.

In the work [2] it is noted that "thanks to the coordinated action of the logistics infrastructure, information exchange, transportation and other functional areas, it is possible to achieve logistics competence"

The logistics infrastructure performs logistics functions [3], a certain set of interconnected logistics operations aimed at performing certain tasks (Figure 1).

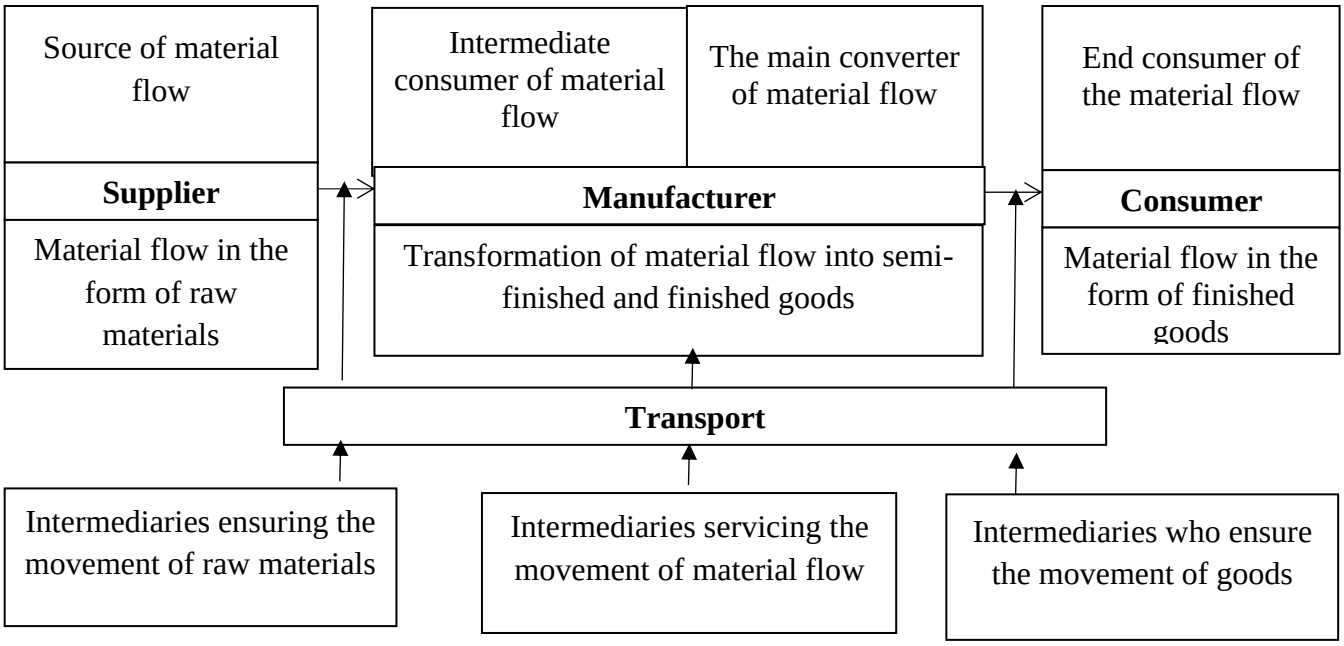


Figure 1 - Functional features of the logistics infrastructure

Note - compiled by the author

Thus, the logistics infrastructure, performing logistics functions, ensures the movement of goods from the manufacturer to the end consumers [3]. It relies on the organizational, material and credit-settlement base.

The main components of the logistics infrastructure management system [3]:

- General aspects of creating, developing, and managing logistics infrastructure
- Managing the fleet of owned or contracted transport
- Utilizing transportation and warehousing equipment
- Expanding main and auxiliary routes and access roads
- Improving the efficiency of warehouse operations

• Management of the operation of rolling stock on the line.

Researchers and practitioners interpret the concept of logistics infrastructure differently, focusing on its functional and structural aspects.

Some scientists define logistics infrastructure as a set of activities aimed at ensuring and supporting the movement of material and financial flows, which forms the basis of goods movement processes [4].

The work [5] analyzes the main elements of logistics infrastructure, such as warehouse, transport and communication components.

Russian scientists offer a broader interpretation, calling logistics infrastructure an integrated system of socio-economic objects. This system is designed to effectively ensure the operation of multi-level logistics systems in the region, in order to optimize the movement of various flows [6].

Economists describe logistics infrastructure:

- as an engineering and economic system that ensures fast and safe delivery of goods from the sender to the recipient. The basis of its functioning are transport vehicles, handling and warehouse equipment, as well as information technologies [7],
- as a complex of interconnected objects and elements, including logistics, trade and warehouse, information and sales components. This complex ensures the functioning of systems of procurement, supply, storage and delivery of products to the end consumer [8].

A synthesis of trends and challenges in shaping and advancing the logistics infrastructure for goods movement corroborates this perspective.

Logistics infrastructure is divided into three key types: technical, institutional, social [9].

Logistics infrastructure objects include warehouses, distribution centers, logistics centers, terminals and other organizational units. An important stage in the formation of infrastructure is the determination of the required number of objects, their geographic location and functional role. This ensures the efficient execution of operations for the processing and delivery of products.

Thus, the logistics infrastructure is a multi-level system that combines technical, organizational and social elements. Its purpose is to optimize and improve the efficiency of goods movement processes.

At the same time, in domestic practice, there are terms such as "logopark", “logistics village”, “logistics center”, "transport and logistics complex”, “dry port” and so on, which are often treated as synonyms.

Currently, a generation of logistics operators has emerged, classified according to the 1PL – 5PL scheme [10]. Thanks to the introduction of digitalization, the collection of various reports for decision-making is automated.

The key functions implemented in the logistics infrastructure depend on the degree of integration of logistics into the business processes of the enterprise. Five distinct levels of logistics integration can be delineated [11]:

• 1PL (First Party Logistics) — autonomous logistics, where all operations are performed by the cargo owner;

• 2PL (Second Party Logistics) — logistics service providers offering traditional transportation and warehouse management;

- 3PL (Third Party Logistics) — the company provides services with significant added value;

- 4PL (Fourth Party Logistic) — companies that plan, manage and control all logistics processes for the client in accordance with long-term strategic goals;

- • 5PL (Fifth Party Logistics) — Internet logistics, acts as a comprehensive virtual platform.

Logistics infrastructure includes a system of economic relations between various entities and institutions, which together provide a market mechanism for the smooth flow of logistics operations [12].

The main components of the logistics infrastructure:

Table 1 presents the main attributes of logistics infrastructure facilities according to classification criteria derived from a synthesis of various sources.

Table 1 - Characteristics of logistics infrastructure facilities

Parameter	*Distribution centers (DC)*	*Dry Port*	*Logistics Center*			*Warehouses and storage*
			local	*Regional*	*National and international*	
Logistics functions	Distribution logistics	Transport logistics	service is limited	service is limited	All service packages	service is limited
Service area	Determined by the company	81-499 km	51-79km	81-499 km	Over 501 km	On a certain territory
Facility territory	Determined by the production characteristics	Determined by processing volumes	3-9 ha	21-49 ha	51-149 ha	2-4 ha
Cargo types	Determined by the production characteristics	Different categories	Consumer	General consumer	Different categories	Perishable
Number of transport types	1	1-2	more than 1	more than 2	more than 2	1-2
Control object	Goods flow	Cargo flow/ container flow	Transport flow, cargo flow			
Note: compiled based on data from [13]						

The components constituting the logistics infrastructure should be analyzed across various managerial tiers—namely, the macro, meso, and micro levels. Each level encompasses a distinct set of infrastructural components and corresponding requirements, thereby influencing the managerial choices aimed at reinforcing the agricultural infrastructure (Table 2).

Transport infrastructure is an integral part and element of the entire market infrastructure or market economy, without it it is impossible not only to operate industries and links of the main production and non-production sphere, but also various types of markets, the creation and expansion of various markets is closely tied to the development and availability of transport infrastructure. Consequently, logistics infrastructure also incorporates transport networks and roads, ports, vehicles,

and cargo terminals for different modes of transportation. Nonetheless, transport infrastructure alone cannot presently ensure the efficient delivery of cargo from shippers to end consumers.

Table 2 - Classification of logistics infrastructure by management levels

Management level	*Type of logistics infrastructure*	*Interpretation*
Macro	Macro	A network of facilities designed to streamline resource flows, enhance the investment appeal of enterprises, and increase the overall efficiency of logistics operations and productivity across all economic sectors
Meso	for supply chain	A configuration of interconnected assets enabling the movement of material flows within a specified supply chain across time and space, while minimizing associated costs
Micro	of the company	A system of warehousing, transportation, loading/unloading, packaging, information, and financial components that provides cross-functional, "door-to-door" and "just-in-time" logistics services at minimal expense to meet customer needs.
	External infrastructure of the company	A cluster of co-located infrastructure units delivering logistics services for both inbound and outbound material flows with optimal cost efficiency and a predetermined service level.
	Internal infrastructure of the company	An enterprise subsystem that integrates infrastructure elements to manage internal material flows, thereby optimizing service processes and maximizing the economic returns on logistics activities.

Note: Compiled based on the materials of the literature review

This requires the integration of transport and logistics infrastructure. The main function of transport infrastructure is to transport goods from the sender to the recipient, providing transport services (loading, unloading, warehousing of cargo, forwarding services, etc.) with minimal costs. The task of the logistics infrastructure is to combine the spheres of production, distribution, circulation and consumption into a single chain by ensuring the safety, security and continuity of cargo provision and integrating transport with warehouse, container and packaging facilities. The composition of the transport infrastructure includes communications of various types of transport [15]: transport and logistics enterprises, operational communication routes, transport service facilities and rolling stock of all types of transport (Figure 2).

In this regard, we have provided a clarification of the logistics infrastructure (LI) as a set of tools for managing logistics flows (cargo, goods). The main task of LI is to ensure the safety, security and timeliness of delivery of goods to the end consumer.

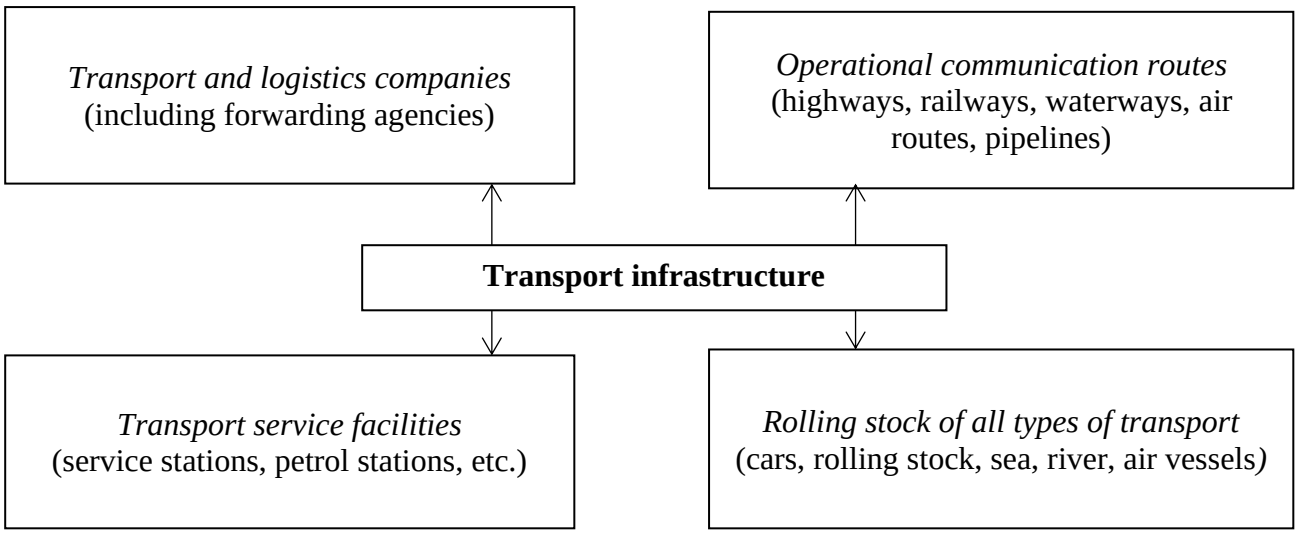


Figure 2 – Main elements of transport infrastructure

Source: [15]

Based on this, LI can include logistics enterprises with a full or partial service cycle, warehouse technologies and equipment, as well as various information logistics and digital technologies by type of transport. The objects of logistics service include enterprises in the manufacturing and non-manufacturing sectors and the population. Figure 3 shows the structure of the logistics infrastructure.

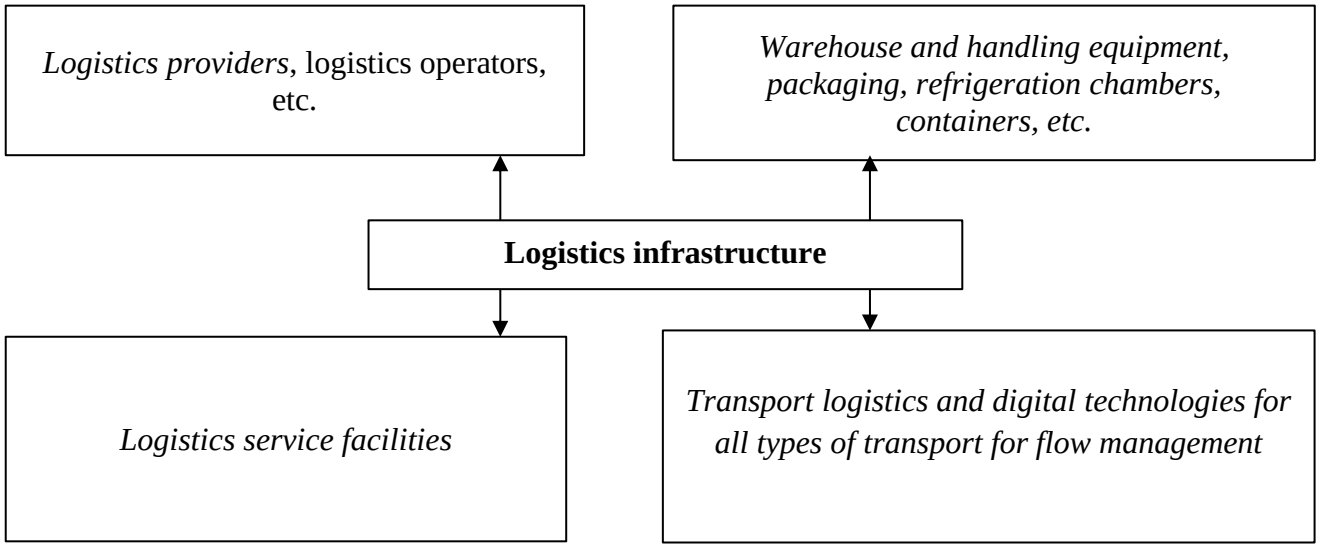


Figure 3 - Basic elements of logistics infrastructure

Note: developed based on sources [16,17]

The coordinated application of transport and logistics infrastructure integrates production, distribution, exchange, and consumption into a unified chain, thereby accelerating the circulation of material, financial, and information flows. The main goal of the formation of transport and logistics infrastructure (TLI) should be the integration of the transport complex and modern models of digital logistics into a

single customer-oriented environment. The expected result of the convergence and, in some cases, the unification of the transport and logistics sectors will be their merger into a single sector, where it will be possible to create a digital model of the functioning and management of TLI.

A thorough examination of different perspectives on the notion of infrastructure yields the following insights, which are crucial for investigating the challenges related to infrastructure formation and development:

- the main features of infrastructure are the creation

of general conditions for production and ensuring the continuation of the production process in circulation [18];

- the concept of "infrastructure" is distinguished from the concept of "services". The first concept includes industries that create the conditions necessary for the promotion of products from production to final consumption, and the second concept - industries that provide services to production and the population;

- it is advisable to consider infrastructure at four levels, corresponding to the levels of functioning of the economy: micro level, meso level, macro level, mega level.

It is necessary to state that we still do not have precise definitions of “logistics infrastructure” or “transport and logistics infrastructure”, but we can come across the interpretation “transport and logistics center, wholesale distribution center, agro-logistics center, logistics terminal, trade and logistics infrastructure”.

For instance, references to “transport and logistics infrastructure” and the advancement of efficient transit, export, and logistics infrastructure in Kazakhstan typically pertain to establishing regional transport and logistics hubs and transport and logistics centers where logistics companies offer transport and logistics services [19]. Moreover, the development of transport, and logistics infrastructure is understood to include the creation of transport and logistics centers [20], along with expanding trade, logistics, and transport infrastructure, and constructing logistics centers, wholesale distribution centers (WDCs), and agro-logistics centers (ALCs).

The above infrastructures provide services not only for consumer goods but also for perishable agricultural products and food products.

In planning the supply chain of agri-food products, one of the main issues is perishability of products and product quality. The longer the harvest time and the longer the delivery time to the market, the lower the price of the products will be. Therefore, time is considered as one of the main factors in the supply chain system. In the supply chain management system, the supply of perishable products is a critical issue due to their short shelf life.

Developing and maintaining a reliable logistics infrastructure is crucial to enhancing economic competitiveness, reducing transportation costs and improving the overall efficiency of the perishable supply chain (SPSC).

The main purpose of the PFP logistics infrastructure is to provide information and warehouse services, storage, cold chain management, inventory management, as well as assistance in transporting and packaging products. The PFP logistics infrastructure should maintain the continuity of the temperature regime of the chain from the manufacturer to the end consumer.

The PFP logistics infrastructure performs important functions to ensure the continuity of production, distribution, exchange and consumption processes in the region: collection and aggregation, cold storage, transportation, information support and trade.

Based on foreign experience, in order to implement state control over tariffs in the markets, ensure unhindered access for domestic producers and achieve the necessary effect in containing prices, it was planned to build a network of wholesale distribution centers (WDC) and agro-logistics centers (ALC) in the Republic of Kazakhstan. This would create effective interregional channels for the redistribution of products. Agro-logistics centers will have to be located near agricultural production centers, allowing farmers to organize the storage, packaging and delivery of their products. In this case, the parameters of the WDC and ALC will differ depending on the needs and availability of existing infrastructure [21].

When examining the transport and logistics system (TLS) and its associated infrastructure, one can regard them as a network comprising vehicular assets, transport and logistics enterprises, and state regulatory frameworks. This configuration facilitates the efficient movement of passengers and cargo, thereby enhancing competitiveness, expediting economic growth, and addressing the country's national security objectives [23].

From our point of view, it is possible to include in the transport and logistics infrastructure (TLI) objects (TLC, cargo terminals, etc.), which can be classified as both transport and logistics infrastructure. This approach recognizes functional characteristics and ensures clarity in assigning infrastructure elements (Figure 4).

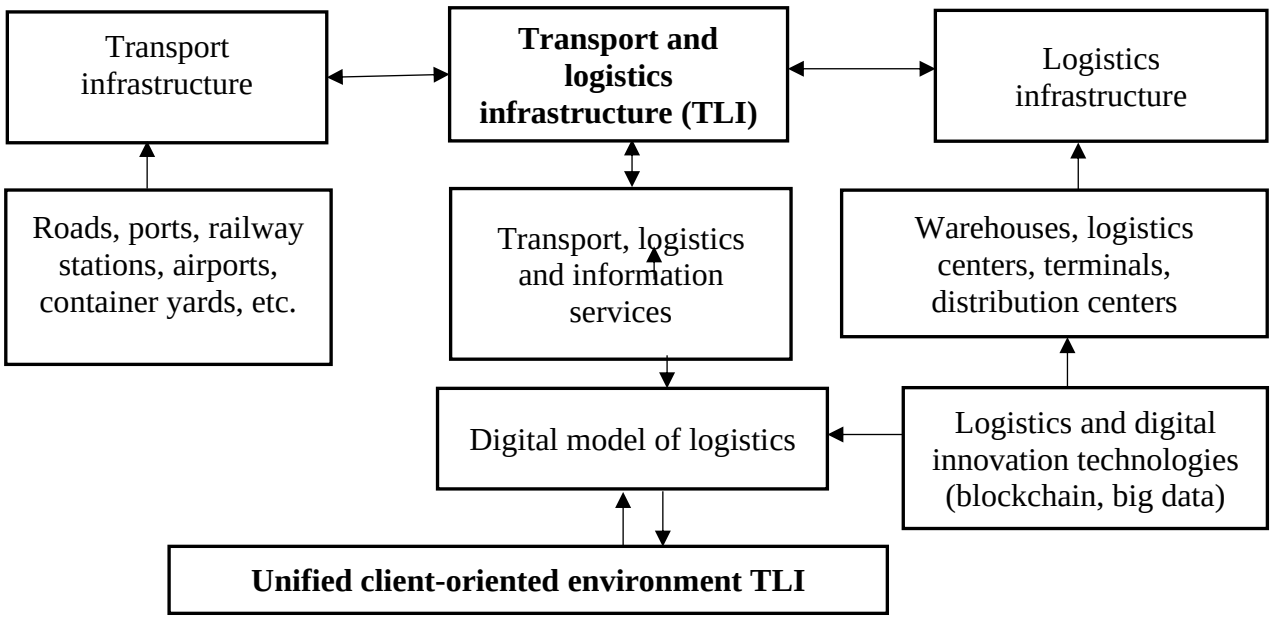


Figure 4 - Structure of a customer-oriented digital model of transport and logistics infrastructure (TLI)

Note: Compiled by the author based on [13].

The entire diversity of logistics infrastructure can be classified according to the following criteria:

- By scale: micrologistics, mesologistics, macrologistics.
- By spatial criterion: local, urban, regional, national, international.
- By service criterion: universal, specialized.
- By completeness of service: full service cycle, partial service, mixed.
- By type of transport: automobile (refrigerated trucks, awnings), railway (containers, refrigerated cars), air, water.
- By type of cargo handled: perishable goods, non-perishable goods; loose, solid.
- By the impact of the environment on products: with temperature control, without temperature control.

By industry: trade (wholesale, retail, external), production, customs.

Based on the conducted study, the essence and content of the key components of logistics infrastructure were revealed.

The establishment of modern logistics infrastructures in the agro-industrial domain—such as agro-logistics centers (ALCs), wholesale distribution centers (WDCs), and retail centers (RCs)—contributes to mitigating price volatility for food products. It also facilitates equitable trade markups for farmers, thereby increasing their income, curtailing post-harvest losses, and enhancing product quality and safety.

The primary objective of the logistics infrastructure for agri-food products is to provide information and warehousing services, organize storage, manage the cold chain and inventory, and facilitate transportation and packaging processes.

1.2 Specific features of the functioning of logistics infrastructure and supply chains in the agro-food market

The concept of a “supply chain” refers to the multifaceted sequence of operations through which raw materials are converted into final goods and subsequently delivered to end users. Accordingly, the supply chain encompasses not merely producers and suppliers of goods, but also warehouses, distributors, wholesalers, retailers, truck drivers and consumers who buy the products.

The manufacturer sells the goods to the distributor, who then delivers the goods to the final consumer. The manufacturer also places orders with suppliers for the materials it needs. This process continues in this way until the product is offered for purchase. This requires extensive coordination between participants in the supply chain to ensure that the right goods reach the right customers at the right time, from production to distribution and retail.

The following figure 5 shows the relationships between the various supply chain networks.

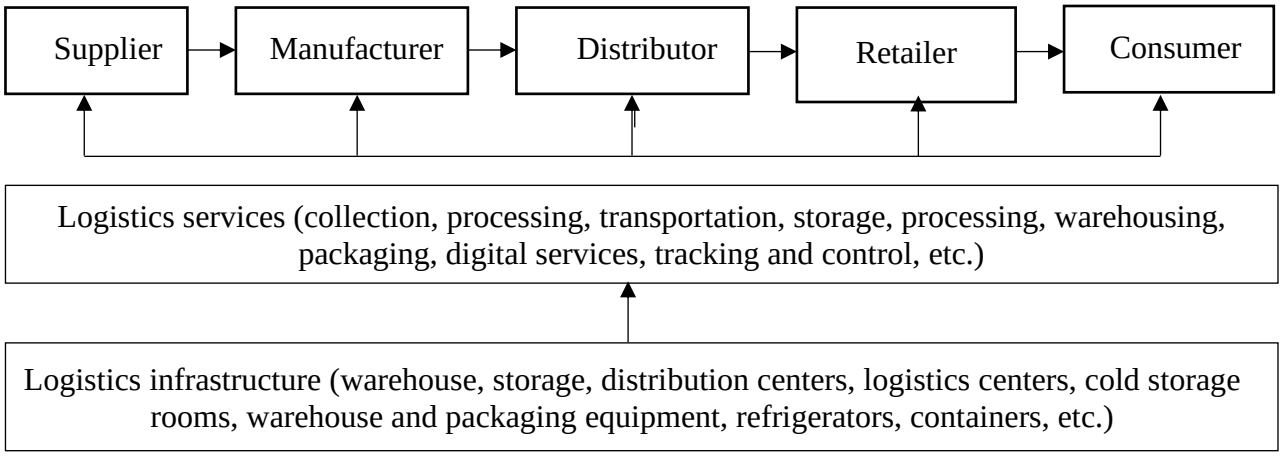


Figure 5 - Relationship between participants in food supply chains and logistics infrastructure

Note: developed by the author

The concepts of "logistics" and "supply chain management" are inextricably linked. And if the supply chain in general ensures the passage of material flow, then logistics itself has a set of tools, means and methods for managing, planning and controlling the passage of material resources along the supply chain. According to Ross D.F. [24], logistics includes warehousing, transportation, materials and information management, as well as the integration of logistics operations for the entire supply chain, while supply chain management combines marketing and production with distribution functions to improve competitive advantages.

Speaking about the role of logistics in the context of supply chain management, Christopher M. points to its ability to integrate pricing processes, production and sales control, as well as the ability to serve consumers at a higher level of quality and at lower costs [25].

Supply chain management (SCM) covers the most important aspects of business: purchasing, ordering, product life cycle management, production and inventory planning, logistics operations, and end-user service. This creates a complex and sophisticated mechanism in which each link in the chain is built into a single flexible system.

According to Akopova E.S. and Evtodieva T.E. [26], “supply chain management entails the holistic planning, execution, coordination, and oversight of all business processes and activities essential for producing and delivering market-ready goods with optimal efficiency.”

Saengsathien A. conceptualizes the supply chain as an integrated, interconnected, and interdependent network of organizations—including suppliers, manufacturers, distributors, third-party logistics providers, and retailers—that cooperate, either directly or indirectly, to source raw materials, transform them into final products, add value to these products, and distribute and promote them to retailers. These retailers, in turn, provide the products to end users and customers, while simultaneously facilitating the exchange of information among all members of the supply chain [27].

Within the agro-industrial sector, the supply chain is notably more complex due to the perishability of products and the imperative of food safety throughout the agricultural processing stages. Consequently, effective risk management across the supply chain requires improvements at every step, particularly during processing [28].

Historically, the evolution of the supply chain management concept can be delineated through several distinct approaches [29]:

1) until the 1980s there was a systematic approach to control of purchasing activities and suppliers.

2) then there was a simplified regulation of logistics processes and integration of business processes of companies into chains.

3) since the 2000s there has been a unification of joint production of consumers and suppliers.

The prerequisite for the development of the supply chain management concept is the logistics approach. The logistics approach to supply chain management has two main development directions [25]:

1. supply chain logistics, i.e. optimization of flows of raw materials, materials and finished products in the chain;

2. service logistics, related to efficient satisfaction of consumer demands.

Food supply chains (FSCs) possess several unique attributes that distinguish them from other product supply chains. Their principal distinction arises from the ongoing and substantial alterations in food quality that occur throughout the entire supply chain, from production through to final consumption [30]. Furthermore, FSCs are notably more complex due to product perishability, substantial fluctuations in demand and prices, elevated consumer focus on food safety, and reliance on climatic conditions [31].

Food loss and waste (FW) can occur at any stage of this chain, extending from initial production to final consumption—often summarized by the phrase “from field to counter”. These losses and waste manifest at all FSC levels, including agriculture, processing, wholesale, and even the consumer segment, and are prevalent in both developed and developing nations and has become a global problem for all participants in the food supply chain [32].

In developed countries such as the USA and EU countries, losses and damage to SPP due to confusion in procurement and ineffective methods of SPP storage occur at the final stage of FSC. And in developing countries such as Kazakhstan and Russia, losses and damage to SPP occur at the beginning of FSC due to technological and infrastructural limitations, as well as insufficient experience, low qualifications of specialists in land preparation, harvesting, etc. [33].

For the active development of the agro-industrial complex in the region, a unified system of procurement, processing and storage of agricultural products is needed [34]. To solve this problem, it is possible and necessary to use agricultural cooperatives and develop a network of logistics centers [35].

The supply chain management process depends on the “efficiency of the supply chain, the sustainability of the supply chain”. Today, consumers around the world

demand more from food products than just their nutritional characteristics. These requirements include safety, quality, integrity, variety and sustainability [36].

There are two approaches [37] in research on supply chain logistics and network design to minimize:

1. or maximize profits (economic);
2. environmental impact.

Integration of economic and environmental approaches is a promising direction that helps achieve both goals: increasing the sustainability and efficiency of supply chains and networks. This approach allows developing adequate solutions to improve the functioning of logistics systems.

A sustainable and efficient logistics system simplifies the flow of goods, information, finance and other resources, and plays an important role in the economic development of the country. In this case, a balanced strategy that takes into account not only economic but also environmental and social aspects is of key importance.

Supply chain sustainability should be based on the following principles:

1. Balanced development: Strategies should combine economic goals with minimizing environmental damage.

2. Coordination and cooperation: Integration and coordinated interaction between all supply chain participants is important to optimize logistics processes. An efficient supply chain logistics system has a number of characteristics:

• Speed and timeliness: Fast and accurate delivery of goods to end consumers.

• Information exchange: Real-time access to data, ensuring process transparency.

• Cycle time reduction: Minimizing the time it takes to complete logistics operations.

• Process coordination: Streamlined management of work processes at all levels of the chain.

• Decision support: Using tools to analyze and optimize logistics.

• Data integration: Combining information on operations to improve consistency.

• Capacity optimization: Reducing redundant management layers and increasing system flexibility.

Inefficiencies in the supply chain are often associated with deficiencies in the physical structure of transport functions. Limited capacity, outdated vehicles and inconsistent infrastructure can significantly hinder the achievement of sustainability and efficiency.

Thus, the integration of economic and environmental approaches, as well as taking into account the multifaceted factors affecting logistics, are key elements for building sustainable and efficient logistics systems that contribute to economic growth and reduce environmental impacts.

Key principles of logistics management in the food supply chain [38]:

• Inventory optimization. Inventory management is a critical aspect of logistics in the food supply chain.

• Efficient transportation to reduce the delivery time of goods. Selecting the most appropriate transportation methods and optimizing routes help to reduce costs and shorten delivery times.

• Quality management to improve logistics service and reduce logistics costs. Ensuring high quality products is important to meet consumer expectations and comply with legal regulations.

• Information technology. The use of modern information systems and technologies can improve the management of the entire supply chain, providing more accurate demand forecasting, product tracking and order management.

• Development of cooperation in the promotion of material and technical resources, raw materials and finished products.

The links of a single macrologistics system of the agro-industrial complex should be both multi-level supply organizations consisting of a chain of links, and single intermediary large and small resource-supplying organizations.

The main functions of the logistics system in the agro-industrial complex should be:

1) providing agricultural producers with goods and services of the required volume and quality, at a certain time with minimal costs,

2) establishing channels for the distribution of goods based on the development of optimal logistics chains,

3) development of agrological services and agrological management.

The transport and technological infrastructure should ensure the performance of the following operations with perishable goods: unloading of goods brought in by road, packaging, bundling, sorting by order, labeling, calibration, refrigeration treatment, etc. It should be noted that perishable goods are transported in isothermal wagons, covered wagons, general-purpose and refrigerated containers. Agricultural logistics or agrologistics is a relatively new interdisciplinary field in the agricultural sector, including the management of supply chains of agricultural products and raw materials from production to delivery to the consumer, combining agricultural production, marketing, management and logistics [39].

Functionally, logistics in agriculture should include [40]: system planning and management; purchasing activities; transportation; inventory management; processing, production, packaging; warehousing, storage; distribution, sales; service support; information system.

To improve the efficiency of the agricultural product market, it is necessary to create a modern agrologistics system based on a network of modern infrastructure facilities. Agrologistics (or agricultural logistics) is the process of planning, organizing, monitoring and managing the transportation and other operations associated with bringing agricultural products from field to table on an industrial scale. Marketing, trade and logistics play a key role in the agrologistics infrastructure (Figure 6).

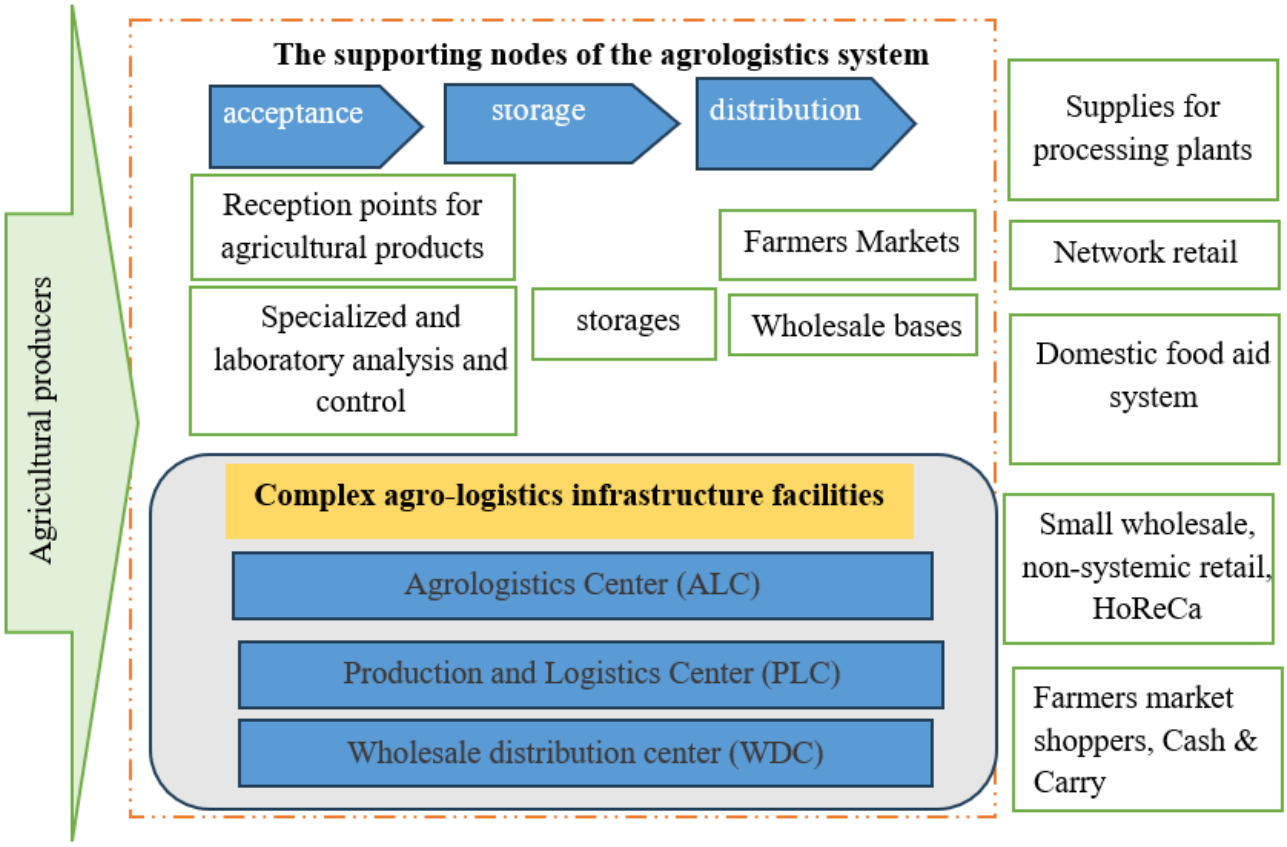


Figure 6 – Functionality of agrologistics

Note: developed by the author

Logistics of the agro-industrial complex has a number of features that are a condition for its functioning:

1. Remoteness of producers from transport infrastructure:.
2. Seasonal dependence
3. Factors of production location.
4. Interregional and international relations.
5. Price imbalances.
6. Weak development of the material and technical base of the AIC and sales logistics.

Logistics in agriculture is aimed at achieving the following goals [41]:

1. Optimization of material flows
2. Creation of a sustainable supply and sales system
3. Reduction of intermediaries.
4. Implementation of innovations
5. Just-in-time delivery of products
6. Safety of products.
7. Developing a rational pricing mechanism within the integrated system of agricultural production, processing, and distribution.
8. Creating an agricultural logistics framework for the agro-industrial complex

9. Ensuring the sustainable functioning of a state information support system for the agro-industrial complex by incorporating objective, real-time data throughout the entire production and sales chain for agricultural goods.

Tasks of logistics in the agro-industrial complex to improve efficiency

• Development of effective strategies for managing seasonal resource flows.

• Providing access to modern transport systems in remote regions.

• Creation of regional and international logistics centers to simplify the flow of agricultural products.

• Implementation of inventory monitoring and management technologies to improve control over product safety.

• Reduction of logistics costs through digitalization and optimization of logistics processes.

Thus, logistics in the agro-industrial complex is a complex system that requires taking into account its specifics and integrating modern technologies to improve the efficiency and sustainability of supply chains.

The supply chain of products begins with agriculture and goes through transportation, processing and distribution before reaching the end consumer (Fig. 7).

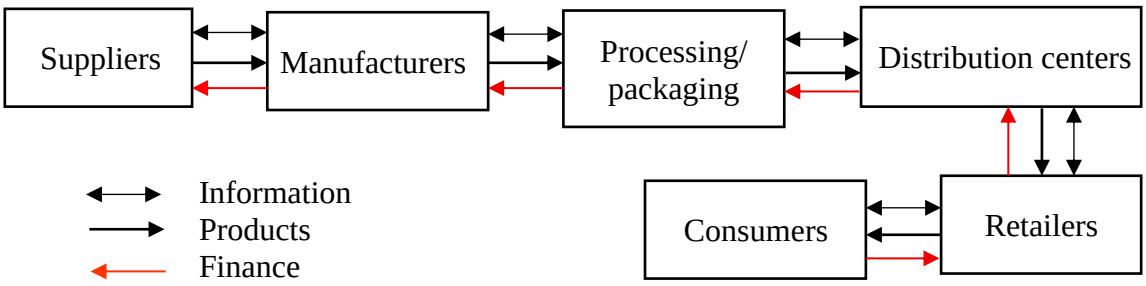


Figure 7 - Flow of products, information and finance between producers, intermediaries and consumers

Note: developed by the author

At all levels, the flow of information and production management are essential to maintaining food safety and quality throughout the chain. The flow of inputs from farms to consumers must be described in detail, and the constraints in each sub-process must be identified to develop appropriate solutions to logistics problems.

The logistics infrastructure of agri-food products (AFP) performs important functions: collection and aggregation, cold storage, transportation, information support and trade. The logistics infrastructure of agri-food products includes enterprises involved in:

- storage of products,
- organization of trade,
- transportation.

Warehouses, wholesale markets, distribution centers, fairs are engaged in storage, distribution, trade and transportation.

In modern conditions, different formats of trade of APP and their infrastructure are used. Let's consider the objects of the logistics infrastructure of APP.

1) Vegetable storage facilities

Currently, the infrastructure of vegetable storage facilities is actively developing in the country, which contributes to the improvement of agriculture and the standard of living of the population. These facilities bring many advantages to the agriculture of Kazakhstan, such as: increasing the shelf life of products, increasing productivity, creating jobs, promoting sustainable development.

However, serious problems remain, including the low provision of warehouses with climate control equipment: only 16.6% of 1.2 thousand storage facilities are equipped with refrigeration units and microclimate systems [42]. To preserve the harvest, a threefold increase in the capacity of potato storage facilities and a twofold increase in fruit storage facilities is required, but the current pace of construction does not allow achieving these goals by 2025.

2) Warehouses and warehouse complexes for food products

Warehouses in Kazakhstan, equipped to perform sorting, packaging, packing and labeling operations, ensure the supply of goods to retail outlets. The warehouse logistics market has demonstrated dynamic growth over the past five years, but demand in a number of regions significantly exceeds supply, which causes an increase in prices for warehouse services. In 2023, the total supply of warehouse space in Kazakhstan amounted to about 5 million sq. m, of which 1.3 million sq. m are high-class warehouses. In 2024, the total area of existing high-quality warehouse facilities in RK is 1.3 million sq. m. The main capacities are concentrated in Almaty and Astana, with smaller facilities in Shymkent and Aktobe.

3) Logistics centers (LC)

A logistics center is a property complex that includes a site with capital buildings and equipment, designed to provide services for the delivery and processing of wholesale lots of goods. A logistics center is a complex of warehouses that provide cargo storage services for the effective distribution of products. A logistics center is understood as the construction of vegetable and fruit storage facilities with primary processing of agricultural products. Ultimately, this will help farmers and private households increase production volumes and expand the range of products.

The fruit and vegetable subcomplex of Kazakhstan has the main elements of the logistics infrastructure, but their interaction and coordination are insufficient. In order to develop the agro-industrial complex, it is necessary to create a unified system for the procurement, processing and storage of agricultural products, including agricultural cooperatives and a network of LCs in this system.

4) logistics wholesale distribution centers (LODC), wholesale distribution centers (WDC), agrologistics centers (ALC)

Depending on the technological specialization and type of services provided, wholesale distribution centers (WDC) are divided into: wholesale distribution center for storage, distribution and trade. WDCs specialize in the storage, processing, distribution and trade of agricultural products, forming effective transport and logistics channels for domestic and export deliveries.

In developed countries, wholesale distribution centers, often state-owned, play a key role in agrologistics. For example, in France, out of 20 wholesale food markets, only one is private, the rest are fully or partially state-owned. In Spain, the Mercasa wholesale distribution center network is also state-owned. 62% of the shares of the Warsaw Agricultural Wholesale Market are also state-owned. In our country, there are plans to place wholesale distribution centers for trade near large cities, and wholesale distribution centers for distribution within city limits; this will speed up customs clearance and other processes. The functional model of a WDC is shown in Figure 8.

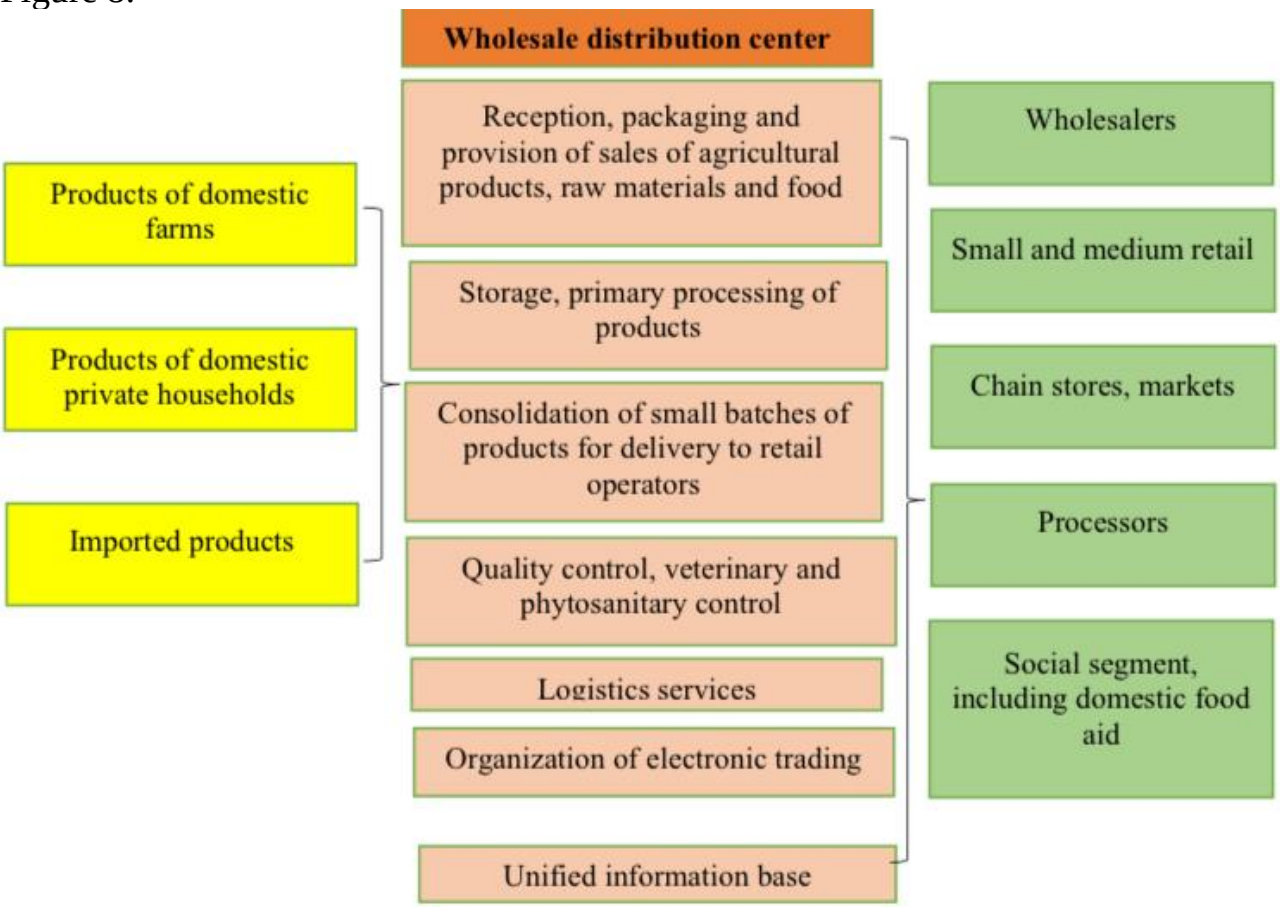


Figure 8 – Functional model of a wholesale distribution center (WDC)

Note: developed by the author

5) Regional food centers /or hubs

Food hubs are a modern model of food distribution that connect small and medium farmers with consumers and distribution agents through the creation of value chains [43]. These centers strengthen local and regional food systems, promoting sustainable development and public health.

The main functions of food hubs [44]:

• Aggregation: collecting products from different suppliers for distribution through a single channel.

• Distribution: storing and transporting products to the buyer.

• Marketing and sales: finding buyers, selling products, promoting farm brands.

The goal of food hubs is to provide small and medium farmers with access to large markets through the coordination of local supply chains and the development of wholesale partnerships, supporting the role of farmers in regional food systems.

The purpose of food hubs is to provide small and medium farmers with access to larger or additional markets. Their role is to collect, distribute and market food products at the farmer and trader level, as well as to act as a regionally owned enterprise (RLE) in implementing the work of food distribution centers.

7. Cold chain infrastructure (refrigerated trucks, cold rooms and equipment)

Cold chain logistics solutions include key elements: warehousing equipment, packaging materials, quality monitoring system, specialized vehicles, product handling during transportation and timely delivery.

The main role in the warehouse infrastructure belongs to climate-controlled multi-temperature warehouses, which ensure the storage of agricultural products at temperatures from -24°C to +5°C. Such warehouses consist of isolated areas with refrigeration equipment and convenient access for loading and unloading operations.

In order to develop the national logistics infrastructure, it is necessary to implement all the tasks set in the Concept for the Development of the Transport and Logistics Potential of the Republic of Kazakhstan until 2030 [45].

So, let us emphasize the features of the functioning of the logistics infrastructure and supply chains of agricultural products: it is necessary to use a logistics approach to create an effective system of goods movement in the Kazakhstani market of agricultural products. This system should be built on the conjugation, integration and cooperation of all elements involved in the movement of goods and include:

- material base for production (farmer production and sales cooperatives);
- warehouse base (modern network of cold storage facilities, storage facilities, hangars);
- transport component (refrigerated trucks, grain carriers, etc.);
- trade infrastructure (distribution centers and exchanges).

Thus, in order to increase efficiency in the country’s agro-industrial complex, it is necessary to develop logistics principles and approaches, which will strengthen the interaction of all elements of the logistics chain.

1.3 Methodological approaches to the formation and development of logistics infrastructure and agri-food supply chains

In most European countries, the practice of regulating the size of retail facilities and their placement has become widespread since the early 1970s, and by the end of the 1990s, a tightening of such legislative measures was noted. Such regulation varies in the reasons and motives for government intervention, as well as in the degree of distribution among countries.

The main goal of government regulation is to maintain the integrity of the territorial distribution of retail infrastructure, prevent the displacement of trade from city centers and protect the interests of socially vulnerable groups of the population who are deprived of the opportunity to visit remote shopping areas. In addition,

regulation is aimed at providing competitive advantages to small and medium-sized businesses, whose ability to resist transnational operators is limited.

"To meet the demand of the population, it is necessary to optimally locate enterprises, otherwise this can lead to a negative result and bankruptcy of trading enterprises" [46].

Thus, as a basic condition for the modern development of retail trade, it is necessary to a priori theoretically fix the need to strengthen the role and participation of the state in this process. The forms and methods, tools of such participation should be differentiated to the required level.

An important direction in this division should be the control of the institutionalization of the country's domestic market, which involves limiting the currently existing spontaneous (natural-evolutionary) transformation of the structure of the material and technical base of trade by forms of ownership, as well as the elimination of significant gaps in the volume of retail sales by trade entities.

In this study, the main attention is focused on the objects of the trade infrastructure related to the group of trade and intermediary and distribution organizations (wholesale and wholesale and retail markets for food products; agricultural cooperative markets, retail stores). Since these organizations have a direct impact on the process of food product circulation, and other elements of the infrastructure complex have general economic significance.

The optimal location of the distribution center depends on many factors. In addition to distances, volumes of transported goods and transport tariffs, their optimal placement is also influenced by such factors as the availability of a developed network of access roads, environmental and legal restrictions, tax regulations and many others.

And only a comprehensive consideration of all significant factors allows you to make the right decision on the optimal placement of the distribution center in the region.

The placement of distribution centers can be defined as a search for an optimal or as a search for a suboptimal solution.

Currently, many methods have been developed for solving the problem of optimal placement of a warehouse terminal, among which the following methods can be distinguished: the exhaustive search method, the heuristic method, the center of gravity method, the trial point method, economic and mathematical models. Let us consider each of these methods.

1) The exhaustive search method, thanks to computer technology, considers all possible alternatives for the placement of distribution centers [47]. In reality, it may not be applicable, since the number of possible options increases exponentially as the scale of the network increases, and with them the complexity of the solution.

2) Heuristic methods are effective for solving complex practical problems and, with a low computational load, can give approximate results, but do not guarantee the absolute optimality of the solution found.

3) The method of determining the center of gravity [48]. Its essence is to determine the location of the warehouse complex in which the minimum total cargo turnover between the warehouse and consumers or supplier would be achieved. 4)

The economic and mathematical model includes the model for determining the optimal location of a warehouse, proposed in the work of D.S. Bukharov [49], the essence of which is to minimize total logistics costs.

Each of these methods has its pros and cons. All this complicates their application and increases the risk of error even when choosing the location of the distribution center. Many macro approaches to choosing the location of logistics facilities are considered in the work [50], simplifying the task of assessing the attractiveness of DC placement options from the point of view of the company's macroeconomic interests. It is also possible to use a methodological approach based on the application of the capabilities of the SPSS 16.0 statistical information processing software package and Internet-based cartographic services [51].

Petrova I.V. [52] criteria for assessing the trade infrastructure of the agri-food market are proposed:

- Quantitative indicators of trade infrastructure facilities within territorial entities and the diversity of trade organization formats;
- Presence of barriers in establishing economic ties between food producers and infrastructure-related enterprises;
- Level of information support concerning the availability of infrastructure enterprises;
- Quality of services delivered by infrastructure enterprises;
- Extent of competitive relationships in the food market.

In our view, this set of criteria enables the simultaneous assessment of both the quantitative provision of trade infrastructure elements within a specific district or region, and the qualitative attributes of the agri-food market’s trade infrastructure

An important element of the trade infrastructure of the agri-food market are wholesale trade enterprises (wholesale food markets (WFM) that are focused on selling goods in large quantities. The overwhelming majority of buyers (commercial structures) focused on purchasing food products in large quantities are concentrated in large cities of the region. In cities with a permanent population of up to 100 thousand people, the placement of agricultural cooperative markets is more effective [52].

In [53], the following procedure for determining the optimal location of a wholesale distribution center (WDC) is proposed:

1) determine the factors (standardization, determination of weighting factors) that significantly influence the decision on the placement of a wholesale distribution center;

2) calculate the rating assessment of each region for the possibility of locating a WDC according to the selected factors and taking into account the weighting factors;

3) determine the location of the WDC using the “center of gravity” method.

Implementing the regional rating method for WDC placement requires selecting location-determining factors. Below are criteria deemed most influential in making such decisions: socio-economic and infrastructural-geographical.

The main feature on the basis of which the efficiency of the functioning of the product distribution system is assessed is its criterion. As such a criterion, scientists

propose various indicators, the correct choice of which determines the effectiveness of agricultural production and trade infrastructure for the sale of products.

In evaluating the suitability of specific areas within the Republic of Kazakhstan for hosting a WDC, the following methodological approaches and criteria are recommended: placement according to consumption and production volumes, based on logistic models and an integrated approach, and also taking into account the existing infrastructure [54].

Each of the specified methods of placing a wholesale distribution center has both its positive side and its disadvantages.

As for transport and logistics centers (TLC) and logistics distribution centers (LDC), in order to solve logistics problems they must have the following functions: transport, warehouse, logistics, financial, control, information, and infrastructure. To do this, it is necessary to determine the criteria by which the localization of the logistics center is selected. These include the following criteria: transport, territorial, communication, security, interaction, personnel, cargo flow, network [55-57]. When creating and determining the location of the TLC, it is necessary to rely on these factors and criteria.

The analysis of the academic literature has identified numerous studies proposing mathematical methods and models or conceptual frameworks for determining the location of a regional network of warehouses and transport/logistics terminals. The choice of location factors is a complex problem, the purpose of which is to make the process of determining the location more scientific, standardized and practical.

Traditional models for choosing a location are based on a large number of assumptions that affect the choice of location and involve an express assessment of the proposed logistics infrastructure. But in practice, some factors of the LC location are not certain, such as geographic factors, environmental factors, transportation time depending on traffic. Thus, an uncertain environment for the location of the LC is formed. When developing a complex logistics system, these uncertain factors should be taken into account. The selection and placement of food distribution networks is influenced by many factors: system factors influencing the design of distribution networks, the choice of their location [58]; the structure of product distribution, including the choice of location of facilities [59]; the efficiency of the DC [60, 61]; design of the logistics channel. Analyzing various factors in relation to the supply chain of agri-food products, influencing the choice of location and placement of logistics facilities for storage, distribution and trade of products, we divided them into five groups of factors: social, economic, regional (infrastructure-geographical), production and environmental. The indicators used in each group of factors may differ in quantity and quality (Figure 9).

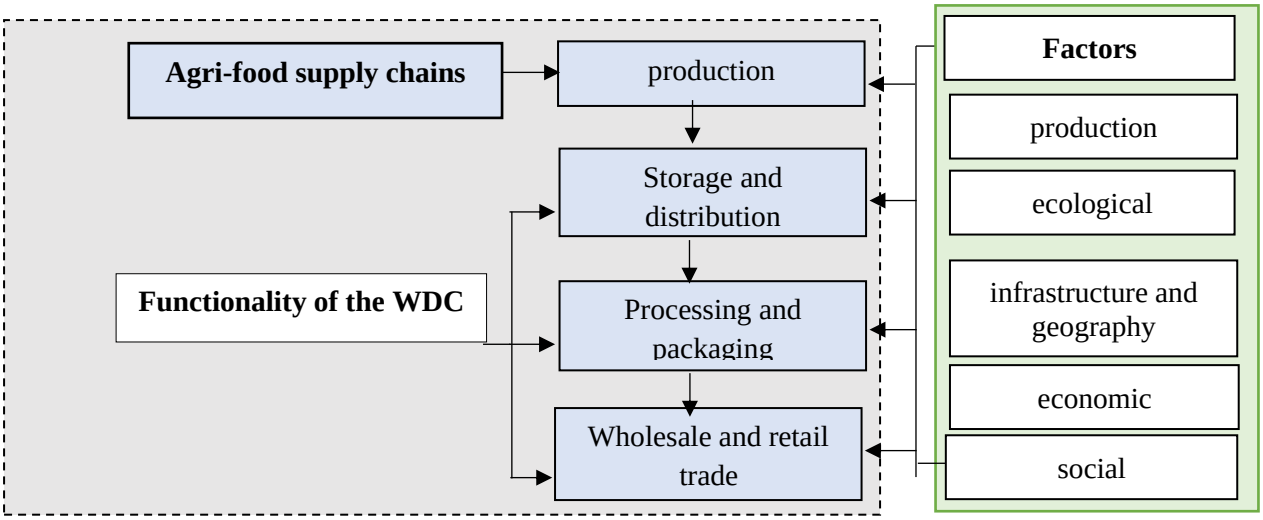


Figure 9 - Interrelationship between the wholesale distribution center, the supply chain of agricultural products and the main factors influencing the choice of location of the logistics infrastructure

Note: compiled by the author based on [13]

To select the indicators in each group of factors, an analysis of the most frequently used indicators was carried out.

Social factors. Indicators that determine the state of the social environment of rural areas should be represented by the population size, income level and purchasing power of the population [59], the level of consumer satisfaction, and the growth of the total level of consumption [62]. This need is designed to identify the degree of influence of social factors on the economic well-being of the territories and determine the further direction of development.

Economic factors. To assess the efficiency of the functioning of the commodity distribution network (CDN) of the districts, it is initially necessary to determine which districts form the effectiveness. In view of this, it is appropriate to include such indicators as the number of producers of agricultural products, gross agricultural output [63], as well as volume indicators of all agricultural products produced in physical terms [62], the level of demand for products [64-66], the growth of agricultural organizations, the share of gross production of small farms in the total volume of agricultural production.

The choice of location and placement of logistics facilities for storage, distribution and trade of products is also influenced by the costs of selling the final product [59]. The efficiency of these facilities is influenced by such indicators as profit per producer, profitability of production and sales of products [67], the share of unprofitable enterprises included in the TPS.

Infrastructure and geographical factors include the following indicators: the number of enterprises and workshops for processing and producing agricultural products, the availability of storage facilities, retail space, etc. [68-70]

Production factors include volume indicators of production and sales of agricultural products [64].

Environmental factors are characterized by the volume of solid waste during product sales, emissions of pollutants into the atmosphere [71].

Such allocation is associated with the presence of a corresponding element in the structure of the system. Each of these factors ultimately affects the efficiency and competitiveness of the DC, reliability, sustainability and quality of service.

It should be noted that the choice of location of logistics facilities depends not only on the above factors, but also on their functional purpose, which were not considered in the indicated works. From the point of view of sustainability, along with economic, environmental and social factors, the geographical and transport capabilities of the region are also important, being important criteria for choosing the location of the LC [62], which was taken into account in our research.

The research methodology consists of the following 3 stages.

Stage 1. Analysis of foreign experience and literary sources in order to determine the main methods, indicators for planning and placement of logistics infrastructures for agri-food products;

Stage 2. Conducting a questionnaire survey of participants in the supply chains of agri-food products in order to identify problems and requirements for existing and prospective logistics infrastructures for storage, distribution and trade of agri-food products;

Stage 3. Research and modeling to build a model of the LWDC of agri-food products for storage, distribution and trade of products.

At the first stage, various studies by scientists were analyzed, thanks to which all indicators influencing the development of logistics infrastructures were grouped into 5 blocks: social, economic, regional (infrastructure-geographical), production and environmental. All selected indicators are taken on the basis of an analysis of literary sources. And also their choice for ranking the administrative-territorial districts of Kazakhstan was based on the availability and reliability of data, comparability of indicators, their minimum quantity, capable of providing a general assessment of the optimality of placement and their economic efficiency of operation. The criteria influencing the choice and placement of logistics infrastructure, ensuring the storage, distribution and trade of agri-food products, are presented in Appendix D.

The presented indicators are a balanced set, capable of providing a comprehensive assessment of the optimality and level of efficiency of the functioning of the TPS.

Thus, based on the conditions of operation of storage, distribution and trade facilities, the factors influencing the choice of the location and distribution of agri-food products also differ. In this regard, based on the study of foreign literature, we substantiated and proposed criteria for the selection and placement of regional agricultural infrastructure for the storage and sale of agri-food products.

A questionnaire survey was conducted at the 2nd stage of the study.

The purpose of the survey is to assess the current state and problems of developing the infrastructure of the cold chain of supplies of perishable goods (PP)

and food products (FP), to develop recommendations for improving the efficiency of functioning and development of the cold chain infrastructure.

The main components of the cold chain supply chain are enterprises of the agro-industrial complex, food and processing industries, trade, transport, enterprises and warehouses for storing products. In this regard, within the framework of this work we conducted research in order to establish the current state of affairs, identify problematic issues and develop recommendations aimed at increasing the efficiency and development of the cold chain infrastructure of agricultural and food products. It should be noted that such studies have not been previously conducted in Kazakhstan.

The information base of the study was the surveys conducted among participants in the cold chain of agricultural supplies with experience in the production, delivery and trade of fresh produce (farmers, owners of warehouses and vegetable stores, wholesalers and retailers, representatives of transport and logistics in the amount of 230 people), also used information from BNS ASPR RK, MTI RK, data from secondary sources (reports, articles, Internet resources). The survey was conducted during October and November 2023.

The questionnaire survey on studying the infrastructure of storage and distribution of SPP and supply chains included the following questions:

1) on general information (region, field of activity, length of service, type of business);

2) on assessing the current state of operation of the infrastructure (deterioration level, frequency of use, proximity to the production point, employee skills and functional problems);

3) on the state of supply chain logistics (sales channels, stability of connections, constancy of temperature conditions, problems);

4) on development prospects (measures to improve the operation of supply chains, types of support, training needs) (Appendix E).

The sphere of activity of the respondents is presented as follows (in %): agriculture - 42.6; trade in perishable products - 27.0; warehousing, storage and marketing infrastructure - 10.0; processing and production - 7.8; transport and logistics - 7.4; government and non-government bodies - 3.0; education and science - 2.2.

At the 3rd stage of the study, a methodology was developed and an assessment was made of the planning and placement of logistics WDCs: storage, distribution and trade.

Based on a critical analysis of existing methods and methodology for designing and placing logistics facilities, a methodology for designing and placing logistics wholesale distribution centers for storage, distribution and trade (LODCs) was proposed [72].

The methodology for constructing a model of LODCs for agri-food products was carried out in the following sequence (Figure 10).

Stage 1. Determining potential locations for the LWDC placement

At this stage, potential sites for the location of a logistics wholesale distribution center (LWDC) were identified using predefined criteria: analyzing agricultural production volumes within each district and urban agglomeration, reviewing the

current transport route network, and examining logistics and transportation infrastructure (both rail and road).

The selection of criteria for placement and determination of the need for logistics infrastructure facilities was carried out using the example of the LWDC in the following sequence.

Step 1. Analysis and selection of indicators that determine the locations of selection and placement based on statistical data for 2019-2021.

Based on the theoretical analysis, 40 indicators were selected from various literary sources to characterize the LWDC, directly or indirectly influencing the choice of location for logistics facilities based on statistical data from BNS ASPiR RK. Calculation of the correlation matrix for the variables involved in the analysis allowed us to exclude dependent (correlated) parameters and select the most significant 19 factors. Of these, 15 indicators are available on the website of the BNS ASPiR RK, and the remaining 3 indicators (X9, X10 and X11) were selected based on a study of the online map (https://yandex.kz/maps/ru/) of transport routes in all regions of Kazakhstan.

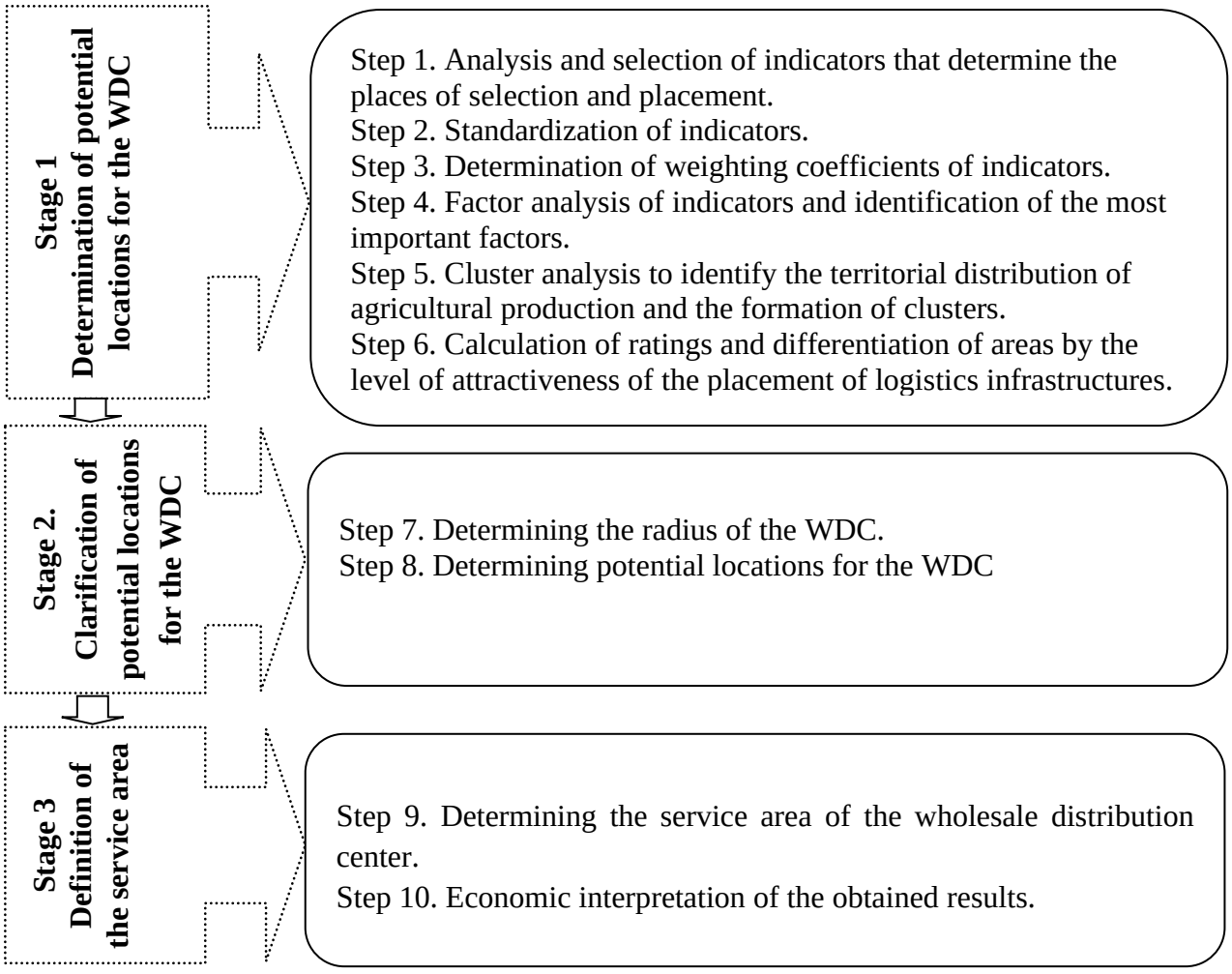


Figure 10 – Algorithm for constructing a model of the LWDC for agri-food products

Note: developed by the author

The significance of the indicators was assessed and insignificant factors were excluded. Table D.1 of Appendix D presents the results of assessing significant correlation indicators by p-value: $p<0.05$; $p<0.01$; $p<0.001$.

Table 3 presents the results of assessing significant indicators.

Table 3 - Variables after excluding correlating parameters

Indicators	Unit of measure	Full name of Variables	Unit of measurement	Description of the indicator
Social factors	X1	Population	person	Average annual population
	X2	Per capita income	thousand tenge	Ratio of annual cash income to the number of months and to the average annual population
Economic factors	X3	Number of agricultural producers	unit	Shows the level of concentration of producers
	X4	Volume of agricultural products transportation	tons	Characterizes the volume of agricultural transportation of food products in the regions
	X5	Volume of agricultural production	million tenge	Determines the volume of production
	X6	Retail and wholesale turnover of food products	million tenge	Determines the volume of retail and wholesale sales of food products
	X7	Investments in fixed capital of logistics infrastructure (trade, transport and warehousing, communications)	million tenge	Investments in infrastructure in the regions
Regional factors	X8	Availability (presence) of logistics capacities for storage, distribution and trade of agricultural products, from 0 to 1	yes - 1, no-0	Physical accessibility (availability) of capacities. Determined by statistical data for each region
	X9	Availability of railway, from 0 to 1	no - 0, yes - 1, partially - 0.5	Shows the level of provision with the railway network. Determined on the basis of the map of regional transport roads https://yandex.kz/maps/ru/
	X10	Average transportation time by road	hour	Transportation time from the district center to the regional center. Determined on the basis of the online map https://yandex.kz/maps/ru/
	X11	Distance from the district center to the regional center by road	km	Transportation distance is determined on the route map https://yandex.kz/maps/ru/
Production factors	X12	Production and sale of meat and milk	tons	Volume of sales of products in each region
	X13	Production and sale of vegetables and melons	tons	

	X14	Production and sale of fruits and berries	tons	
	X15	Production of grain	thousand tons	
	X16	Volume of production and sale of eggs	thousand pieces	
	X17	Volume of production and sale of potatoes	tons	
Ecological factors	X18	Volume of solid waste from product sales	tons	The amount of waste during the sale of products based on statistics https://stat.gov.kz
	X19	Emissions of pollutants into the atmosphere	tons	Emissions into the atmosphere are determined based on statistics https://stat.gov.kz
Note: compiled by the author				

Step 2. Bringing the indicators to a standard form due to the unequal measurement.

Standardization of indicators, in order to bring unequal values of indicators to homogeneous values, is necessary for comparing indicators with different units of measurement. The matrix dimension is defined as n * m, where n is the number of observation objects or 204 administrative-territorial districts, and m is the number of elementary features (in this case, 19 indicators).

The transition was made from the matrix of initial data (x) of dimension (204 x 19) to the matrix of standardized indicators (z) of dimension (204 x 19). When recalculating all elements of the matrix into a standardized form, the following formula was used (formula 1):

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{\sigma_j}, \quad (1)$$

where xij is the i-element of the j-observation;

$\bar{x}_j$ is the average value of the i-elements of the j-observation;

σj is the average deviation of the i-elements of the observation.

Step 3. Determining the weighting coefficients of the indicators to determine their significance for forming the rating.

These actions were carried out using the SPSS 21.0 program.

Step 4. Conducting a factor analysis to identify the most important factors.

Factor analysis allowed us to form, reduce the number of variables and group them. Based on the analysis, matrices of factor values Fji were constructed for all 204 territories (districts, urban agglomerations), which were subsequently used to calculate the rating of the location of logistics facilities obtained using the SPSS 21.0 program.

Step 5. Conducting a cluster analysis based on k-means, forming clusters.

To study the territorial distribution of agricultural production, the regions of Kazakhstan were divided into groups using the cluster analysis method. To conduct cluster analysis, statistical data for 2019-2021 were used, processing was carried out using the SPSS 21.0 program.

Step 6. Calculation of ratings and determination of the integral indicator, differentiation of districts by the level of rating value.

The calculation of the rating itself was carried out according to the formula 2,3:

$$R_i = \left(\frac{\sum_{i=1}^{n} F_i}{n}\right), \quad (2)$$

$$R_i = \frac{\sum_{i=1}^{n} F_{ji}}{\sum_{i=1}^{n} b_{nji}}, \quad (3)$$

Ri - integral indicator of attractiveness of the location of the integrated distribution center of the i-th region;

Fji - value of the j-th factor of the i-th region;

n - number of factors.

b_{nji} - weight coefficient n of the indicator j of the factor of the i-th region.

The integral indicator obtained during the calculation was ranked from the highest number to the lowest. A high rating score indicates the potential attractiveness of placement in the region.

Stage 2. Clarification of potential placement locations

In the second phase, these potential sites for integrated logistics distribution centers in the regions were further refined via the center of gravity method, focusing on agricultural production clusters, transport accessibility, and other consolidated technical and economic parameters in one location.

Step 7. Determination of the radius of action of the logistics infrastructure.

At this stage, the radius of action of the integrated distribution center was calculated using the “center of gravity” method [73];

Step 8. The determination of potential locations for the integrated distribution center was carried out on the basis of a factor analysis of the matrix of Fi values.

The average Fi value was determined for each of the 204 territories. The types of WDCs were selected based on separately grouped factor loadings Fi, which affect the choice of storage, marketing and trade, respectively. Their average value was determined for each district/city. The potential location of the facilities was determined if their average Fi value adjusted for weights was greater than one.

Stage 3. Determining the service area

Step 9. The service areas of WDCs (groups of agricultural districts) were determined in accordance with the potential locations in the districts and urban agglomerations.

Step 10. Economic interpretation of the results obtained.

The work focused on objects related to the group of intermediary, distribution and trade organizations: warehouses for agricultural products (grain, vegetable, fruit, berry and potato storage facilities) and WDCs. Since these organizations have a direct impact on the process of food product circulation, i.e. storage, marketing and trade.

The methodology allows designing and determining the locations of the WDC on the territory, taking into account transport networks and transit potential, as well as regional factors (socio-economic, environmental, production). Currently, such a methodology is not available. The proposed locations and proposed capacity are described in various documents on the development of the agro-industrial complex and trade in Kazakhstan. However, they lack methodological approaches, methodology and recommendations for the development of logistics infrastructure by region.

The solution to the problem of optimal placement of the wholesale distribution center makes it possible to implement two state Concepts for the development of the agro-industrial complex [21] and trade [20], and to determine long-term investments in the development of wholesale distribution centers in the regions of Kazakhstan. [20]. It also facilitates the determination of long-term investments required for WDC development across regions of Kazakhstan.

The proposed method can be used both by logistics providers to analyze and select the optimal location for the logistics center, taking into account the existing client base, by the owners of agro-industrial and transport zones located directly on the territory of large regions, and by government agencies to plan the placement of logistics infrastructures throughout the country. The models and methods used in practice to determine the optimal location of logistics infrastructure facilities provide an approximate solution. In addition, they do not provide for the process of forming interconnected warehouse and transport infrastructure in the region.

It can be concluded that there is no consensus in the literature regarding the stages of the design process, selection and use of indicators that determine the location of objects that should be optimally followed when deciding on the selection of elements and the structure of storage or distribution. The beginning of the process and its sequence are also disputed.

Thus, in this section, the criteria for the selection and placement of regional agricultural infrastructures for the storage and sale of agricultural products were substantiated and proposed.

The implementation of the conceptual provisions of the mechanism for the functioning of the market for the sale of agricultural products requires a change in traditional approaches to assessing its selection and placement. At the regional level, the criteria for optimality and efficiency of placement should be measured using an integral multiplicative indicator. The method of its calculation consists of forming a system of indicators characterizing the optimality and efficiency of using elements of the distribution infrastructure, determining indices indicating their change in a time interval, and calculating an aggregated indicator representing the average value of the indices.

The contribution of this research lies in the combined use of different methods at various stages of the study. The application of standardization, cluster analysis,

regression analysis, factor analysis, center of gravity method, and ranking of regions by the criteria we developed for selecting WDC types allowed us to develop a more practical method for determining the number of WDCs, considering regional demand factors for WDCs. This method, considering the proposed factors, will help to avoid the construction of underutilized WDCs. Another feature of the proposed methodological approach is the construction of an interconnected transport and logistics infrastructure in the region. The proposed option will significantly increase the efficiency of using transport and logistics infrastructure in the regions in accordance with their needs based on socio-economic, geographical, environmental, production factors and requirements. Fulfillment of these requirements will dramatically improve the process of creating and implementing the consumer value of the wholesale distribution center: systematically providing the client with exactly what he wants, at the time he needs and in a place convenient for him.

2 CURRENT STATE AND DEVELOPMENT OF LOGISTICS INFRASTRUCTURE AND SUPPLY CHAINS

2.1 Current state and functioning of the product distribution system

Over the past 20 years, Kazakhstan has achieved sustainable economic growth. A favorable condition for rapid industrialization is the country's logistics and transit potential, which is positively influenced by its geographical location, political stability and investments in infrastructure [74, 75]. In recent years, the country has seen a significant increase in the production of perishable goods (PPG). However, the development of cold chain infrastructure has not become a priority, which limits the ability to safely store and transport such products to markets. A modern refrigerated storage and delivery system is a key element in reducing PPG losses, improving product quality, and strengthening the country's food security.

An important aspect is the role of cold chain logistics, which ensures the safety of products, allows farmers to receive more favorable prices and helps reduce the overall level of product losses.

Today, the cold chain logistics market in Kazakhstan is divided into several segments:

- Services: storage, transportation, value-added services.
- Temperature conditions: chilled and frozen products.
- Types of products: fresh fruits and vegetables, dairy products (e.g. milk, ice cream, butter), meat and fish, processed foods, pharmaceuticals.

The bulk of all refrigerated cargo in the country is made up of meat, fruit and vegetable and fish products. This segmented approach allows for more precise organisation of logistics processes and increased efficiency of the cold chain system.

Cold chain storage is a complex set of technological operations that include not only cooling and maintaining specified temperatures, but also ventilation, maintaining a gas environment, and thermal drying.

These operations require advanced and costly equipment, as well as trained personnel to maintain it [76]. The main causes of seasonal price increases and volatility in the fruit and vegetable market are the near absence of a continuous technological chain integrating “production” and “sales,” coupled with inadequate infrastructure [77, 78].

To minimize losses of fresh produce (e.g., fruit and vegetable products), global best practices emphasize unwavering adherence to the “cold chain” principle during production and sales [79]. Many countries place heightened attention on these matters, passing specialized legislation and standards, while professional associations collaborate with businesses to address ongoing issues in cold chain logistics [80].

A review of the literature [81,82] indicates that key logistics solutions for effectively managing perishable food products involve maintaining and monitoring temperature conditions during transport, storing goods in specialized warehouses, and ensuring robust information support for the cold chain [82–84]. Despite the longstanding practical application of cold chains for perishable food products, numerous deficiencies persist in supply organization [85]. Most businesses individually maintain temperature conditions by operating their own vehicle fleets

and refrigerated warehouses, an arrangement that many enterprises cannot afford given the resultant impact on trading profits.

These and related challenges emerge from multiple logistics domains. First, personnel and the clear organization of business processes remain problematic for many companies. Secondly, a mechanism that will continuously monitor compliance with the required temperature conditions for storing and transporting goods is especially important. Another factor is the underdeveloped transport infrastructure, as well as a large number of intermediaries between the manufacturer and the end consumer, namely, a multi-stage distribution scheme [86, 87].

Integrating different transport modes and employing advanced methods for planning and optimizing supply chain operations can significantly improve the overall efficiency of cold chain management [88].

The use of information and communication technologies (ICT) is also considered an important factor in logistics management in the cold supply chain. The application of IoT in cold chain logistics system can not only control costs but also improve the practical efficiency of supply chain operation [89, 90].

Currently, Kazakhstan lacks comprehensive regulatory provisions governing cold chain logistics for food products during storage and transportation. Oversight and regulation of the cold chain in the production process depend on each business's technology and capabilities. There is also a lack of statistical data regarding existing capacities and refrigeration equipment used by agriculture, the agro-industrial complex, food production, trade, and transport enterprises. Each sector separately addresses the logistics processes for the cold food chain, with no coordinated efforts at the association, industry, or ministerial levels.

Unfortunately, today we can state the fact of the lack of cooperation in the development of the cold chain at the level of associations, industries, ministries. Today, issues of innovative cold chain solutions from domestic and foreign manufacturers are discussed only at the Central Asian International Exhibition "Cold Warehouse, Transportation and Service for Cold Logistics" in Almaty. Although the problems of ensuring the cold chain concern many ministries and departments of the RK, including the MoA, the MTI, the MPS, the MT, the MIA. However, none of these ministries, whether individually or jointly, currently address cold chain management challenges. Consequently, numerous issues persist in developing more sustainable and efficient supply chain management for agricultural and perishable products and, therefore, in achieving adequate food security—a situation that demands both study and resolution.

The current cold chain supply system for agricultural products and the agri-industrial complex includes several chains, such as storage during harvesting by farmers, long-term storage in warehouses and warehouses, a refrigerated truck or isothermal vehicle (TV) for delivery, a distribution center, a retail store.

The paper examines these supply chains based on available statistical materials and our own research. A typical logistics scheme for the supply of PFP from the farm to the end consumer is shown in Figure 11.

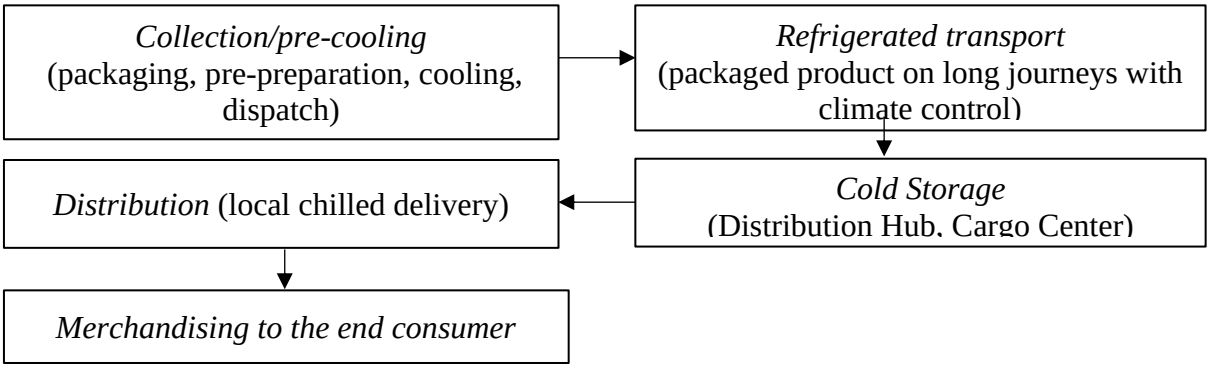


Figure 11 - Logistics scheme for the supply of perishable products

Note: developed by the author

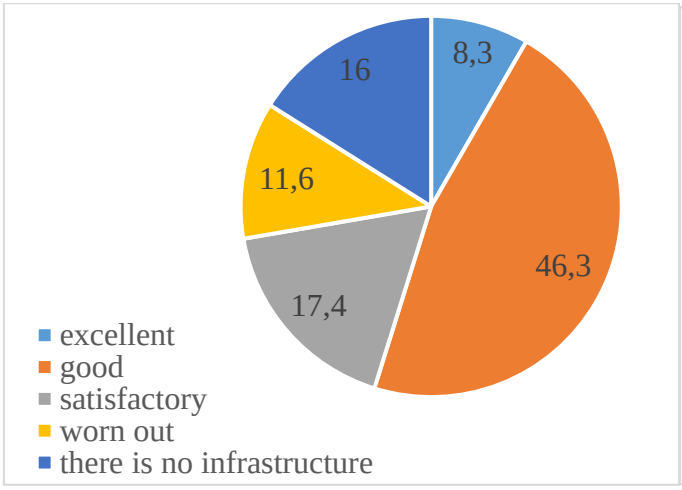
Thus, the primary constituents of the cold supply chain for the main types of raw materials and products are agricultural enterprises, agro-industrial complexes, food and processing industries, trade and transport organizations, and warehousing facilities. Correspondingly, investigations were conducted to assess the current development status, detect issues, and formulate recommendations for enhancing the logistics infrastructure of the cold chain for perishable food products (PFP) and perishable products (PP). Analysis of survey data [91] revealed several key findings pertaining to the functioning and advancement of the logistics infrastructure and supply chains for PFP (Figures 12–14, Appendix E).

Results of the Survey on Infrastructure and Logistics Development Prospects:

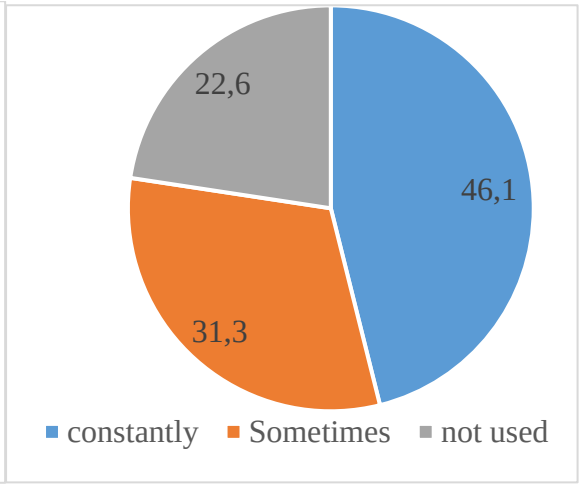
- A majority of respondents (58.3%) advocate adopting measures to foster sustainable supply chains for perishable products, including enacting a “Law on Perishable Products” to combat fraud and promote cold chain maintenance for safeguarding food security, as well as developing quality standards for supply chain management (41.0%).
- Additional suggested measures include integrating various services in one location (trade, storage, processing, food safety certification, customs clearance, transportation, delivery, and marketing advisory services) (10.5%) and deploying an automated system to manage goods, inventory, and resources (using SCM, ERP, WMS, etc.) (10.0%).

When considering the establishment of a modern cold chain supply network for the food market—a crucial infrastructure element—it is imperative to have data on volumes of production, consumption, storage, and transportation for both raw agricultural commodities and finished food and fish products. Such data are generally lacking.

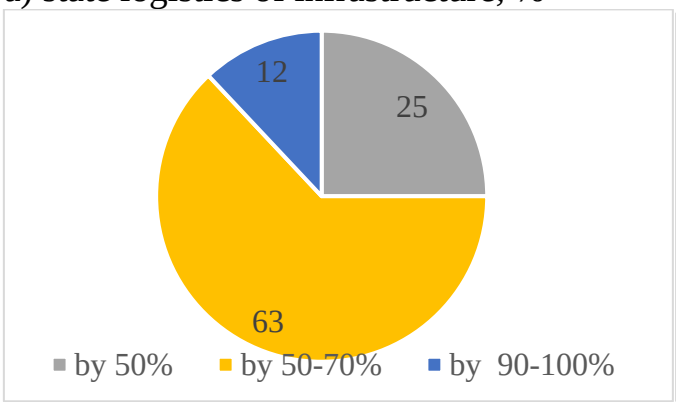
According to the BNS ASPR RK [92], total annual production of fresh plant products in the past two to three years has ranged between 12 and 14 million metric tons. Of this amount, approximately 4–4.5 million tons (one-third) are allocated for sale, 2.5–3 million tons for storage, and 2.5–4.0 million tons for processing.



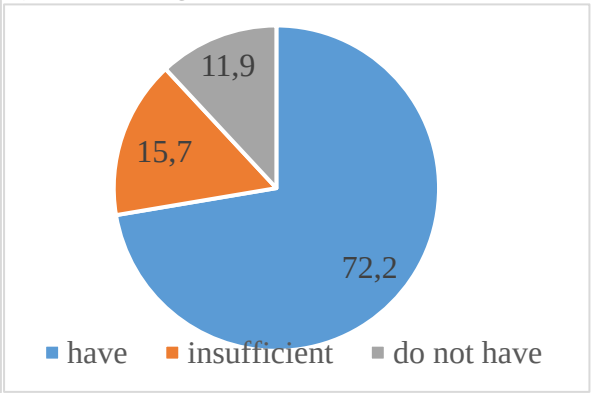
a) state logistics of infrastructure, %



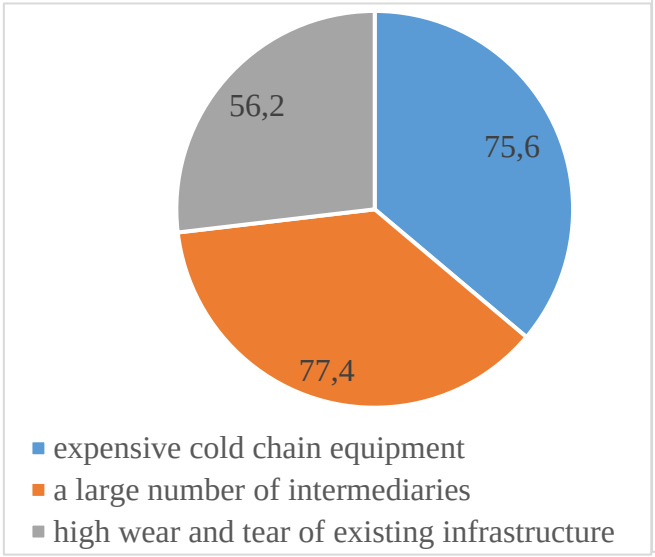
b) use of logistics infrastructure, %



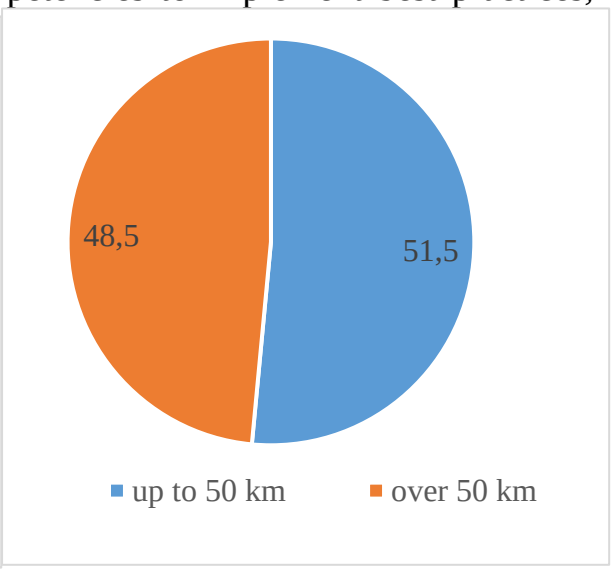
c) infrastructure load, %



d) employees with the skills and competencies to implement best practices, %



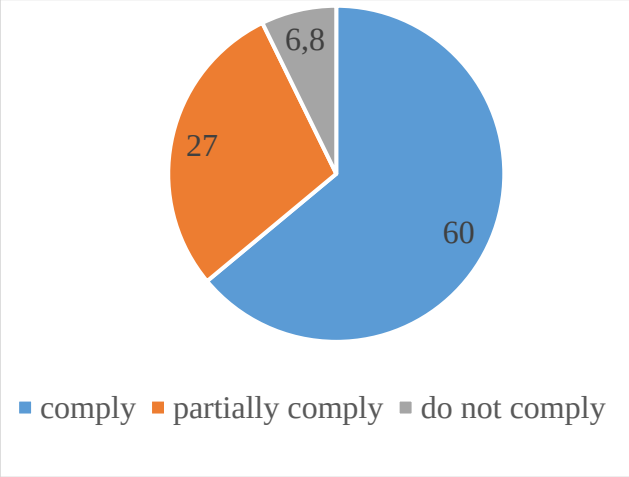
e) problems that hinder the quality provision of a cold chain for the supply of fresh products



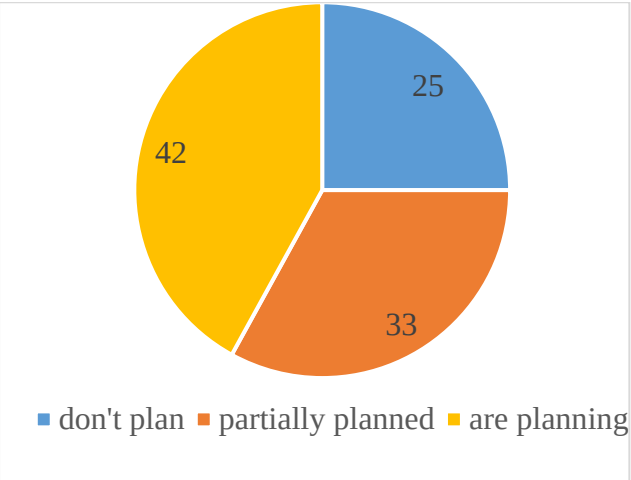
f) location of the logistics infrastructure close to the place of production consumption, %

Figure 12 - Results of the survey on the state of infrastructure development

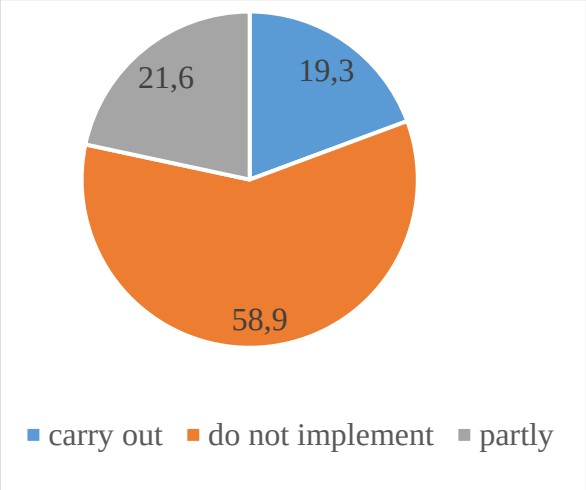
Note: developed by the author



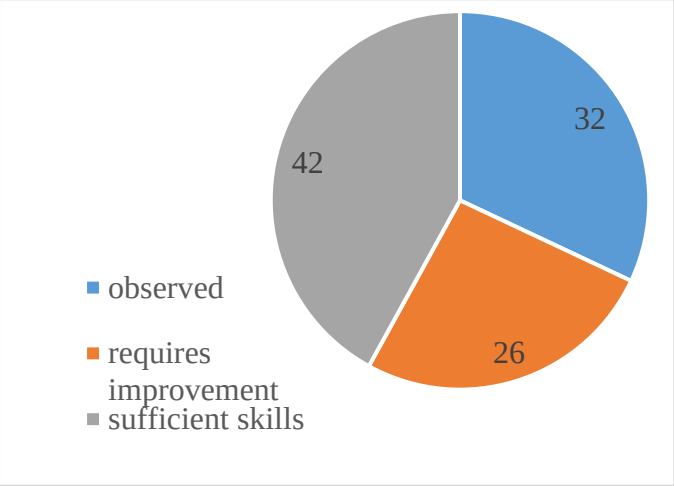
a) compliance with (monitoring) temperature conditions in cold chains for the supply of perishable products, %



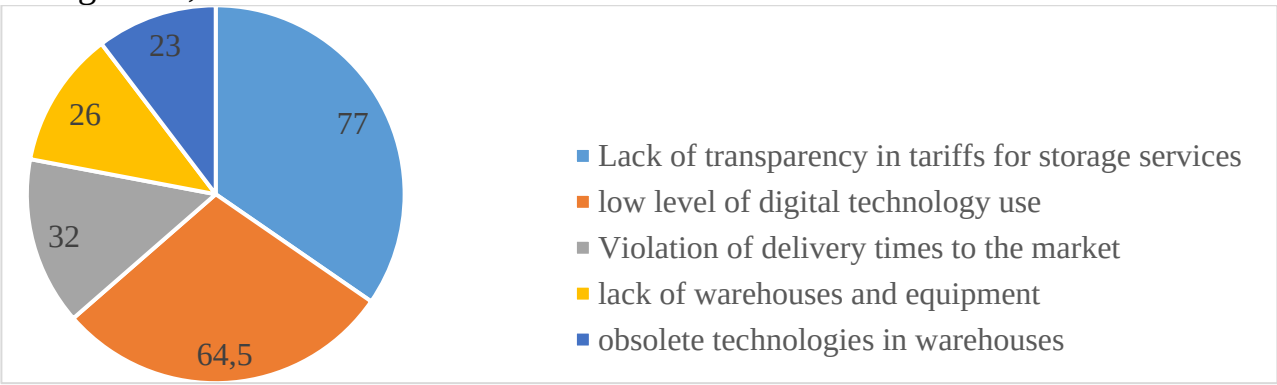
b) organization and management of purchases of perishable products, %



c) joint work with manufacturers and others on issues of forecasting, production, warehousing, price management, %



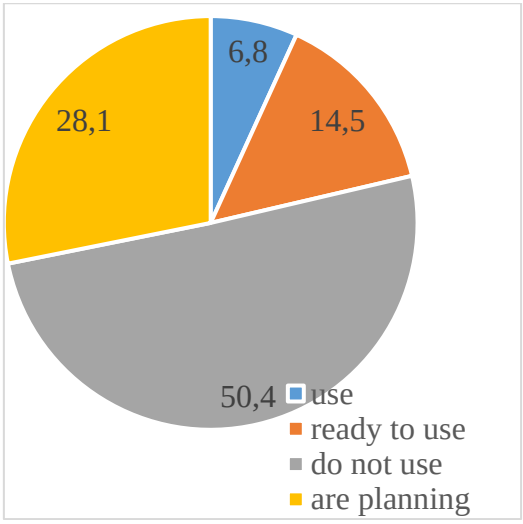
d) lack of professional competencies, %



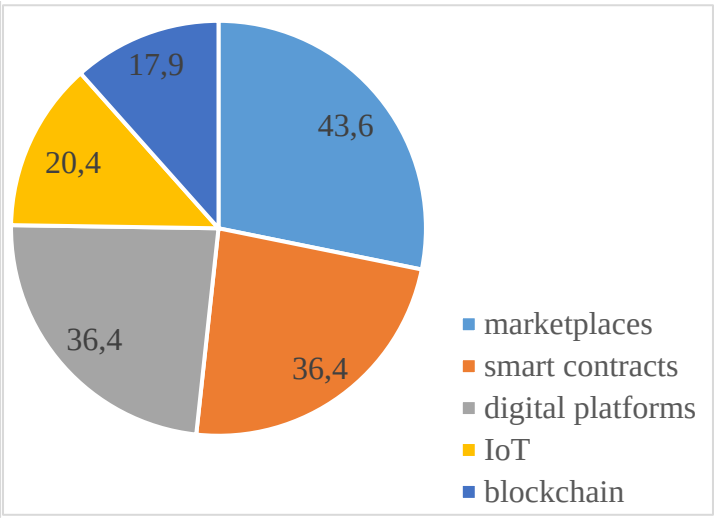
e) problems encountered in the logistics of PFP supplies, %

Figure 13 - Results of the survey on the issue of supply chain logistics

Note: developed by the author



a) use of innovative technologies (blockchain, RFID), %



b) plan to use in the future, %

Figure 14 - Results of the survey on the prospects for the development of infrastructure and logistics of supply chains

Note: developed by the author

With regard to livestock products, the situation is as follows: for January - March 2024. the volume of slaughter on farms or sales for slaughter of all types of livestock and poultry in live weight increased by 1.6% compared to the corresponding period of 2023, and cow's milk production by 3.7% (Figure 15).

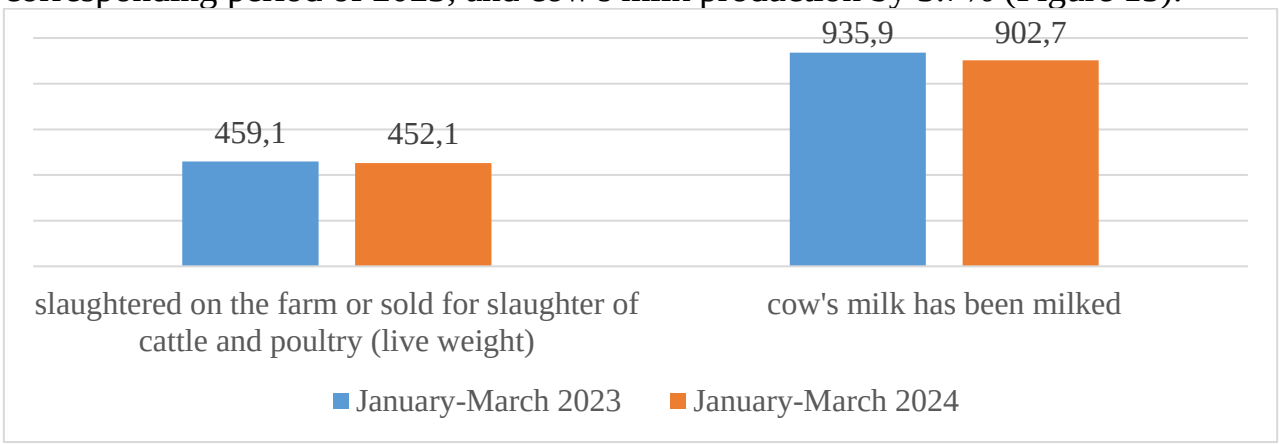


Figure 15 - Production of individual types of livestock products, thousand tons

Note: compiled by the author based on the source [92]

The volume of production and consumption of fruit and vegetable products per capita is distributed unevenly across the regions of Kazakhstan (Figure 16).

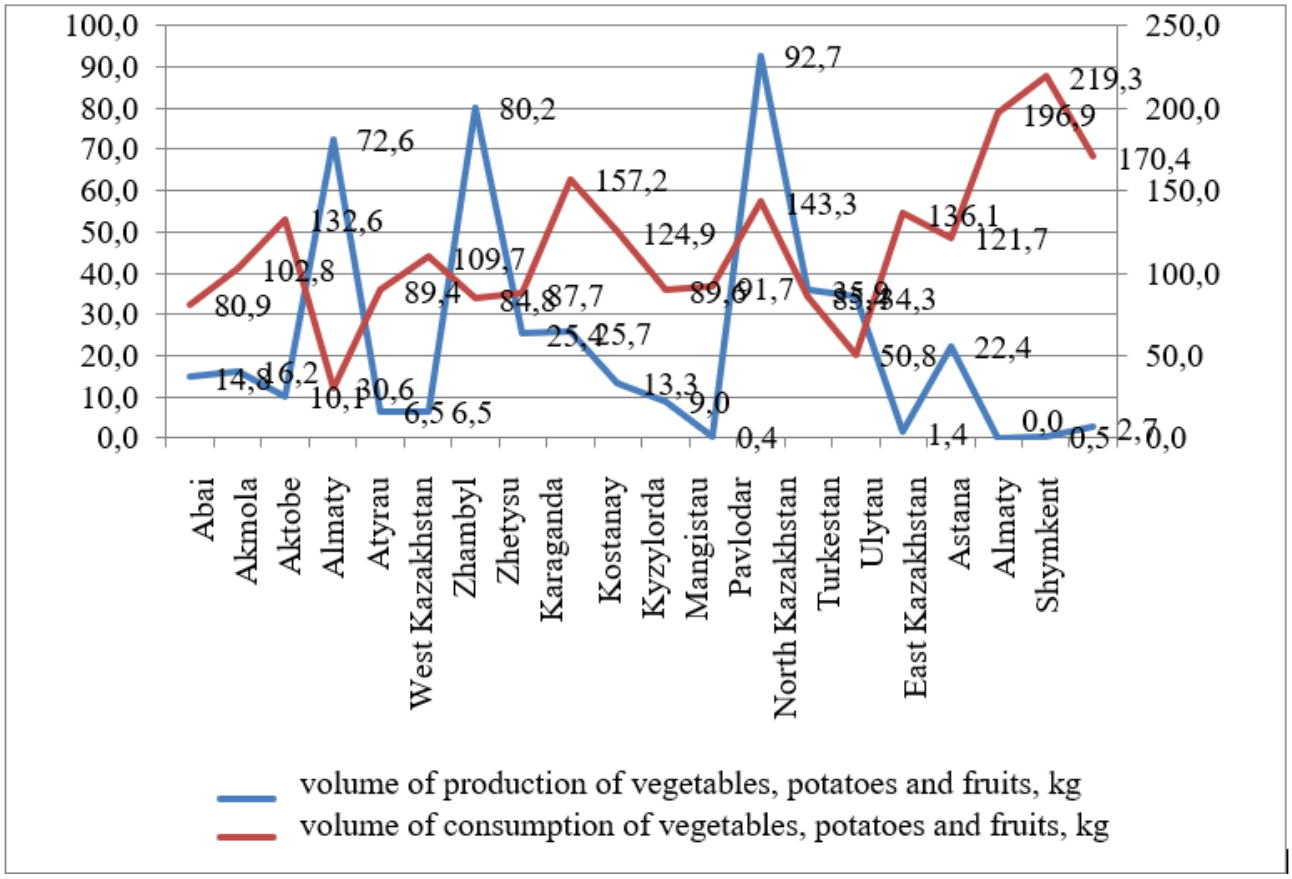


Figure 16 - Volume of production and consumption of fruit and vegetable products and potatoes per capita in the regions of the Republic of Kazakhstan for 2022

Note: compiled by the author based on the source [92]

The main producers with high indicators (above the national average) in terms of the volume of production of fruit and vegetable products per capita are Almaty (72.6 kg per person), Zhambyl (80.2 kg), Pavlodar (92.7 kg) regions; with average production volumes - North Kazakhstan (35.9 kg), Turkestan (34.3 kg), Karaganda and Zhetysu (25.55 kg each), East Kazakhstan (22.4 kg) regions. High consumption rates per capita are in the cities of Astana (197 kg), Almaty (219.3 kg), Shymkent (170.4 kg), Karaganda (157.2 kg), Pavlodar (143 kg), Aktobe (132.6 kg), Kostanay (125 kg).

Low level of production of fruit and vegetable products in West Kazakhstan, Kyzylorda, Kostanay regions. Low level of consumption - in Mangistau, Turkestan, North Kazakhstan, Zhambyl, Zhetysu, Abay, Atyrau, Akmola, West Kazakhstan regions. A similar situation is observed for livestock products.

The volume of production of PFP, requiring compliance with the temperature regime during transportation, according to our research, is approximately 40-45%; of which requiring strict temperature conditions - 25% and during processing 15-18% (table 4).

Table 4 - Volumes of production of perishable products of the agro-industrial complex of the Republic of Kazakhstan, requiring compliance with temperature conditions*, 2008-2023, thousand tenge

Year	Total production volume	Of these			Total volume of PFP	Of these, requiring temperature control		Growth rate of the volume of PFP, %
		vegetables, potatoes and melons	meat of animals and poultry	eggs		during transportation	during processing of finished products	
2008	7102,3	5504,1	1433,8	164,4	2 954,1	1775,6	1178,5	-
2009	7699,9	6065,1	1453	181,9	3 183,5	1925,0	1258,5	107,8
2010	7955,5	6249,7	1501,2	204,6	3 313,8	1988,9	1324,9	104,1
2011	8917,8	7201,8	1511,5	204,5	3 682,9	2229,5	1453,4	111,1
2012	9549,2	7837,8	1509,4	202	3 747,1	2387,3	1 359,8	101,7
2013	10061,1	8298,1	1548,7	214,3	4 022,5	2515,3	1 507,2	107,3
2014	10646,9	8808,4	1602,5	236	4 266,4	2661,7	1 604,7	106,1
2015	11085,1	9173,5	1651,1	260,5	4 343,8	2771,3	1 572,5	101,8
2016	11375,4	9411,8	1702	261,6	4 461,2	2843,9	1 617,3	102,7
2017	11511,3	9436,2	1794,4	280,7	4 598,4	2877,8	1 720,6	103,1
2018	12210,9	10031,5	1871,9	307,5	4 885,6	3052,7	1 832,9	106,2
2019	12928,7	10649,5	1975	304,2	5 270,4	3232,2	2 038,2	107,9
2020	13359,9	11022,8	2058,5	278,6	5 485,9	3340,0	2 146,0	104,1
2021	14007,0	11578,7	2162,2	266,1	5 671,5	3501,8	2 169,7	103,4
2022	13877,4	11433,4	2166,2	277,9	5 837,4	3469,4	2 368,1	102,9
Note: *except for milk. Data on milk tankers and storage and distribution infrastructure in the Republic of Kazakhstan are not available and require special research								

The volume of production and transportation of PFP in 2022 amounted to 5.8 million tons. The annual growth rate over the past 5 years was 4.9%.

Since 2020, there has been an increase in the number of storage facilities and greenhouses (103.8%), due to which there has been an increase in the production of vegetables, potatoes and melons (103.3%) (Table 5).

The deficit of storage capacities for fruit and vegetable products by product category is declining: from 36.5% in 2020 to 35.4% in 2022, and according to the forecast of the Ministry of Transport and Infrastructure of the Republic of Kazakhstan - to 30.2% in 2025 [93].

Table 5 - Growth rates of storage capacities and production of fruit and vegetable products in the Republic of Kazakhstan, thousand tenge

	2020	2021	2022	2023	2024*	2025*	Average
Total, of which	1752,1	1835,2	1933,5	2038,1	2057,7	2087,7	1950,7
vegetable storage facilities	1180,8	1255	1326,3	1409,3	1427,3	1457,3	1342,2
potato storage facilities	496,1	499,1	521,1	527,7	529,3	529,3	517,1
fruit storage facilities	75,1	81,1	86,1	101,1	101,1	101,1	90,9
Capacity growth rate compared to the previous year, %	105,1	104,7	105,4	105,4	101,0	101,5	103,8
Production of vegetables, potatoes, fruits, thousand tons	9042,7	9234,6	9316,3	9827,6	10146,4	10465,3	9672,1
Production growth rate compared to the previous year, %	104,4	102,1	100,9	105,5	103,2	103,1	103,3

*Forecast data of the Ministry of Agriculture of the Republic of Kazakhstan taking into account the construction of new storage facilities for 2023-2025.

For the domestic economy, the key mode of transport for ensuring the connectivity of territories is automobile transport. The analysis of the structure of the perishable goods (LNG) transportation market by type of communication, presented in Table 6, shows the relative stability of cargo distribution. The volume of transported frozen or chilled products and fruit and vegetable products in 2022 decreased to 57.1% or from 4,390.1 to 2,506.1 thousand tons. Of these, according to international communications, it decreased to 53.3% - from 4,075.9 to 2,173.9 thousand tons, and according to domestic communications, to 78.1% - from 331.5 to 258.9 thousand tons, which is due to import restrictions due to phytosanitary and other requirements of the country, as well as sanctions imposed against the Russian Federation.

The transportation of fruit and vegetable products decreased to 78.2%, of which according to international communications - by 9% (table 6).

The volume of transportation of protected areas in 2022 decreased to 51.5% compared to 2021 (table 6). This primarily concerns the international direction of transportation. The transportation of LNG also decreased to 78.2%, especially within the republic. Of all the LNG transported, 83% were transported by road in 2021, 57% in 2022, and the remaining cargo was transported by rail. In the structure of cargo transportation in 2022, international transportation of LNG accounts for 87.6%, and LNG - 96%.

The deficit of road vehicles in 2021 was 20.5% (3340 - 9.83x270 days of operation). In 2022, due to the small volume of transportation (1475.3 thousand tons), there was an overabundance of road vehicles by 2.6 times (1475.5 thousand tons - 12.81x270). In 2023, the deficit of vehicles also increased.

The number of vehicles for LNG transportation is growing annually and in 2023 amounted to 14,040 units, which is 22.0% more than in 2021. Of these, 70.3% are low-capacity vehicles (from 500 kg to 2 tons), medium-capacity - 17.9%, medium-tonnage - 10.8%, large-tonnage - 1.0%.

Table 6 - Structure of the market for transportation of perishable goods in the RK by all types of transport by messages, 2021-2022, thousand tenge

	Total in all messages			Of these					
				frozen or chilled foods (FCF)			fruit and vegetable products (FVP)		
	2021	2022	2022 to 2021%	2021	2022	%	2021	2022	2022 to 2021, %
Cargo, baggage, unloaded baggage transported, total	4390,1	2506,1	57,1	3882,0	1998	51,5	508,1	397,4	78,2
international	4075,9	2173,9	53,3	3635,3	1751,3	48,2	422,6	384,7	91,0
intra-republican	331,5	258,9	78,1	246,2	246,3	100,0	85,3	12,6	14,8
suburban	0,20	0,4	200,0	0,2	0,4	200,0	x	x	
urban				0,4	x		0,2	x	
of which by road transport									
Cargo, baggage, unloaded baggage transported, total	3340	1475,3	44,1	3226,1	1447,7	44,9	113,9	27,6	24,2
international	3225,5	1383,3	42,8	3188,3	1360,2	42,7	37,2	23,1	62,1
intra-republican	113,7	88,4	77,7	37,2	84	225,8	76,5	4,4	5,8
suburban	0,2	0,4	200,0	0,2	0,4	200,0	x	x	
urban				0,4	x		0,2	x	
Note: compiled by the author based on the source [92]									

Small and medium-tonnage vehicles are used in intra-city or interregional deliveries within the country, their share is 88.2%. Vehicles with a large carrying capacity make up only 11.8%. They are used for long distances and, mainly, in international transportation.

It is possible to note the shortage of large-tonnage refrigerated trucks for long distances, for example, in 2021, in international transportation of 3188.3 thousand tons and a total carrying capacity of 5.78 thousand tons, the deficit in international transportation was 51.1% (3188.3 thousand tons - 5.78 thousand tons x 270 days) (Table 7).

Table 7 - Number and structure of the carrying capacity of refrigerated trucks and isothermal vans of the Republic of Kazakhstan, 2020-2023, in kg

Load capacity	2020	2021	2022	2023	Structure in 2023, %	Change in 2023 to 2022	
						(+,-)	в %
Small (from 500 kg to 2 t)	5334	7128	8421	9865	70,3	1444	117,1
Medium (from 2 to 5 t)	1177	1638	2030	2511	17,9	481	123,7
Large (from 5 to 16 t)	642	835	997	1519	10,8	522	152,4
Large-tonnage (from 16 t and above)	34	46	57	145	1,0	88	254,4
Total	7187	9647	11505	14040	100,0	2535	122,0
Note: Compiled based on data from [93]							

The total carrying capacity of vehicles increased from 9.83 thousand tons in 2021 to 17.31 thousand tons in 2023 - by 1.76 times (Table 8).

Table 8 - Carrying capacity of vehicles in the Republic of Kazakhstan for the transportation of perishable goods, 2021-2023.

Type	2021			2022			2023		
	Quantity	LCa., kg	LCt., thousand tons	Quantity	LCa., kg	LCt., thousand tons	Quantity	LCa., kg	LCt., thousand tons
Total, including	9647	3500	9,83	11505	3740	12,81	14040	4004	17,31
refrigerated	1944	2975	5,78	2320	3138	7,28	2998	3344	10,03
isothermal van	7703	525	4,04	9185	602	5,53	11042	660	7,29
LCa. - average load capacity, LCt. - total load capacity Note: Compiled according to data from [93]									

The highest total carrying capacity of vehicles is observed in the cities of Almaty (28.6%), Shymkent (9.4%), Astana (6.9%), Zhambyl and Karaganda regions (5.4% each). Low - Zhetysu (1.8%), Abay (1.1%), North Kazakhstan (1.9%), Akmola (2.2%) regions.

The main barriers to solving the problems of this area are the moral and physical obsolescence of a significant part of the vehicles used for cargo transportation, which necessitates their large-scale modernization and renewal.

In Table 9 we observe a tendency towards a reduction in the number of places and volumes of one-time storage of food products, vegetables and fruits.

Table 9 - Performance indicators of warehouse facilities from services of enterprises of auxiliary transport activities, 2018-2022.

Warehouse performance indicators	Purpose of warehouses	2018	2019	2020	2021	2022	2022 to 2021, %
Number of one-time storage places, units	warehouses for storing food products	210	205	211	198	126	63,6
	warehouses for storing vegetables and fruits	23	22	19	18	13	56,5
One-time storage capacity	warehouses for storing food products, thousand square meters	301,5	299,4	303,3	244,5	1022,3	339,1
	warehouses for storing vegetables and fruits, thousand square meters	74,1	73,2	73,4	69,2	61,3	82,7
Revenue per unit of one-time storage places, billion tenge	warehouses for storing food products, billion tenge per unit	0,021	0,024	0,021	0,014	0,142	10,1 раз
	warehouses for storing vegetables and fruits, billion tenge per unit	0,089	0,088	0,084	0,104	0,217	2,1 раз

Note: Compiled and calculated based on data from [92]

At the same time, a significant increase in the capacity of warehouses for storing food products was recorded, which increased 4 times and reached 1,022.3 thousand square meters (Table 9).

Storage and warehousing services grew by 155% from 2016 to 2022 (Figure 17).

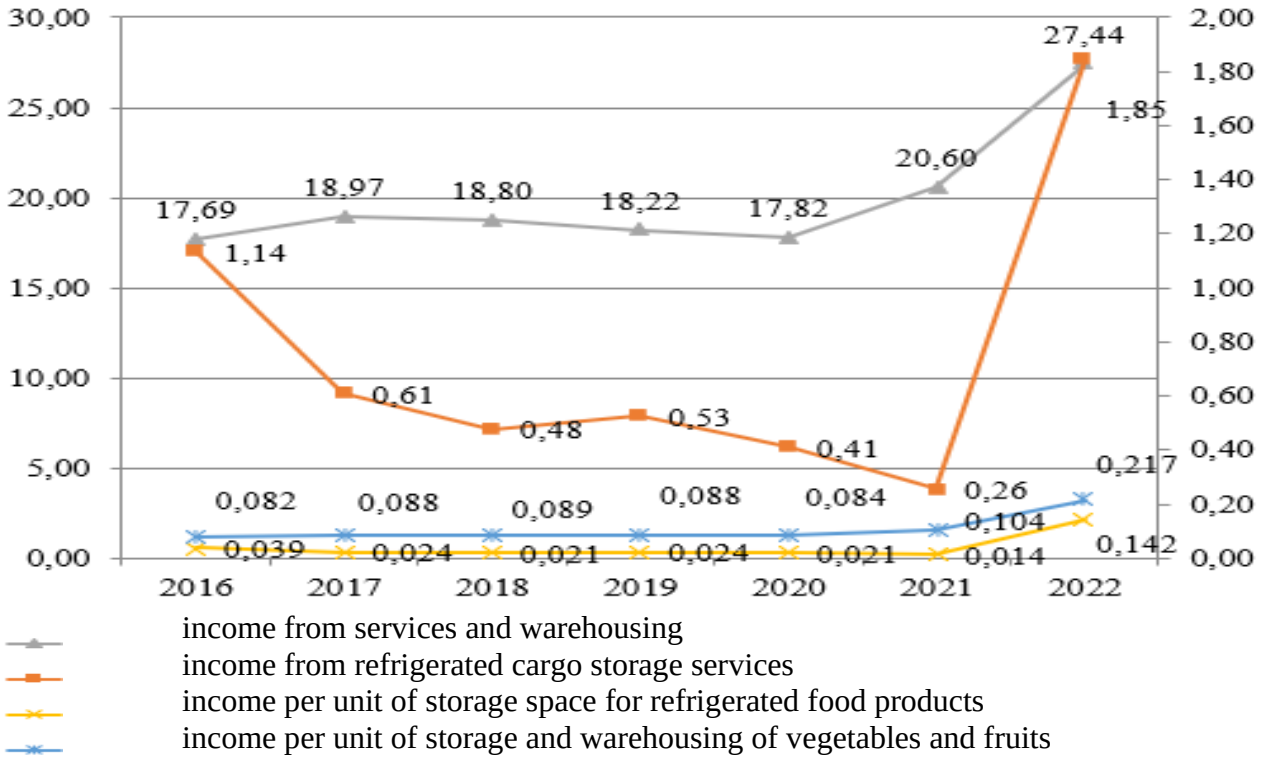


Figure 17 - Revenues from auxiliary transport activities of enterprises for 2016-2022*, billion tenge

Note: developed based on materials from [92]

Refrigerated cargo storage services have decreased by 4.4 times since 2016, but in 2022 they increased by 7 times (by 62% compared to the base year).

Income from storage and warehousing services in 2022 compared to the previous year increased by 2 times, i.e. this type of business has growth potential. Note that vegetable and fruit storage services are 2-4 times more efficient than refrigerated food storage services.

Note that there is an acute shortage of high-quality refrigeration facilities and equipment with various temperature options. The primary barriers are high construction costs for logistics infrastructure and insufficient government support [93]. Only through industry consolidation—uniting producers, retailers, providers of logistics services, and equipment suppliers—can the sector effectively guarantee freshness and product quality for consumers [94].

There is a need for ongoing courses that train farmers, owners of warehouses and storage facilities, representatives of trade, transport and logistics on the issue of continuous safety and security of the PFP to the end customer in supply chains, training in the use of innovative technologies in logistics supply chains (smart

contracts, AI, the Internet of things, blockchains, marketplaces, etc.). This requires the development of standards in these areas of activity. It is also necessary to develop and adopt regulatory documents to prevent fraud in the trade of perishable agricultural products, as well as develop measures to maintain the cold chain.

Conclusions and recommendations for improving the logistics infrastructure for perishable products (PPP)

There are a number of problems that hinder the development of logistics infrastructure for PPP:

1. Insufficient capacity and development of the storage, packaging and delivery infrastructure network, which limits the ability to increase storage volumes and ensure uninterrupted delivery of products to consumers.

2. Insufficient level of transport and logistics services that meet modern requirements.

3. Low degree of digitalization and automation of processes, including management of production, storage, transportation and data exchange between supply chain participants.

4. Shortage of large-capacity refrigerated trucks for international transportation.

5. Unsystematic pricing for storage services, etc.

6. Deterioration of warehouse and refrigeration infrastructure, constant violations of delivery times, low level of competence of specialists.

7. Low level of integration of supply chain participants in the process of joint planning, organization and management.

Having analyzed the most significant problems in order to adopt the most optimal and economically feasible methods for their solution, the following recommendations can be made.

Recommendations for businesses:

1. Modernization of cold chain infrastructure: take into account the specifics of small-scale product deliveries.

2. Implementation of modern storage and transportation technologies: use large-capacity and refrigerated containers; create the necessary specialized infrastructure.

3. Support for farmers and cooperatives: stimulate the creation of logistics enterprises providing marketing and supply services.

4. Creation of a cold chain center with the participation of all the above ministries: to coordinate the planning, regulation and development of logistics infrastructure.

5. Personnel training: organize training for specialists in universities, colleges and advanced training courses on the cold chain.

6. Digitalization: conducting educational courses in each region through the efforts of trade unions and associations together with the Atameken National Chamber of Entrepreneurs on the use of digital technologies such as IoT, blockchain, artificial intelligence and automated control systems.

7. Vertical integration: strengthen ties between producers, vegetable stores and retailers to improve efficiency and reduce losses.

Recommendations for the state:

1. Regulatory framework: develop laws "On perishable raw materials and products" and "On support of the cold chain" to regulate relations in the sphere of circulation of perishable raw materials and products.

2. Rational planning: develop long-term state planning for the creation of logistics infrastructure in the territory of mass production and consumption.

3. Infrastructure audit: systematically conduct an audit of the condition of refrigerators, warehouses and freezers.

4. State investments: direct investments to the creation of warehouses with controlled temperatures and the development of transport logistics for SPP.

5. Development of railway infrastructure: produce specialized trains for the transportation of SPP.

6. Subsidies: provide financial support for the construction of refrigeration infrastructure in wholesale markets.

7. Development of wholesale markets and processing centers: invest in infrastructure to minimize losses and ensure high product quality.

These measures are aimed at removing barriers, increasing the sustainability and efficiency of the PFP supply chains, as well as ensuring food security and meeting the needs of the population.

Research has shown that Kazakhstan lacks a centralized body at the state level responsible for solving the problems of the cold chain of perishable food products (PFP). This leads to a number of problems, including insufficient attention of government agencies to PFP issues, difficulties with monitoring and traceability of supply chains, as well as poor organization of the processes of collection, transportation, storage and sale of products.

Elimination of these deficiencies requires:

1. Organization of statistical accounting of cold chain activities and infrastructure.

2. Continuous training of specialists in the field of cold chain management.

3. Creation of a special government body for regulation of work in the field of PPP cold chain.

To improve the efficiency of logistics management and temperature control in the cold chain, it is necessary to:

1. Increase investment in cold chain infrastructure, including vehicles, freezing and refrigeration equipment, temperature monitoring and control systems.

2. Develop multi-profile production with deep processing of PFP in warehouses and storage facilities to minimize product losses.

To eliminate problems with demand management for PFP, it is necessary to:

1. Conclude long-term contracts with producers.

2. Establish information exchange with farmers.

3. Organize storage facilities for excess products and forecast demand.

To increase the transparency and traceability of supply chains, it is necessary to:

1. Implement vertical integration of farmers and other participants in the logistics chain.

2. Use modern technologies, such as the Internet of Things, blockchain and remote temperature control systems.

Compliance of infrastructure with modern requirements is possible through:

1. Developing local wholesale markets, aggregation and product processing centers.

2. Investing in expanding the cold chain infrastructure, including packaging workshops, ripening units and refrigerators.

3. Providing integrated cold chain solutions, taking into account the supporting infrastructure.

An integrated approach to the modernization and development of the cold chain will reduce product losses, improve their quality and ensure the sustainability of the cold chain supply chain in Kazakhstan.

2.2. Analysis of the process of formation and development of logistics infrastructure (using wholesale distribution centers as an example)

The problem of selling agricultural products is one of the main and most important tasks of agricultural producers. These products are often sold without taking into account regional and global market conditions. These reasons contribute to the purchase of agricultural products at reduced prices by various intermediary structures, which subsequently receive significant profits on their resale. All these facts negatively affect the competitiveness of products.

To solve this problem, in most European countries, wholesale trade in all perishable products is organized through wholesale food markets (WFM). Examples of successful distribution networks based on networks of wholesale distribution centers (WDCs) are the wholesale food market "Rungis" (France) (http://www.rungisinternational.com/), the network of wholesale food markets "Mercasa" (Spain) (http://www.mercasa.es/) and the wholesale food market "Bronisze" (Poland) (https://www.bronisze.com.pl).

More than 75% of agricultural products are transported by road. Transportation takes from one to two days, since the length of the territory from west to east exceeds 3000 km, from south to north - 1700 km, which is also the cause of high costs and product losses.

Despite various government support measures, there is a large deficit of logistics infrastructure for storage, packaging and transportation, modern trade formats, which leads to large product losses, which amount to up to 40% in fruit and vegetable production, and up to 20-25% in livestock farming. This is especially evident in the activities of small agricultural producers.

Currently, the distribution of goods and services along the supply chain as a whole is irrational and random.

In 2020, Kazakhstan resolved to address this issue by launching a project to construct a network of distribution centers [20]. Consequently, tackling the challenge of optimal placement and service radius for logistics infrastructure—encompassing storage, distribution, and trade of agricultural products at the national level—alongside ensuring its effective operation, is a critical concern for Kazakhstan.

Having studied various developments on the selection of the location of the distribution center, assessing the effectiveness of their activities, we note that the organizational and methodological support for the formation of logistics infrastructure requires a more detailed study. This is due to: 1. industry specifics and the difference between agricultural products and products of other types of industrial production, 2. a methodological gap in modern methods based on scientifically substantiated criteria for assessing the rational placement of logistics facilities. Given our large territory and low population density, the placement of infrastructure requires a scientifically substantiated solution taking into account various factors [13].

The construction of a model for the placement of the distribution center for agri-food products was carried out in the following sequence.

Stage 1. Determining potential locations for the placement of the WRC

The results were analyzed in stages, according to the above sequence.

1) Analysis and selection of indicators that determine the selection and placement locations. Descriptive statistics of the selected indicators are presented in Table 10.

Table 10 - Descriptive statistics of the selected indicators (n=204, m=19)

Indicators	Mean	Standard Deviation	Median	Kurtosis	Skewness	Jarque-Bera test	p-value*
X1	93665,9	195561,2	39478,5	55,31	6,67	0,95	0,41
X2	125394,7	38483,4	119790,0	2,32	1,29	1,12	0,24
X3	9267,5	8627,2	6743,0	6,67	2,26	1,35	0,31
X4	233,1	224,4	172,9	5,34	1,82	2,17	0,51
X5	35791,7	25323,2	32653,5	1,87	1,09	1,85	0,05
X6	43085,7	291685,9	1759,4	167,57	12,52	0,87	0,14
X7	3797,8	4533,7	2011,1	8,55	2,36	0,97	0,41
X8	33280,7	60580,9	5825,0	7,95	2,68	1,23	0,15
X9	17,6	26,6	6,0	6,18	2,31	2,47	0,52
X10	3,3	2,0	2,9	0,22	0,75	1,84	0,50
X11	216,0	147,0	195,0	0,03	0,64	0,78	0,34
X12	215,8	150,3	194,8	0,00	0,63	2,68	0,45
X13	36945,1	92134,7	6184,0	27,85	4,82	2,74	0,38
X14	2994,5	10905,2	150,4	49,13	6,50	0,81	0,27
X15	80521,7	107472,3	30717,3	2,26	1,64	1,21	0,31
X16	24655,9	59291,9	6209,3	13,69	3,69	0,87	0,12
X17	19762,7	26773,7	8121,2	5,61	2,24	2,37	0,49
X18	3369,9	3094,9	2435,0	49,46	6,10	1,41	0,34
X19	12983,7	44868,1	2133,2	31,38	5,47	0,97	0,24
Note: *significant at $p<0.05$ Source: Review of statistical data of the Republic of Kazakhstan for 2017-2021 [92]							

The asymmetry coefficient and excess are close to zero, which makes it possible to approach the normal distribution. Acceptance of the normality hypothesis is confirmed by the Jarque-Bera statistics at a significance level of 5%. It follows that

for further analysis, all parameters of Table 10 can be used as methods of parametric statistics.

2) Standardization of indicators was carried out for a 204x19 matrix of indicators using the above formula.

3) Determination of weighting coefficients of indicators (Table 11).

Table 11 - Weighting coefficients of indicators influencing the choice of placement

Indicators	Weighting factors
Population size (X1)	-0,9784
Per capita income (X2)	0,5314
Number of agricultural producers (X3)	-0,9529
Volume of agricultural cargo transportation by road (X4)	-0,8194
Volume of agricultural sales (X5)	0,9930
Volume of wholesale and retail turnover of food products (X6)	0,4546
Investments in fixed capital of logistics infrastructure (X7)	0,4387
Availability of agricultural storage facilities (X8)	0,8754
Availability of railway* (X9)	0,6654
Transportation time of products by road** (X10)	-0,8427
Distance from the district center to the distribution center in the regional center** (X11)	-0,7123
Production of agricultural products in physical terms (X12-X17)	0,9508
Volume of solid waste from product sales (X18)	-0,6412
Emissions of pollutants into the atmosphere (X19)	-0,4517
Total variance	2,2305
Share of total variance	0,9327
* determined based on the online map of the railways of the Republic of Kazakhstan https://nkregion.kz/info/maps/63-railways.html ** determined based on the map https://www.google.kz/maps Source: Review of statistical data of the Republic of Kazakhstan for 2017-2021 [92]	

The use of weighting coefficients allowed us to determine that the selected indicators are significant, since the dispersion coefficient is 93.2%

4) Factor analysis of indicators and identification of the most important factors. In the first block of indicators, the principal component explained 27.38% of the variation of xj, in the second block - 20.17% of the variation and 15.95; 11.39; 6.76% of the variation, respectively, by components (Table 12).

Table 12 - Explained total dispersion (principal component method)

Initial Eigenvalues	Component				
	1	2	3	4	5
Total	4,108	3,026	2,393	1,709	1,015
% Variance	27,387	20,174	15,954	11,393	6,767
Cumulative %	27,387	47,561	63,516	74,908	81,675
Source: Calculated using SPSS					

The application of this method enabled the identification of principal components in each group of indicators that characterize the effectiveness of the logistics infrastructure by effectively "compressing" the variables (Table 13).

Table 13 - Factor loadings for the main components for choosing the location of the logistics infrastructure for storage, distribution and trade

Indicators	Average component values for 2017-2021				
	F1	F2	F3	F4	F5
X1	0,058	**0,826**	-0,087	-0,193	0,014
X2	-0,346	**0,753**	0,371	0,052	0,035
X3	**0,856**	-0,027	-0,048	-0,074	0,034
X4	**0,854**	-0,057	0,315	0,003	0,196
X5	**0,835**	-0,085	0,280	0,043	0,378
X6	-0,076	**0,972**	-0,047	-0,073	-0,013
X7	-0,455	**0,954**	-0,001	-0,008	0,014
X8	-0,083	-0,014	**0,924**	-0,043	-0,095
X9	0,002	-0,026	**0,922**	-0,077	-0,081
X10	-0,022	-0,088	-0,049	**0,979**	-0,088
X11	-0,007	-0,149	-0,036	**0,976**	-0,077
X12	**0,739**	-0,081	0,010	0,164	0,316
X13	**0,728**	0,036	-0,158	0,011	-0,166
X14	**0,700**	0,050	-0,044	-0,139	-0,247
X15	**0,726**	-0,106	0,204	0,044	0,320
X16	**0,828**	0,040	-0,012	-0,163	0,062
X17	**0,698**	-0,013	0,010	-0,114	0,372
X18	0,024	0,217	-0,171	0,008	**0,854**
X19	0,173	0,018	**0,719**	0,131	0,042
Note: Factor extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Rotation converged in 5 iterations.					

The following results were obtained from the factor analysis: Cronbach's alpha is 0.81 - the selected variables are acceptable. Kaiser-Meyer-Olkin (KMO), equal to 0.73, is satisfactory.

A matrix of values was obtained for five groups of factors: F1, F2, F3, F4 and F5 for each of the 204 territories.

In the matrix of principal components, the average value of the weight coefficients was determined by the following variables:

F1 (X3, X4, X5, X12, X13, X14, X15, X16, X17),

F2 (X1, X2, X6, X7),

F3 (X8, X9, X19),

F4 (X10, X11),

F5 (X18).

Thus, the following factors are identified:

Factor F1 - production,

Factors F2 - trade,

Factor F3 - transport and warehouse accessibility,

Factor F4 - geographical (time and distances),

Factor F5 - environmental.

The contents of factors F1, F3 and F5 determine the summary characteristics of product storage in the region: the number of product manufacturers, the volume of production and cargo transportation, the volume of production in physical terms, solid waste and emissions of pollutants into the atmosphere.

The contents of factors F2 and F4 characterize the possibilities of distribution and trade in the region: the number and per capita income of the region's population, the volume of trade and investment in infrastructure, the time and distances of cargo transportation in the region.

The content of factor F2 characterizes the possibilities of trade in the region: the number and per capita income of the region's population, the volume of trade and investment in infrastructure.

The relationship between the variables and the principal component is represented by the following relationship:

F1=0.856*X3+0.854*X4+0.835*X5+0.739*X12+0.728*X13+0.7*X14 +0.726*X15 +0.828*X16 +0.698*X17

F2=0.826*X1+0.753*X2+0.972*X6+0.954*X7

F3=0.924*X8+0.922*X9+0.719*X19

F4=0.979*X10 +0.976*X11

F5=0.854*X18

The solution to the principal component equation was the construction of a matrix of values of factors F1, F2, F3, F4 and F5 for 204 objects of study, which became the basis for conducting cluster analysis in order to differentiate regions by the level of readiness for the placement of logistics infrastructure.

5) Cluster analysis to identify the territorial distribution of agricultural production and the formation of clusters.

In order to determine the significance of the main components that determine clustering, the F-criterion was used. The higher its value, the greater the contribution of the main component to clustering (Table 14).

Table 14 - Values of the F-criterion of the main components for 2017-2021.

F-criterion value	Main component				
	F1	F2	F3	F4	F5
	51.39	58.15	37.69	24.08	8.77
Note: obtained on the basis of calculation of models F1- F5 according to data from Table 12					

The main variables determining the grouping were those related to trade factors, production factors, transport and warehouse accessibility. Clustering is also determined by the results of the variables of social, production and, least of all, environmental factors of the main component. This reflects the state policy of developing the trade infrastructure of the agri-food market in rural areas and districts.

Of all the available methods for conducting cluster analysis, the most popular k-means method was chosen. From the conducted reconnaissance analysis, the optimal

one was dividing the regions into six clusters, which include administrative-territorial districts that are qualitatively different from each other.

The belonging of territories to clusters has the following features.

The first cluster included 7 districts that have developed diversified agriculture with the production of crop products. This region accounts for 5% of agricultural product output (in monetary terms), including 11% of total potatoes, 36% of eggs, 5.1% of milk, and 4.1% of meat (by volume).

The second cluster comprises districts more strongly oriented toward livestock farming while also engaging in crop production, potato farming, and vegetable cultivation. This cluster includes 159 districts of all regions. It produces 67.0% of Kazakhstan's agricultural products (in value terms), of which meat - 79.7%, milk - 71.8%, potatoes - 66.2%, grains - 55.5%, vegetables - 49.9%, fruits and berries - 54.9% (in physical terms).

The third, fifth, and sixth clusters consist of districts and cities with a relatively low level of agricultural development, constituting 2.0%, 4.7%, and 2.3% of production, respectively.

The third cluster contains a single territory (Enbekshikazakh District in Almaty Region), predominantly characterized by fruit and berry production (16.9%) and vegetable and melon production (4.1%).

The fourth cluster encompasses districts with significant crop production, particularly soybeans and grain (37.8%) and potatoes (16.3%), as well as livestock production for meat and dairy products—meat (10.4%), milk (15.8%), eggs (7.3%), fruit and berries (6.4%)—totaling 18.9% of Kazakhstan’s agricultural output (in value terms).

The fifth cluster features substantial crop production, with fruits and berries accounting for 17.9% across all clusters, vegetables and melons 22.0%, potatoes 2.9%, milk 3.5%, meat 2.6%, and eggs 3.8%. This cluster contributes 4.7% of agricultural production in value terms, primarily encompassing southern districts that grow vegetables and fruits.

The sixth cluster specializes in vegetables and melons, producing 18.4% of such goods among all clusters, though representing just 2.3% of total production in monetary terms. This cluster includes southern regions producing melons.

The obtained results of the clusters are summarized by production and regional potential characteristics of the infrastructure in the final table 15.

The classification results allow us to conclude that universal storage facilities for agricultural products should be located in the districts of clusters 1, 2, 4 and 5.

- Clusters 2 and 3 – grain storage facilities;
- Clusters 1, 2 and 4 – potato storage facilities;
- Clusters 1, 2 and 4 – refrigeration equipment for storing meat and poultry;
- Clusters 2 and 4 – refrigeration equipment for milk;
- Clusters 2, 3, 4 and 5 – fruit and berry storage facilities;
- Clusters 2, 3, 5 and 6 – vegetable storage facilities.

Table 15 - Characteristics of the logistics infrastructure depending on the identified clusters of the Republic of Kazakhstan

CN	ND	Characteristics of production potential	Potential infrastructure characteristics
1	7	Crop production (potatoes) and grains, meat and milk, eggs	grain and potato storage facilities, refrigeration equipment for milk and meat of animals and poultry
2	159	Dairy animal husbandry, beekeeping, crop production (soybeans, oats, corn, buckwheat), potato growing, vegetable growing	grain-fruit-berry-vegetable storage facilities, refrigeration equipment for milk and meat of animals/birds
3	1	Fruits and berries, vegetables and melons, potatoes, meat, milk	Potato, fruit, berry and vegetable storage facilities, refrigeration equipment for milk and animal meat
4	27	Meat and dairy animal husbandry, poultry farming, crop production, potato growing, vegetable growing	grain-fruit-berry-potato storage facilities, refrigeration equipment for milk and meat of animals and birds
5	5	Crop production, potato growing, vegetable growing, fruits and berries, poultry farming	large fruit and berry storage facilities, vegetable storage facilities, potato storage facilities, as well as refrigeration equipment for milk and meat of animals and poultry
6	2	Vegetable growing and melons	large vegetable storage facilities, as well as fruit and berry storage facilities, refrigeration equipment for milk and meat of animals

Note: CN- cluster number; ND - Number of districts

The above-mentioned districts have significant production potential and produce 95.7% of agricultural products in the Republic of Kazakhstan.

- Clusters 3 and 6, where fruits and berries (16.9%), vegetables and melons (18.4%) predominate, with a low population share. These areas should be provided with specialized vegetable and fruit storage facilities.

6) Calculation of ratings and differentiation of areas by the level of attractiveness of the placement of logistics infrastructures.

The integrated rating of areas/cities was determined by the average values of the grouped factors F1-F5, adjusted for their weights.

The specified groups of factors F1, F2, F3, F4 and F5 were the basis for selecting the types of wholesale distribution centers:

- Average values of criteria F1, F2, and F3 for selecting a storage wholesale distribution center,

- Average values of F2 and F4 for selecting a distribution wholesale distribution center,

- The F3 value for selecting a trade wholesale distribution center (Table F.2, Appendix F).

Stage 2. Clarification of potential locations for the placement of wholesale distribution centers (WDC)

At this stage, potential locations for the placement of integrated logistics DCs were clarified taking into account the optimal location, minimization of transportation costs and product losses.

7) Determination of the radius of action of the WDC.

To refine the service radii of wholesale distribution centers (WDCs), the “center of gravity” method was employed. Its central principle is to identify the optimal WDC location that minimizes total distances both from agricultural producers to the WDC and from the WDC to end consumers. The calculations of the center of gravity presented in Table F.1 (Appendix F) show that for different regions the radius of action of the WDCs varies from 142.2 km (Atyrau region) to 424.2 km (Akmola region), which indicates a significant spread of distances (up to a threefold difference) between potential WDCs and regional consumption centers. This spread of distances leads to an increase in transportation costs and product losses during transportation, which reduces the efficiency of the logistics system. To solve this problem, a differentiated approach to the placement of WDCs was used. For example, it is advisable to concentrate servicing regions with a large radius of action (424.2 km, Akmola region) in Astana, where the service radius will be less than 150 km, and transfer some areas to the responsibility zone of Pavlodar with a radius of about 250 km.

Thus, rational redistribution of service areas taking into account the differentiated approach to the placement of WDCs allows optimizing the logistics infrastructure, reducing transport costs and minimizing product losses during transportation.

8) Determining potential locations for WDCs.

Potential locations and calculations of the center of gravity for determining the radius of action of wholesale distribution centers (WDCs) for storage are presented in the appendix (Table F.2, Appendix F). The analysis made it possible to assess the degree of influence of the selected WDC placement points on adjacent territories and determine the circle of consumers of their services.

The rating assessment of the regional entities by factors F1–F5 identified key territories for the placement of WDCs taking into account their functional specialization. In order to form large wholesale distribution centers integrated into the national network, it is recommended to consider territories adjacent to cities of national significance:

- Almaty, Astana (trade and distribution wholesale distribution centers),
- Shymkent, Aktobe and Karaganda (trade wholesale distribution centers).

It is advisable to place distribution wholesale distribution centers near large regional centers with high ratings for factors F2 and F4 (for example, Alakol, Zhezkazgan, Beineu, Ayaguz, Kurchum). It is recommended to place storage wholesale distribution centers in rural areas where agricultural production and processing of products are concentrated, as well as in adjacent urban agglomerations demonstrating high ratings for F1, F3 and F5.

Based on the analysis (Table F.2, Appendix F), a network of 25 wholesale distribution centers was formed, including:

• 13 storage wholesale distribution centers;

• 7 distribution wholesale distribution centers;

• 5 trade wholesale distribution centers (Figure 18). The WDC network must operate in a continuous refrigeration chain mode, i.e. a system of refrigeration technologies, technical means, organizational measures that ensure the necessary

modes of storage, transportation and sale of chilled and frozen products throughout the entire path from production to consumption. Such a structure allows for optimal coverage of territories, minimization of transportation costs and creation of an effective system of logistics infrastructure.

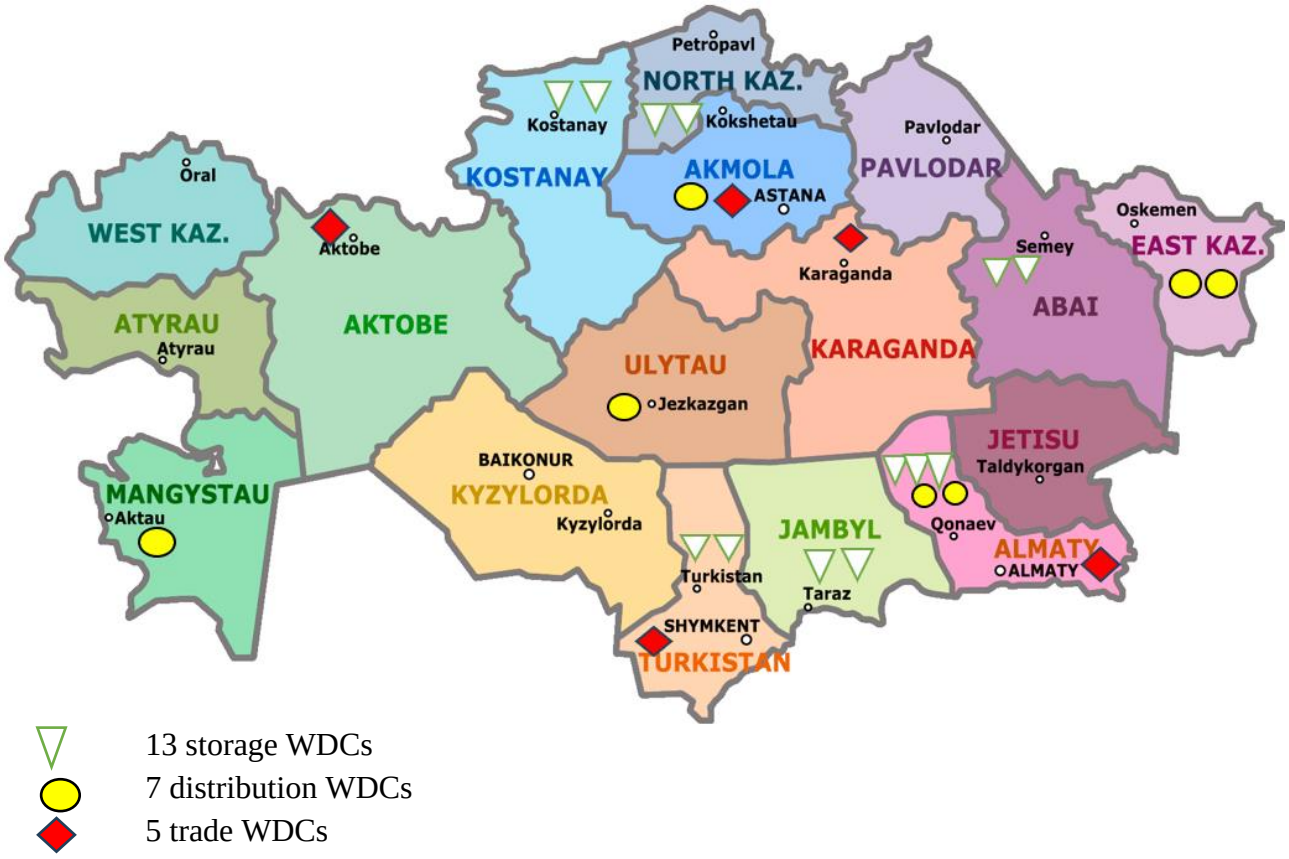


Figure 18 – Project for the placement of the WDC network in accordance with the zones of concentration of production of the main types of products

Note: developed by the author

Stage 3. Determination of the WDC service area

At this stage, the WDC service areas and the advantages of their use are determined.

9) The WDC service areas are determined in accordance with potential locations in the districts and urban agglomerations.

The logistics network of agricultural distribution centers (DCs) in the Republic of Kazakhstan will be presented as follows:

- Determination of the WDC service areas: Agricultural DCs should cover service areas within a radius of 142 km (Atyrau region) to 424 km (Akmola region), which is determined by the distance from the districts to the proposed location of the WDC or wholesale market. When calculating the service areas, it is necessary to take into account the results obtained by the "center of gravity" method, which are calculated individually for each region (oblast). To optimize service areas, modern

online maps of the area can be used, which will allow areas located at a significant distance from regional centers to choose the nearest ODC, even if it is located in a neighboring region.

- The functional role of the storage ODC: Storage ODCs (in the amount of 13 units), in addition to performing their basic functions, should play the role of transshipment bases for large areas of the regions. This will allow the redistribution of flows of agricultural products and raw materials with subsequent direction to processing plants located in urban agglomerations. This approach will ensure the integration of warehouse capacities into the overall logistics network, improve coordination between producers and processors, and minimize product losses during transportation.

This structure helps to increase the efficiency of the logistics network, reduce transportation costs and improve the quality of service to the regions.

10) Economic interpretation of the results obtained.

The creation of a network of agricultural distribution centers will ensure the formation of an effective distribution system for agricultural raw materials and food. This will gradually eliminate the chaotic activities of numerous intermediaries and streamline supply chains.

The implementation of the agricultural DC development system will create economic incentives for agricultural producers, which will lead to an increase in production volumes and improved product quality. This, in turn, will ensure the saturation of the country's food market with domestically produced goods and will have a positive impact on the socio-economic development of the agro-industrial complex (AIC) in the regions.

The effective functioning of the DC network will contribute to achieving the following results that form a multiplier effect:

• reduction in product losses at all stages of their transportation and storage;

• increase in tax revenues due to the growth in the volume of economic activity;

• creation of new jobs, which will improve employment in rural areas;

• reduction in population costs for the purchase of socially significant food products.

Preliminary calculations confirm the feasibility of creating a wholesale food market system in Kazakhstan from both economic and social points of view. The development of such a system will be an important factor in strengthening the country's food security, improving the infrastructure of the AIC and improving the quality of life of the population.

Thus, the paper proposes a methodical approach to determining the optimal placement and number of wholesale distribution centers (WDCs) based on integrated indicators obtained using factor analysis. This approach differs from existing methods in its adaptability and efficiency, which allows taking into account the intended purpose of the facilities and promptly identifying the needs for logistics infrastructure. This, in turn, increases the accuracy and validity of decisions when choosing locations and forming a WDC network.

Optimal placement and efficient operation of the trade and sales infrastructure should be based on a differentiated approach focused on agricultural producers. This

approach facilitates the implementation of targeted agricultural and trade policies, as well as government support, including the development of storage, sales and trade infrastructure.

To improve the validity of decisions made, it is advisable to classify territories taking into account similar production, infrastructure and socio-economic conditions. This approach allows taking into account the specifics of the regions and more accurately designing logistics infrastructure facilities.

The conclusions and the proposed methodological approach are consistent with the results of studies conducted by Popov P. V., Miretsky I. Yu., as well as Wang P., Chen X. J. and Zhang X. B. [62, 67], which confirms their theoretical and practical significance for the development of agricultural logistics.

The classification is based on the calculation of an integral indicator that allows identifying territories that are unfavorable for agricultural production. The areas identified as the most favorable for the development of crop production (potatoes) and grain, meat and milk, eggs (clusters 1, 3, 5 and 6) should also be presented with special conditions, consisting not only of increased state assistance in the construction of specialized warehouse storage facilities, such as grain and potato storage facilities, fruit and berry storage facilities, vegetable storage facilities, refrigeration equipment, but also in the development of program documents for these areas that develop entrepreneurial initiative taking into account the increased risks of agricultural production, as well as special conditions for the interaction of these areas with retail chains. This may concern fast and uninterrupted delivery throughout the year, financing of retail chains of business entities growing agricultural products. The areas identified as the most favorable for the development of dairy livestock farming, beekeeping, and crop production (clusters 2 and 4) should also be presented with conditions for the construction and development of universal agricultural distribution centers. In the areas included in these clusters, conditions should be created for the joint use of trade and sales infrastructure due to their large number (159 territories out of 204).

Conducting an analysis using this methodology allowed dividing the studied areas into 6 clusters, depending on the specialization of production and infrastructure for the sale of agricultural products.

The rating assessment, determined on the basis of the integral indicator, identified the leading regions.

Implementing the conceptual provisions governing the functioning of the agricultural product sales market requires altering traditional approaches to the selection and spatial allocation of distribution centers. At the regional level, the criteria for the optimality and efficiency of placement should be measured using the integral multiplicative indicator, as in the work [95].

The work defines a methodology for selecting the location of the WDC, including a territory rating based on factor analysis and the "center of gravity" method, which made it possible to identify 13 storage WDCs, 7 distribution WDCs and 5 trade WDCs in Kazakhstan. Our research is consistent with the research conducted in [61, 62], with the only difference being that our research took into account the contribution of each factor for each of the 204 objects of study.

The originality of the proposed methodology lies in its integrated approach, which allows for simultaneous consideration of the locations of WDCs depending on their functional purpose and the influence of socio-economic and infrastructural factors.

The methodology developed for selecting sites for transport and logistics infrastructure can be recommended for:

- Incorporation into regional government programs for logistics development.
- Making investment decisions by large companies in the field of logistics.

The methodology includes the following stages:

- Formation of a system of indicators characterizing the optimal placement and efficiency of using elements of the logistics infrastructure.
- Determination of indices reflecting changes in key factors over time.
- Calculation of an aggregated indicator representing the average value of the indices.

The application of this methodology, based on statistical data and online maps of transport networks, made it possible to identify potential regions for the construction of WDCs. In particular, taking into account the F3 factor, it was determined that it is advisable to place 5 WDCs in large cities of Kazakhstan: Almaty, Astana, Shymkent, Aktobe and Karaganda.

Based on the calculations, the following were determined:

- The number and locations of WDCs for storage, distribution and trade.
- Service areas for each type of WDC.

The results obtained are consistent with the initiatives of the Government of the Republic of Kazakhstan aimed at creating a commodity distribution system. Within the framework of the state program, it is planned to build a network of 24 WDCs with a total cost of 273 billion tenge [20].

This methodology allows optimizing the placement of WDCs, ensuring a reduction in logistics costs, an increase in the efficiency of the transport and logistics infrastructure and support for the development of the agri-food sector.

Thus, a set of indicators of socio-economic, regional, production and environmental factors of the region served as a key parameter in solving the problem of efficient placement of the warehouse network.

The methodology for selecting indicators and placing logistics infrastructure facilities was carried out on the basis of calculating the integral indicator, determining the effective location, service zones and their number in the regions, using a set of methods.

The proposed methodological approach consists of three stages. At the first stage, territories (districts and urban agglomerations) are determined where it is advisable to place key objects of logistics infrastructure. To solve this problem, an approach based on the use of the combined potential of a two-stage cluster, factor analysis and a rating method is proposed. The consistency of the results of the combined use of these methods was demonstrated using the example of Kazakhstan. At the second stage, it is necessary to geographically link the logistics infrastructure facilities to a specific area. For this purpose, the center of gravity method is used to

determine the optimal locations for infrastructure, taking into account the time and distance of transportation by road. Certain optimization tasks are aimed at minimizing the costs of moving the material flow from suppliers to consumers. At the third stage, the service areas of the wholesale distribution center are determined based on minimizing the costs of servicing the districts.

A notable feature of this method is that when forming the logistics infrastructure, it is possible to simultaneously take into account both the intended purpose and the type of carrier of the goods - storage, distribution or trade. Based on this, it is possible to select the necessary capacities, types of refrigeration and ventilation equipment, specialized vehicles (refrigerated trucks, isothermal vans), etc.

The proposed methodology for selecting WDC locations to handle storage, distribution, and trade could be beneficial both for state-level planning of logistics infrastructure development in the country's regions and for large enterprises seeking to invest in the logistics sector.

The use of this methodology allows government agencies or private investors to calculate in advance, before making a decision on the design or modernization of existing distribution networks, possible options for their optimal placement, based on population density and transport, logistics and trade infrastructure, economic and physical availability of food products and other factors, which allows increasing the efficiency of production and sales and the sustainability of supply chains for agricultural products.

2.3 Assessment of factors influencing the development of logistics infrastructure and supply chains

The functioning of the food environment and supply chains requires taking into account many interdependent processes inside and outside the organization of limiting factors that affect the effective and sustainable functioning of the supply chains of food products.

Factors influencing the food supply chain: 1) innovation, technology and infrastructure factors, 2) demographic, 3) political, 4) economic, 5) biophysical and environmental, 6) socio-cultural [96].

The key elements of the food environment that determine the choice of products, their acceptability and diet are physical and economic access to food (physical proximity and financial availability); activities to stimulate the sale of food products, advertising and information regarding them; quality and safety of products [97, 98].

Systematization of the conditions and environment of the functioning of the distribution system made it possible to identify the key conditions and environment that determine the functioning of the supply chain. These include: 1) physical, 2) economic, 3) institutional, 4) socio-cultural, 5) anthropogenic, 6) consumer environment. Each of the listed environments creates specific conditions that ensure the functioning of the supply chain, while they are affected by various factors that can generate risks. These risks limit the sustainability of the supply chain, reducing its efficiency and stability [99].

Physical, financial, economic, institutional, social, sanitary-epidemiological, environmental, consumer factors influence the supply chain and logistics infrastructure of agri-food products and limit the activities of the food environment and supply chain.

The presence of restrictions on the movement of people and transport have different impacts on the operation of supply chains and on the economic and physical availability of food products (Figure 19).

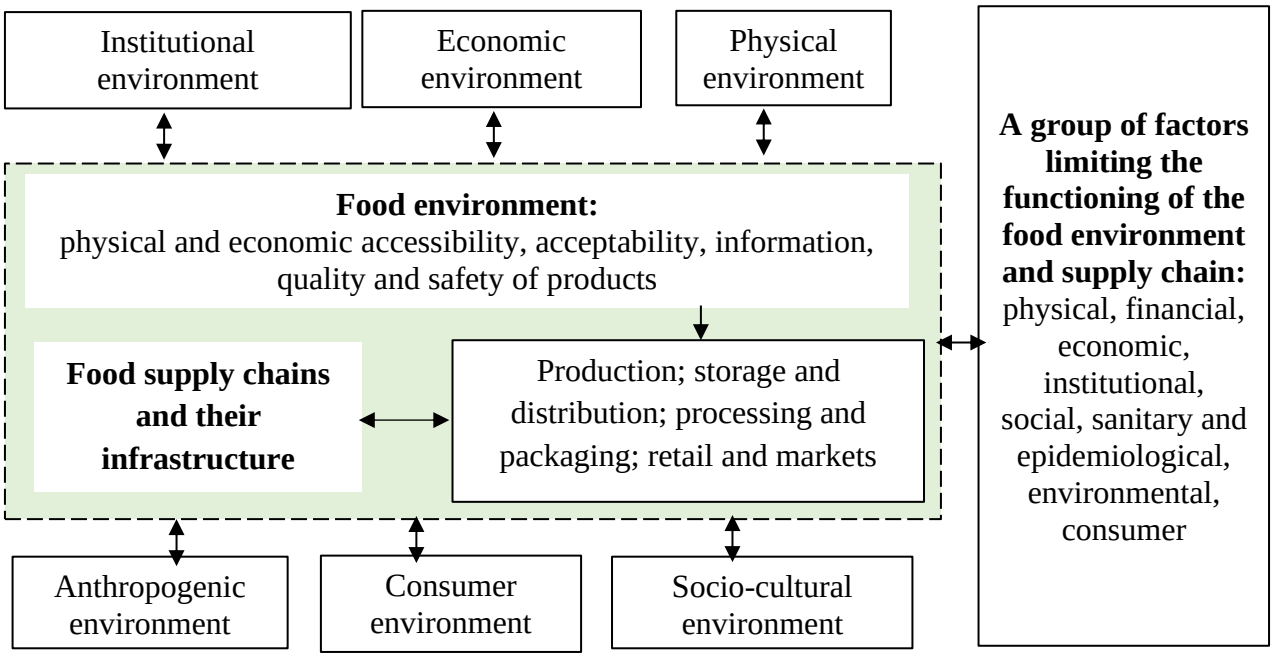


Figure 19 - Environment of the food supply chain and factors limiting the functioning of the food environment

Note: compiled in collaboration with [100]

Thus, based on a theoretical analysis of the literature, we will consider the environment, conditions, factors and risks affecting the CPP.

1. The physical environment (availability and physical accessibility) ensures the physical availability of food, that is, the availability of food products at any time and in the required assortment in any part of the country. We have identified three groups of operating conditions associated with physical restrictions on the operation of the food supply chain:

1) geographic,

2) technical and technological,

3) infrastructural restrictions in the food production and distribution system (disruptions in supply chains, lack of access to digital technology services, restrictions on the capacity of infrastructure, including transport, logistics and trade).

1) Geographic restrictions (spatio-temporal restrictions) are associated with a ban on moving to other countries or moving goods and people within the country [101], or strict border, sanitary and epidemiological requirements when visiting other countries; suspension of intercity transportation; ban/restriction of public transport

and passenger air transportation [102]; the formation of barriers to the delivery of goods within the region and/or to other regions.

2) Technical and technological restrictions (interaction with the environment due to innovations, equipment and technology; digitalization and automation). Risks: low level of integration and interaction of the CU participants, low level of technology implementation, risk of non-use of digital technologies due to communication problems or lack of competence; lack of access to digital technologies.

Technological limitations are associated with technical and technological consequences in the food production and distribution system: failures in supply chains; lack of access to digital technology services; limitations on the capacity of infrastructure, including transport, logistics and trade; underutilized capacities [103]; cyclical demand for transport services; delays in deliveries and damage to goods [104].

3) Infrastructure limitations (availability and density of trade, transport, and other infrastructure by region). Risks: high depreciation of infrastructure; low level of infrastructure provision; low quality of infrastructure; remoteness of raw material bases from product processing centers; failure to meet product delivery schedules; lack of receiving points; low investment attractiveness and long payback period of infrastructure projects in the food market.

2. The economic environment is characterized by the economic availability of food, that is, the ability to purchase food products of the proper quality at current prices, in volumes and assortment corresponding to the income of the population.

Factors associated with economic restrictions include: a decrease in demand for food products, a ban on the export of certain goods outside the country [105], rising prices in local food markets [106], restrictions on business activity and the accompanying decrease in demand, restrictions on the export of basic crops [107].

Factors associated with financial constraints affect the decrease in purchasing power of the population [108], loss of income of the population and firms [109], low wages, lack of or inability to purchase personal protective equipment, limited access to financial resources for the development of the industry for the production and distribution of products. A slowdown in sales at both ends of the chain reduces the income received [110].

The effectiveness of national logistics is largely determined not only by internal factors, but also by the degree of integration of the state with foreign trading partners, as well as the quality of the logistics capabilities of the partners themselves.

To measure the LPI (Logistics Performance Index) indicator, the World Bank methodology is used, which allows assessing the effectiveness of the country's logistics system. The LPI index reflects the convenience of transporting goods and the general state of trade logistics both within the country and internationally [111]. The main components of the LPI are: customs; infrastructure; international transportation; competence and level of logistics services; the ability to track and control cargo; efficiency of delivery.

To analyze the LPI, annual World Bank reports are used, starting from 2007 to 2023 [111], which provide detailed information on logistics indicators in more than

160 countries. Each of the above characteristics is assessed on a scale from 1 to 5 points, where 1 means the lowest level, and 5 is the highest.

The LPI indicators of the EAEU member states occupy the bottom position of the rating (Table 16). Over the two years since the previous study, Kazakhstan has risen in the rating by only 6 positions and has not yet reached the 2010 indicator – 62nd place.

Table 16 - Logistics Performance Index (LPI) in the EAEU countries, 2007–2023.

Country	Integrated LPI indicator (country rank)						
	2007	2010	2012	2014	2016	2018	2023
Kazakhstan	2,12 (133)	2,83 (62)	2,69 (86)	2,70 (88)	2,75 (77)	2,81 (71)	2,7(79)
Russia	2,37 (99)	2,61 (94)	2,58 (95)	2,69 (90)	2,57 (99)	2,76 (75)	2,6(88)
Armenia	2,14 (131)	2,52 (111)	2,56 (100)	2,67 (92)	2,21 (141)	2,61 (92)	2,5(97)
Belarus	2,53 (74)	—	2,61 (91)	2,64 (99)	2,40 (120)	2,57 (103)	2,7(79)
Kyrgyzstan	2,35 (103)	2,62 (91)	2,35 (130)	2,21 (149)	2,16 (146)	2,55 (108)	2,3(123
Source: [111]							

The data in Table 16 demonstrate that Kazakhstan is the leader among countries in terms of logistics development indicators for 2010-2023.

One of the factors restraining the effective development of the logistics services market is the weak development of internal logistics of enterprises in the real sector of the economy, primarily those with state ownership. Some transport and logistics enterprises strive to make a quick profit and do not pay due attention to the complexity and quality of logistics services, and cannot ensure the safety and reliability of the supply chain [112-114].

The market of manufacturers strives to concentrate their efforts on performing core functions, which determines the development of outsourcing in the field of logistics. Today, 2PL services are more developed in Kazakhstan, and 3PL services are less common.

As previously stated, in Kazakhstan, due to a lack of storage space, many agricultural producers are not harvesting their crops because they could not find a way to sell their products.

Currently, there are about 100 units operating in the country. refrigeration units in agriculture, in trade - more than 700 units, transport refrigerators - 0.1 thousand units.

There is an insufficient level of development of trade and logistics centers, modern format retail chains, wholesale distribution and logistics centers.

Kazakhstan does not have a system of modern wholesale markets and wholesale distribution centers (WDC) capable of optimally accumulating and distributing products of domestic manufacturers.

In 2021, there were 761 wholesale and retail markets in the country, with 184.5 thousand trading places. Currently, there is a decrease in the number of markets with

a slight increase in the number of trading places (in 2010, there were an average of 215 places per market, and 10 years later - 242). About 70% are general markets, and the share of food markets is about 4%, agricultural cooperative markets - 1.1% [92].

Factors of logistics and its impact on trade and economic growth. We studied the impact of logistics and their individual components on the intensity of Kazakhstan's trade with trading partner countries, as well as their mutual impact on economic growth [115, 116]. For this, we used the most widely used indicator - the index of intensity of bilateral trade flows, which is known as the trade intensity index (TII). The index takes on a value equal to 1 if the countries of the regional group trade with each other with the same intensity as with other countries of the world. Exceeding the threshold value indicates the presence of a "geographical bias", that is, regional preferences that are explained by geographic proximity, lower transaction costs, historical and cultural ties [117]. The TII is of greater interest both from the point of view of the impact on the dynamics of trade changes and the impact of logistics or its components. The study was conducted in the following sequence.

a) The intensity of trade was studied using the initial data of The International Trade Centre (ITC) [118] based on formula 4.

In general, the index of trade intensity is calculated based on the trade of country "i" with its partner "j":

$$I_{ij} = \frac{X_{ij}}{X_I} : \frac{M_j}{(M_w - M_i)} = \frac{X_{ij} \times (M_w - M_i)}{X_i \times M_j}, \qquad (4)$$

where Iij is the index of intensity of bilateral trade flows of country i to country j;

Xi is the total export of country i;

Xij is the export of country i to country j;

Mj is the total volume of imports of country j;

Mi is the total volume of imports of country i;

Mw is the total volume of world imports.

b) The analysis of the logistics performance index (LPI) and its components according to the World Bank data is carried out.

c) the empirical model of the influence of logistics on trade is considered (formula 5); the influence of individual components of logistics on macroeconomic parameters according to formula 6:

$$\boldsymbol{TII_{it} = \alpha X_{it} + \beta LPI_{it} + \varepsilon_{it}} \quad (5)$$

$$\boldsymbol{KP_LPI_{it} = \alpha X_{it} + \varepsilon_{it}} \quad (6)$$

где TII_{it} – index of trade intensity between countries for a certain period of time (t);

X_{it} – dependent variables: export, import, GDP;

LPI_{it} – logistics efficiency index;

KP_LPI_{it} − key parameters of *LPI*;

ε — error.

The intensification of trade flows between Kazakhstan and the EAEU countries is influenced by the level of logistics development and their joint development. The indices of intensity of Kazakhstan's mutual trade with the EAEU countries and foreign trade of the EAEU are more than 1, which indicates the significant importance of the markets of both sides for each other.

Our analysis revealed that logistics efficiency is substantially affected by export activities and related factors, notably infrastructure conditions, workforce competence, and streamlined customs procedures. These findings align with the research of Marti S. [119] and Maswana J. [120]. In order to enhance logistics competitiveness and foster its future development, it is essential to invest in upgrading core components—such as infrastructure quality and specialist expertise—while improving tracking and delivery timeliness, as well as reducing border and trade barriers to facilitate goods movement.

The average Logistics Performance Index (LPI) score for the EAEU countries (2.66) is below the global average, highlighting delays in modernizing and constructing transport infrastructure, reducing customs barriers, organizing deliveries at competitive prices, training personnel and enhancing their qualifications, improving the quality of logistics services, and implementing cargo control systems to ensure timely product delivery [121].

Econometric analysis showed that the growth of foreign trade and the economic growth of the country depend on the direction of trade, the state of logistics and its individual indicators. Improving the LPI components of the countries of Russia, Armenia, Belarus and Kyrgyzstan by 2.5 times leads to the alignment of mutual trade with Kazakhstan. It is necessary to work on improving the quality of infrastructure and training specialists in the field of international logistics and trade, reducing customs restrictions (cost and time of customs clearance). To equalize the trade flow with Kazakhstan, the EAEU countries should increase their logistics costs.

Improving individual logistics indicators leads to an increase in the volume of foreign trade. To achieve greater consolidation and management of the transport and logistics services market, it is necessary to carry out a number of institutional transformations. These measures should be carried out according to the priority of Kazakhstan's trade, primarily with the EAEU countries. At the same time, the analysis of the situation presented in this study showed that in order to increase the volume of bilateral trade between Kazakhstan and the EAEU countries, it is necessary to bring individual components of logistics in line with the intensity of bilateral trade.

It was determined that in the groups of countries under consideration (large countries, the EAEU, the countries of the Caucasus and the Central Asian region), LPI has different effects on trade intensity. In Table 17, countries are grouped with similar LPI indicators and ranked by the level of logistics efficiency from relatively high (large countries) to low (CAR).

Table 17 - The impact of LPI on trade intensity between groups of countries

Exogenous variable, X	Constant coefficient (α) (t -statistics)	Variable coefficient (β) (t -statistics)	Determination coefficient
Trade intensity: major countries	3.29*** (0.008)	-0.066 (0.155)	61.3
Trade intensity: EAEU	2.87*** (0.007)	-0.011** (0.016)	62.5
Trade intensity of European CIS countries	2,73*** (0,004)	-0,010 (0,103)	66,7
Trade intensity: Transcaucasia	2.64*** (0,005)	-0,009 (0.173)	59.7
Trade intensity: CAR	1.79*** (0.026)	0.0205** (0.023)	60.4

*p < 0.10; ** p < 0.05; *** p < 0.01

Source: own research

Increasing trade intensity leads to a mutual increase in LPI. Increasing LPI to constant values of regression coefficients (α) has a positive effect on trade intensity. We found that trade intensity affects LPI (by trade directions) and GDP. Countries with high income levels (large regional countries, CIS countries, EAEU) have higher logistics efficiency, while low-income countries (Transcaucasia and CAR countries) have the worst indicators.

The obtained values of the analysis of the trade intensity index and logistics efficiency in countries show the presence of gaps in the development of logistics and an increase in trade volume. Moreover, the smaller the country in terms of economic potential, the more noticeable this gap is, which is confirmed by this study.

We also managed to determine the impact of various logistics components (infrastructure, customs) on trade and GDP, which means the need for continuous investment in logistics. The data we obtained allow us to diversify investments in logistics and trade based on the size of a country or group of countries, as well as the direction of their trade (export, import), their proximity to a trading partner, and actively support public-private partnerships in logistics and trade, which can contribute to increasing the efficiency of international trade and economic growth.

Based on the research results, the following recommendations are proposed in terms of increasing the efficiency of trade and logistics, increasing their contribution to economic growth and distributing trade flows in the EAEU countries.

1) In the area of political regulation. One of the obvious areas is improving the infrastructure: developing and implementing joint state projects and programs for the EAEU countries in the area of infrastructure and customs, since this is associated with high costs for transport and trade infrastructure.

In this regard, when making important state decisions by the authorities of groups of countries participating in foreign economic activity or supporting in the area of logistics and trade, it is necessary to take a differentiated approach taking into account the direction of bilateral trade and its intensity. High intensity in the direction

of trade flows requires greater activity in investments and in regulating the foreign economic activity of the participants.

2) In the area of supply chain operation and distribution of trade flows. Reducing the cost of international transportation can give impetus to the rapprochement of trading partners located in the neighborhood, optimize the routes of transportation vehicles, build international logistics centers on the borders of the Russian Federation, Kazakhstan and the Republic of Belarus, increase the productivity of employees, and form consolidated batches of products transported in bilateral directions.

For full international "outsourcing" of transport and logistics services using 3PL technology, it is necessary to create an integrated logistics company of the EAEU countries. This measure will allow to significantly expand the range of transport and logistics services at the mega level. This requires a coordinated tariff policy and unitarization of regulatory and technical regulations.

3) Improving Kazakhstan’s attractiveness and supporting the continued growth of its logistics sector can be achieved by improving such components as the quality of infrastructure and the competence of the workforce, monitoring transit goods, ensuring timely deliveries and reducing border and trade barriers. To achieve this, it is necessary to: improve the quality of infrastructure and professionalism of workers, simplify customs procedures, and comply with the terms and conditions of delivery of goods.

Our country, together with the EAEU countries, must strive to improve logistics performance indicators to the level of developed countries. Achieving this goal involves implementing a set of measures to introduce increased requirements for infrastructure modernization, training, improving legal norms, implementing digital technologies and harmonizing national and international standards, as well as applying the best foreign practices in logistics and trade management, taking into account the requirements of national customs and traditions. To improve interaction between countries, it is necessary to create logistics links and alliances, create uniform service standards and improve the quality of transport and logistics services for international trade flows.

As a result of the analysis, factors, environment and conditions influencing the development of logistics infrastructure and the supply chain of products were identified. The main factor constraints include technological, financial, economic, social, epidemiological, and geographical. It is necessary to ensure the efficient functioning of food supply chains with minimal or no intermediaries, due to the close proximity of production and consumers.

There is a need to implement digital e-commerce platforms for SMEs. These companies will be able to manage markets at the local level and respond more quickly to SC disruptions

The study showed that Kazakhstan's high international trade intensity is associated with existing economic ties, huge economic potential and the country's geographical location. High intensity of trade turnover in various directions and low logistics efficiency (below the world average) emphasize the need for dynamic

development of logistics infrastructure, reduction of customs barriers and costs, improvement of the quality of training and service, which will affect greater scalability of transport and logistics and increase their contribution to the economy.

3 PRIORITIES AND ORGANIZATIONAL AND ECONOMIC MECHANISMS FOR THE DEVELOPMENT OF LOGISTICS INFRASTRUCTURE AND AGRI-FOOD SUPPLY CHAINS

3.1 Key directions for the development of logistics infrastructure and agri-food supply chains

An analysis of the logistics infrastructure (LI) in the area of storage, distribution and trade in the country revealed that the joint functioning of the infrastructure elements of the constituent districts and cities is poorly coordinated.

This is explained by the inconsistent development of logistics infrastructures in individual regions, which are unable to independently optimize the functioning of material flows in an integrated format. As a result, the load on individual links in supply chains is reflected unevenly.

The main areas of development of the logistics infrastructure of Kazakhstan in relation to agri-food products (AFP), the interaction of districts and cities with agricultural producers, intermediaries, trade and consumers are the following (Figure 20):

1) Institutional support should include the following tasks:

- Defining national priorities in the field of logistics infrastructure and supply chains: public procurement, pricing mechanism, marketing and information support system, product quality and safety, creation of an information base;
- Developing regulatory and legal requirements for agricultural producers, intermediaries, suppliers;
- Training and education of specialists in logistics and food supply chain management;
- Improving the planning of activities of the agricultural, transport, warehousing and food trade sectors at the macro level and the active use of innovations at the level of logistics enterprises.

2) State regulation of the logistics infrastructure, food supply chains by improving the public procurement system, price regulation of sensitive food markets, especially for low-income groups of the population.

3) Formation of National Logistics Infrastructure**.** This formation involves:

- Establishing and expanding a regional multimodal refrigerated supply chain network for agri-food products.
- Developing digital ecosystems of transport and logistics services for supply chain participants.

4) The formation of logistics systems at various tiers (enterprises, cooperatives, industries, regions, etc.) should consider regional specialization in developing transport and logistics centers (TLCs), as well as the specific characteristics and attributes of goods (cargo) prevalent in the region. Presently, the nation’s terminal and warehousing facilities can, at best, primarily handle cotton, agricultural commodities, foodstuffs, grains, construction materials, chemical products, and consumer or household goods. These facilities will be organized based on respective industry specializations. In our estimation, it is also necessary to develop wholesale and logistics (trade) centers alongside multifunctional TLCs.

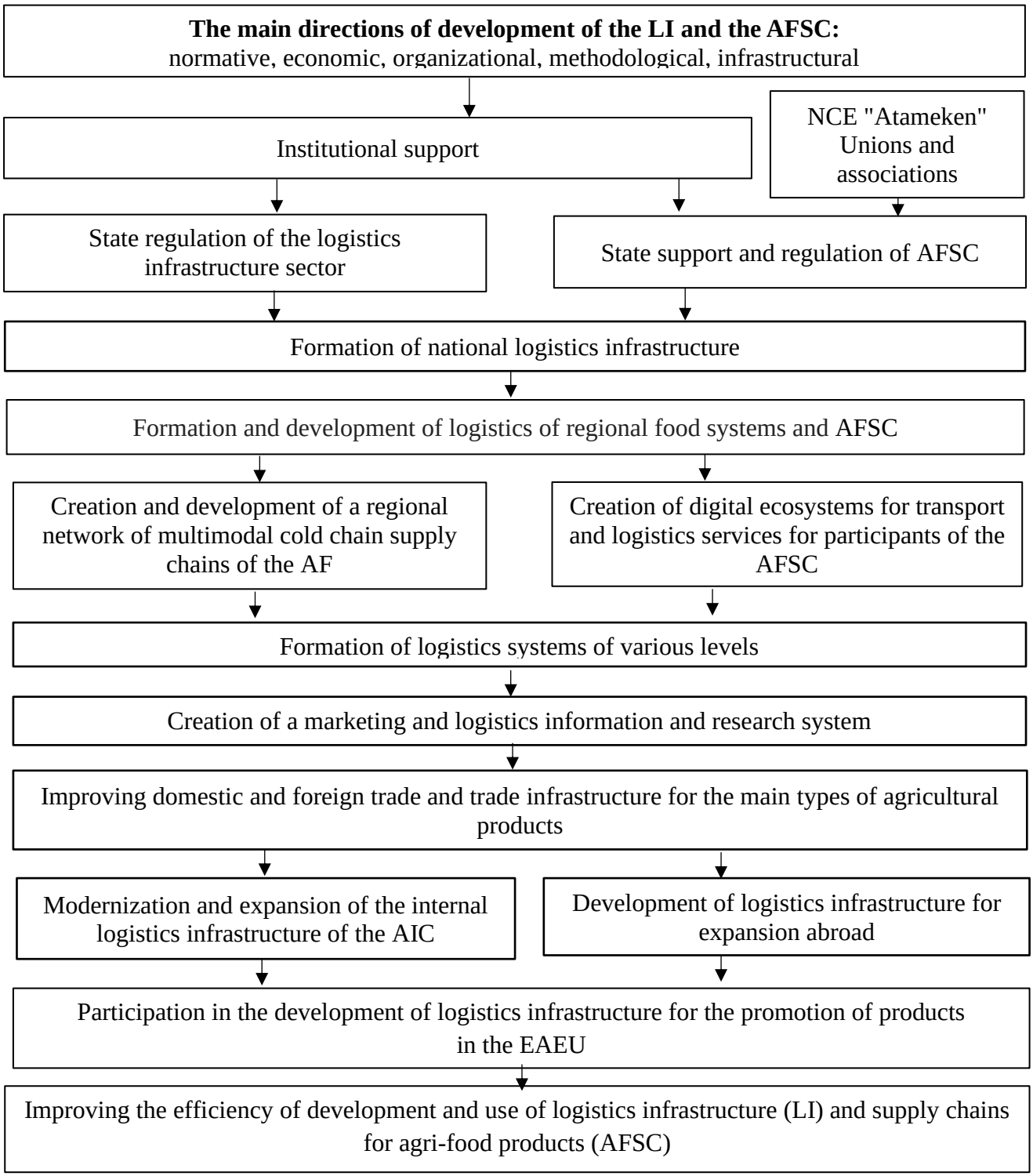


Figure 20 – Main directions of development of logistics infrastructure and supply chains of agro-food products (AFSC) in the Republic of Kazakhstan

Note: compiled by the author

Today, terminal and warehouse facilities in Kazakhstan have a number of shortcomings:

• Technical capabilities and equipment do not meet modern requirements.

• Facilities are not located systematically, often without mutual connections to each other and to transport and information networks.

• They are used mainly for temporary storage of goods.

To solve these problems, the logistics system of Kazakhstan should include a network of TLCs. They will be formed depending on the industry focus. At the same time, in our opinion, it is necessary to develop wholesale and logistics (trade) and multifunctional TLCs.

Based on strategic goals, along with an assessment of current challenges and risks, several priority areas have been identified for the development of logistics in Kazakhstan [122]:

1. Creation and expansion of public TLCs both within the country and in major border transport hubs.
2. Creating LCs for domestic trade, which include WDLCrs.
3. Advancing logistics infrastructure by leveraging customs warehouses, specifically at existing cargo terminals of JSC Kedentransservice within the Republic of Kazakhstan.
4. Creating and developing trade and logistics centers abroad.
5. Reconstruction and expansion of employment at enterprises in various sectors of the economy, including industrial and agro-industrial complexes (AIC).

The development of the logistics system requires an integrated approach, including the modernization of the existing and the creation of new TLCs focused on industry and regional features. This will improve the efficiency of cargo handling and distribution, integrate the transport and logistics infrastructure in creating a supply chain, and ensure the development of regions and the country as a whole.

5) Creation of a system of marketing and logistics information and research.

In order to increase the volume of product sales, it is necessary to conduct comprehensive research. The technologies for studying markets should directly represent a holistic approach, based on the analysis and forecast of trends in the development of world trade, competitive positions of goods taking into account their internal situation, including changes in economic, scientific, technical, demographic, environmental, legislative and other factors. The projected and actual sales volumes, potential needs of wholesale and retail buyers, opportunities and risks are also studied. The result of marketing research is the development of recommendations that should follow from the results obtained, be substantiated and reliable, aimed at solving the problems under study.

To improve the system of marketing information and research in the agricultural sector, it is necessary to carry out organizational and managerial measures, including:

- development of a plan of distribution and incentive measures that allow a business entity to adequately respond to changes in the state of the food market caused by unfavorable conditions; - creation and strengthening of marketing services of all major enterprises and their development to a level corresponding to modern requirements and specifics of their production and sales activities;

- formation of a modern information system and database of research results, including planned sales markets and main types of agricultural products, export potential of agricultural enterprises and processing industries;

- implementation of an effective personnel policy for the selection and training of qualified specialists with knowledge in the field of marketing policy, as well as experience in foreign trade operations.

6) Improving domestic and foreign trade and trade infrastructure for the main types of agricultural products: traditional, exchange, electronic and digital trade

- Modernization and expansion of the logistics infrastructure of the agri-industrial complex. Improving the efficiency of the country's agri-food sector requires the necessary marketing infrastructure, which must meet modern requirements, facilitate the acceleration of goods movement, ensure an uninterrupted supply of products to both the population and a number of sectors of the economy (processing, food, light industry). The formation of the internal marketing infrastructure of the agro-industrial complex implies the simultaneous transformation of the functioning elements of the market infrastructure and the creation of new structures that are fundamentally different from traditional ones; streamlining and deepening the specialization of enterprises and organizations of the marketing infrastructure; diversification of the activities of trade and intermediary, foreign economic and information systems; balanced development of individual elements of the infrastructure.

- The growth of external logistics infrastructure necessitates the establishment of international logistics centers, cargo hubs, “cargo villages,” terminals, and other such facilities.

The expansion of the distribution infrastructure of the food market must be carried out on the basis of a competitive multi-channel system of goods distribution. This requires solving certain problems:

- creation of marketing and logistics centers that ensure the distribution of agricultural products, development of trade and economic relations, formation of a common database of potential suppliers and consumers;

- the development of wholesale distribution systems, for example, by building a wholesale distribution center;

To expand the possibilities for the sale of agricultural and processed products, work will be carried out in two directions [21].

The first is the creation of a network of wholesale distribution centers for the formation of large consignments of food and their distribution to the domestic market and export.

The second is the creation of an electronic trading system for agricultural products. In the era of digitalization, effective sales of agricultural products can be carried out using digital technologies. The task is complicated by the fact that the WDC unites not just one product group, but all fresh products – meat, dairy products, fruits and vegetables and fish. WDCs are designed to unite the interests of dozens of companies on one platform, which would gain access to centralized infrastructure, processing, packaging, storage and marketing capacities for agricultural products. However, small farms and farmers doubt that they will have equal opportunities with large agricultural holdings [123].

In international practice, such projects were implemented mainly by the state. In Kazakhstan, this task will be transferred to private capital with budget support based on the PPP mechanism.

The implementation of this project can solve many problems at the state level, but at the same time new problems will arise, such as the problem of attracting large companies to the implementation of the construction of the ORC. Since we are talking about 10 billion tenge with a payback period of the project (with state subsidies) of about 10 years. Small companies will not be able to financially implement such a project.

It is envisaged that introducing wholesale distribution centers (WDCs) will not dismantle the current market framework but instead will refine it by minimizing intermediary markups, ultimately lowering product prices as wholesale margins decrease, thereby boosting the consumption of fresh food products.

The wholesale distribution centers will work directly with manufacturers and provide their services to market participants, which includes:

- formation of networks of small wholesale markets, which could become platforms for promotion of goods by small enterprises, primarily agricultural ones;
- increasing the efficiency of functioning of branded trading organizations, as well as production and trade networks directly related to agricultural producers and processing enterprises;
- formation of an integrated system of marketing information and research, allowing to forecast the market situation and plan the development of appropriate marketing measures in order to ensure the efficiency of agricultural enterprises;
- creation of a specialized state structure for regulation of the agricultural market;
- approximation of the domestic system of quality control, regulations and standardization to European and world standards.

7) Participation in the development of logistics infrastructure for promotion of products within the EAEU.

Enhancing Kazakhstan’s future attractiveness and further developing its logistics sector should be undertaken by improving infrastructure quality, enhancing the competence of specialists, controlling cargo flow, ensuring timely deliveries, and reducing both border and trade barriers. Achieving this goal requires implementing a set of measures to introduce increased requirements for infrastructure modernization, training, improving legal norms, implementing digital technologies and harmonizing national and international standards, as well as applying the best foreign practices in logistics and trade management, taking into account the requirements of national customs and traditions. To improve interaction between countries, it is necessary to create logistics links and alliances, create uniform service standards and improve the quality of transport and logistics services for international trade flows.

To expand bilateral trade volumes between Kazakhstan and other countries within the EAEU (Eurasian Economic Union), it is crucial to align specific logistics elements with the trade intensity among participating nations. The following measures are thus prioritized:

- Develop and implement joint state projects by the EAEU countries in the field of infrastructure and customs, as this is associated with high costs of transport and trade infrastructure.

- LPI components (training, infrastructure modernization, international transportation) should be transferred to the management of the private sector, where logistics activities are carried out more effectively. Perhaps, by creating joint private companies or a public-private partnership mechanism.

- Digitalize the sphere of foreign trade, transport and logistics, create a single ecosystem of digital transport corridors in the EAEU countries.

- It is necessary to strive for harmonization, perhaps even joint planning of logistics and international trade processes in order to increase efficiency indicators to the level of logistics in developed countries.

- Reduce customs barriers by transferring the interaction of participants in foreign economic activity with customs and other regulatory government agencies to a digital format.

-Increasing the level of professional training for the logistics sector's workforce, restructuring the EAEU countries' logistics systems, and integrating them into a Eurasian logistics system.

-Transitioning toward a comprehensive suite of logistics services, delivering full "outsourcing" of transport and logistics functions in the international market. Achieving this goal could involve establishing a unified logistics company among EAEU countries to broaden transport and logistics service offerings, capitalizing on third-party logistics (3PL) technologies.

- Improving the regulatory framework among the involved countries, prioritizing mutual trade in key areas such as interstate intermodal transportation, standardized documentation, and the creation of unified, transparent tariffs for cargo transport and information services, all supported by a unified document flow.

- Implement a coordinated tariff policy and the unification of regulatory and technical regulations (rules for the transportation of various types of cargo, parameters of the rolling stock used, environmental standards, etc.).

8) Improving the efficiency of development and use of logistics infrastructure and supply chains of the APP involves:

- Development of cold chain infrastructure for perishable goods (discussed in Chapter 2.1).

- Optimal placement and efficient operation of trade and sales infrastructure (discussed in Chapter 2.2).

- Improving individual logistics indicators depending on the intensity of storage, distribution and trade.

- Institutional reforms should increase integration and sector oversight, promoting accessibility and security in the market for transport and logistics services.

- Use of technological advances in logistics and digital technologies in the logistics infrastructure and food supply chains.

- Improving food supply chains.

Ensuring a balanced domestic market and building export capacity demands upgrades to production and marketing practices, particularly:

- Focusing the development strategy on shorter distribution channels to expedite movement of goods, given the limited shelf life of certain products and the complexity of transportation.
- Expanding infrastructure that underpins the distribution system.
- Establishing distribution (logistics) centers proximate to both production and consumption sites.

Addressing specific food markets also entails additional measures for refining distribution systems:

- The milk and dairy market should evolve innovatively, supported by modern infrastructure that enhances product quality and expands product range. Such a market relies on enduring and dependable contractual relationships throughout the supply chain—linking whole milk production, rural producers, and processors to the ultimate consumer.
- Upgrading the sugar, vegetable oil, and other food product markets involves building necessary infrastructure, principally wholesale markets and distribution centers. This makes these markets more transparent, reduces intermediaries, and ultimately drives down retail prices.
- Potato market development is determined by innovative advances in the industry. A large proportion of potato output (65–70%) should undergo processing, delivering high-quality finished goods and semi-finished products to domestic and international consumers.

One of the important ways to promote domestic goods to international markets is the formation of logistics systems of various levels. Such systems aim to optimize product movement and sales mechanisms, grounded in thoughtful planning and management of implementation processes in target countries, as well as directing merchandise, service, and information flows. To further elevate the role of logistics and maximize its utility, it is necessary to enact suitable legislation, train highly skilled professionals in the field, and establish a National Information and Analytical Center.

Mechanisms guiding the establishment and functioning of distribution networks abroad for product exports should encompass regulatory, economic, and organizational measures. First, it is necessary to study the product market, the ways of selling products in a specific region, since the results of the country's foreign economic activity depend on a constant analysis of the external marketing environment, including the specifics of legislation, international rules, the socio-cultural environment, etc. [124].

Inclusive business models, such as agricultural contracting and blockchain technologies, can help to better integrate into modern and more complex production and supply chains. Blockchain technology improves the following areas in the agricultural sector:

a) optimization of the food supply chain - reduction of the time for tracking the origin;

b) crop insurance, by monitoring cargo, route details, compliance, and product quality, as well as pricing, locations, and stakeholders involved.

c)transactions, by lowering transaction costs, enabling smaller enterprises to participate in the market.

d) traceability, by accelerating and simplifying risk insurance through smart contracts.

For systemic digitalization of agriculture in the Republic of Kazakhstan, the Qoldau.kz web portal has been established, offering a wide array of resources and services for agricultural producers. These include electronic applications for subsidies and state support, digital mapping of agro-industrial entities, electronic pasture management and usage plans, satellite-based land and infrastructure monitoring, an electronic registry for breeding achievements in crop and livestock farming.

The goal of the E-APC Program is to digitalize business processes to increase labor productivity and export processed agricultural products by 2.5 times. Levels of digitalization of the agro-industrial complex:

1. basic, where it is quite possible to use electronic field maps and soil analysis;

2. advanced with partially automated farms. Fuel consumption sensors, GPS trackers, weather stations, etc. are used here;

3. digital farms operating due to new tools and technologies.

There are already more than 20 digital farms and about 170 advanced ones operating in the Republic of Kazakhstan. After the completion of the digitalization process of the agro-industrial complex, at least 20 more digital and 4,000 advanced farms are expected to appear in the country [125].

Thus, the priority areas for the development of marketing infrastructure in the national agro-industrial complex should be:

- Supporting and constructing new storage facilities to guarantee extended and high-quality preservation of agricultural products; involving agricultural enterprises in trade and procurement interventions in the agro-industrial market through authorized organizations and tenders for state food needs.
- Further developing exchange-based trading, including the widespread use of forward and futures contracts.
- Widespread use in business practice of the mechanism of double warehouse receipts, which allow to smooth out seasonal fluctuations in prices for agricultural products.
- Expanding wholesale food markets and facilitating direct engagement between producers and consumers.
- Further digitizing the agricultural market to equip enterprises with current data on the food market’s conditions, both domestically and internationally.
- Development of the export potential of the republic and optimal access of agricultural products to the foreign market.

Thus, the main directions of development of the logistics infrastructure and supply chains of agricultural products should be:

- Institutional support,
- State regulation of the logistics infrastructure sphere. - Formation of national logistics infrastructure,
- Formation of logistics systems of various levels,
- Creation of a system of marketing and logistics information and research.

- Improvement of domestic and foreign trade and trade infrastructure of the main types of agricultural products,

- Participation in the development of logistics infrastructure for the promotion of products within the EAEU,

- Increasing the efficiency of development and use of logistics infrastructure and supply chains of the APP.

3.2. Development of a model and organizational and economic mechanism for the development of efficient supply chains (based on DCs and WDCs)

It is advisable to carry out the process of forming and developing the distribution infrastructure in stages. Development strategies and programs in Kazakhstan should include elements related to the growth of wholesale trade and logistics infrastructure.

State, industry and regional programs and strategies for the development of the infrastructure of the distribution system must provide for the solution of a number of strategic tasks, namely:

• creation of regional (interregional) logistics centers - providing warehousing, storage (in compliance with the required humidity and temperature conditions) and picking orders for products for other regions;

• development of a regulatory framework that sets priorities for local producers, which will allow them to effectively compete with foreign manufacturers.

Development of a regulatory framework that establishes priorities for local product manufacturers, thus enabling them to compete effectively against imported goods.

The following activities involve the creation of a single information space in the regions, allowing for the exchange of regulatory, reference and current data with manufacturers of products, both within the district and on an interregional scale.

The study collected information about economic entities that trade in the country's territories, as well as about economic entities that supply products (except for manufacturers) in these areas and their facilities.

The information obtained made it possible to identify problem areas in order to create a uniform distribution of retail facilities. As a result of the study, stages of development of the logistics infrastructure of the food distribution network of Kazakhstan were developed, which are presented in Table 18.

The development and formation of modern logistics centers in the regions should become one of the main areas of development of the food market due to the creation of infrastructure in the coming years.

A comprehensive package of organizational and economic measures should be developed through a public–private partnership platform, integrating the latest advances in information technology and international best practices.

Table 18 - Development of logistics infrastructure and supply chains of agri-food products in Kazakhstan

Necessary functionality	Development priorities
At the first stage of the formation of new types of wholesale trade and distribution organizations	
Distribution centers; wholesale-retail associations; stores - warehouses; logistics centers; wholesale food markets	Evaluation of existing retail facilities; modernization of existing ones, restoration of non-working ones; construction of new sites, use of the latest technology; development of an IT communications system and an algorithm for coordination between local/central authorities
At the second stage of development of the logistics services market	
Determination of economic growth indicators for wholesale organizations, implementation of a rating system based on an integrated indicator, which takes into account the number of clients served and the quality of services provided	Increase in consumer demand and trade turnover; sustainable growth of regional export-import operations; expansion of transit cargo flows; attraction of foreign retail chains and transnational food companies, expansion of sales markets
At the third stage of interaction between trade enterprises and producers, local governments	
Creation of a single database; automated planning of production and delivery of products; control over the execution of decisions	Automated data collection and processing; software standardization; Automated adjustment of planned indicators based on actual results, incentive mechanisms for PPP participants
At the fourth stage of development of warehouse infrastructure	
Construction of modern warehouses that meet the objectives of building and enhancing transport and logistics infrastructure	Inspection of existing warehouse facilities, Designing a unified construction plan with designated land plots, Aligning warehouse construction planning with existing infrastructure initiatives, Emphasizing the development of Class “A” and “B” warehouses, modernizing current warehouses to Class “B”, Creating a holistic support program for new projects, granting investors a complete package of assistance (e.g., land plots without bidding, tax incentives, investment loans)
At the fifth stage of development of vegetable and potato storage facilities	
Modernizing existing and building new storage facilities in proximity to production and consumption locations using PPP mechanisms	Creating a comprehensive support program for new projects, offering investors a full suite of assistance, from land allocation (without bidding) to tax benefits and investment loans
At the sixth stage of organizing an integrated information and analytical system (IS)	
Establishing a unified regional logistics information system Generating specialized development plans for each locality	Enacting regulatory measures that encourage the use of IS, Offering remote training for both wholesale business managers and line staff on information logistics, Standardizing equipment and software to support the logistics information system
At the seventh stage of digitalization of food markets	
Providing access to digital platforms and automating business processes	Implementing digital technologies and blockchain solutions for product sales and distribution, Ensuring traceability and control over product movements

Note: Compiled by the author

Currently, Kazakhstan is engaged in a project to construct a wholesale distribution center (WDC) and develop a logistics hub associated with upgrading the transport infrastructure.

The main principle of selecting projects is to create favorable conditions for attracting representatives of small and medium-sized businesses that will attract investment, assist in creating additional jobs, and reduce the burden on the budget.

According to international and domestic experience in the field of infrastructure development, it is possible to propose using the following groups of instruments:

1. construction of infrastructure facilities financed by the state,

2. use of PPP mechanisms along with various incentives,

3. creation of the necessary administrative conditions for attracting private capital for the development of logistics infrastructure.

Measures related to the first category—state-financed infrastructure construction—impose the highest costs on the government budget.

The European model of regional development is based on state participation and effective projects for the construction of logistics infrastructure.

Within the framework of regional development programs, the range of functions performed by RLCs allows them to be considered both as national transport and logistics hubs, but also as a framework that integrates the transportation process, rolling stock and infrastructure into a single transport system both at the national level and, in the future, for international markets.

In this regard, it is crucial to consider European experiences, particularly those of the EU, in forming similar models. The contemporary European model for building logistics centers exhibits specific features, most notably robust state backing at all levels grounded in federal and local legislation. For example, in Germany, the federal budget partly funds investments through Deutsche Bahn AG, complemented by the frequent allocation of subsidies to regional budgets, along with targeted subsidies and loans for designated investments. Financial support for investments in logistics centers is provided by both federal states and local governments.

Figure 21 shows the optimization of product distribution taking into account the functioning of a regional logistics center.

Developing a network of logistics centers across Kazakhstan—and creating regional logistics transport and distribution systems on that foundation—should be an integral component of broader interstate or regional transport policies, playing a pivotal role in strengthening transport infrastructure, streamlining transport and economic relationships, and optimizing the overarching cargo and goods movement system [16].

Naturally, the construction of terminal facilities cannot proceed without the knowledge and approval of local authorities. In many instances, regional administrations (akimats) recognize the significance of cohesive terminal system development in their respective regions and aspire to coordinate and guide this process, rather than remain mere observers.

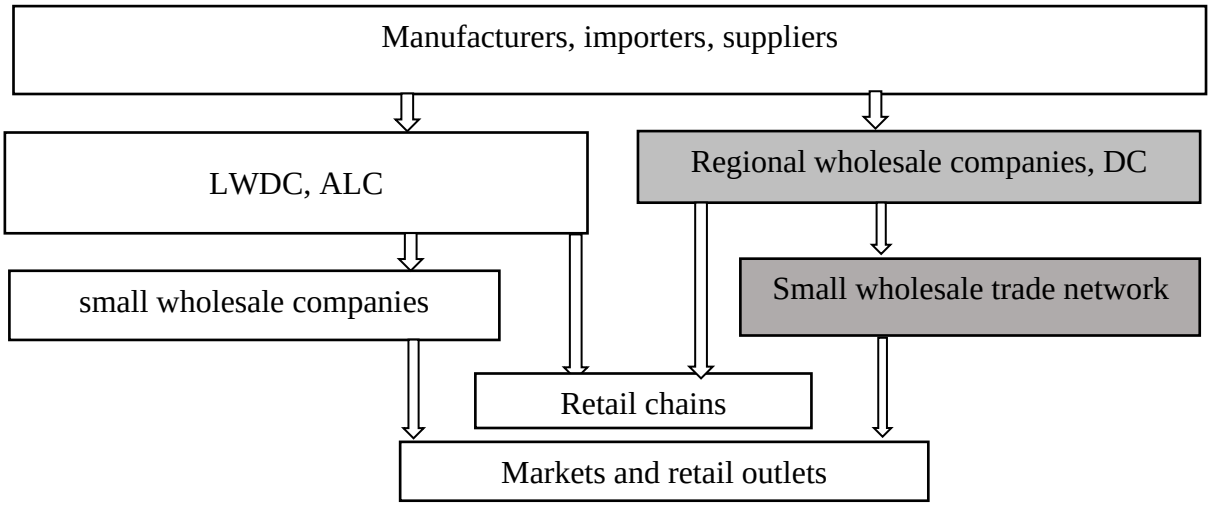


Figure 21 - Optimization of distribution of agricultural products taking into account the functioning of a regional logistics wholesale distribution center

Note: developed by the author

Key Areas for the Advancement of Logistics Infrastructure in Kazakhstan include:

- Targeted lending at 5-7% rates
- Provision of guarantees to second-tier banks to secure loans.
- Subsidizing interest rates on existing loans for logistics-related construction.
- Allocating land plots under preferential terms for building logistics infrastructure.
- Connecting utilities and communications to the construction sites.
- Implementing innovative forms of state-business collaboration, such as extensive use of PPP frameworks and risk-oriented approaches.

All of the above measures will increase the investment attractiveness of the creation of logistics centers, will allow the territory to be put on a trajectory of sustainable growth. The experience gained in the creation of modern infrastructure will make it possible to assess the economic (material, financial, time) advantages in the further planning of new facilities.

According to independent experts, the most effective mechanisms for accelerated development of trade infrastructure are those primarily related to long-term financing:

- provision, if possible, of certain benefits for loans for construction of trade facilities and distribution infrastructure;

- government guarantees for loans provided to the trade sector and organizations that form distribution infrastructure;

- a public-private partnership, within the structure of which the government allocates land for a distribution facility and invests financial resources in the construction of necessary and sufficient communications.

When implementing the above programs, a number of constructive measures should be taken:

- provision of a "one-stop shop" mechanism in order to reduce the time it takes entrepreneurs to organize the search for real estate, prepare documents for entrepreneurial activity;

- financial support for small and medium-sized businesses by providing state financing for part of the costs of developing organizational documentation, providing organizations with the opportunity to purchase vehicles, warehouse and commercial equipment, technical devices for various purposes under a leasing agreement;

- support in acquiring property, in renting premises that meet modern requirements for quality, technology and functionality, with the possibility of providing certain benefits when purchasing and further operating retail and auxiliary premises;

- providing an effective system of information support for entrepreneurial activity, in particular, trade, through training events in the field of financial literacy for companies starting and already operating in the personnel market (conferences, participation in the media, round tables).

Measures that include state financing, for example, the creation of infrastructure, its construction at the expense of the state, are the most expensive for the state budget. In the current economic conditions, it is not possible to increase funding for the construction of infrastructure facilities through state financing.

Next in terms of the financial burden on the state budget are the principles of PPP. Currently, these measures are actively taken in Kazakhstan in the process of economic development when creating special economic zones, where the state builds various communication facilities, and also provides tax benefits to investors.

For this purpose, in order to optimize the process of state participation in the development of retail trade in sparsely populated and remote areas, it is necessary to classify regions by the degree of economic interest of investors in retail companies.

These efforts can be categorized into three types of territories:

1. Attractive for trade investors, where retail outlet owners can derive dividends from capital investments by opening new stores.

2. Moderately Attractive, where companies may secure limited excess profits but cannot realize full returns on invested capital.

3. Unattractive for investment, where owners of retail outlets can only achieve break-even results without government support.

The regions that are considered attractive, the most advanced in terms of the development of distribution infrastructure, have the opportunity to receive fairly high incomes, due to the high number and density of population in the territory.

From an economic point of view, some regions of the country are attractive enough for retail organizations that they do not require additional trade development measures from the government, other than those included in the overall regional development strategy.

In regions whose trade growth prospects are more moderate, even well-developed distribution infrastructure, mid-range per capita incomes, and medium-to-high population size and density may necessitate supplementary actions to achieve minimal profitability levels. Instruments such as tax exemptions, bulk purchase discounts, lower freight tariffs, or obligations for allocating retail space through

tender processes can contribute to profitability. Urban planning documentation may impose specific guidelines on retail space allocation, consistent with each territory's socio-economic development strategy. As a result, local authorities select the most appropriate approach—among the three described above—to implement development programs and planning initiatives.

For territories that are not attractive for business, the state should organize the supply of goods or grant direct powers to trading companies to organize and deliver consumer goods to territories of this type.

Implementing these strategies effectively calls for each **region** to have a clearly defined "regional passport," describing various local features and facilities that characterize the corresponding type of territory. In order to determine the optimal instrument of state influence on the development of retail trade in sparsely populated and remote territories, it is proposed to classify regions by two parameters: population density and per capita income of the population (Table 19).

Table 19 - Income and population density in Kazakhstan, June 1, 2024

Regions	Average per capita nominal monetary income of the population, tenge	Area, sq. km	Density, persons/sq.km
Republic of Kazakhstan	194971	2725000	7,3
Abai	173569	185500	3,3
Akmola	174116	146219	5,3
Aktobe	174470	300629	3,1
Almaty	139088	223911	6,8
Atyrau	362866	118631	5,9
West Kazakhstan	198658	151339	4,6
Zhambyl	134849	144264	8,4
Zhetysu	129531	118000	5,9
Karaganda	212647	239100	4,7
Kostanay	184505	196001	4,2
Kyzylorda	137954	226019	3,7
Mangistau	235295	165642	4,7
Pavlodar	207646	124755	6,0
North Kazakhstan	166277	97993	5,3
Turkestan	109628	117249	18,3
Ulytau	260814	188936	1,2
East Kazakhstan	211317	97800	7,4
Astana	264259	722	2028,2
Almaty	287213	682	3304,2
Shymkent	121994	1170	1057,2
Source: [79]			

Low density and incomes below the national average are found in most regions and cities in the southern, western and northern regions of Kazakhstan, which must be taken into account when financing within the framework of the regional development program.

The implementation of the program of state support and financing for the development of an effective commodity distribution system includes the creation of a logistics organization with full or partial state management, which will provide the following benefits for participants in commodity distribution channels for manufacturers in the republic:

- increase the degree of market prospects for small and medium-sized manufacturers and provide them with more favorable conditions from trade organizations;

- entry into new areas and commodity distribution chains (including approaching the requirements of large retail companies in terms of rhythm and volume of deliveries, quality compliance, and the presence of labeling);

- reduce the risk associated with the activities of small manufacturers and, as a result, reduce the level of financial burden for these organizations.

For regional wholesale and retail enterprises, the following benefits become feasible:

- Favorable procurement conditions from suppliers, both through economies of scale and preferential terms from national development programs.
- Reduction of intermediary links and direct purchasing from manufacturers.
- Establishment of efficient distribution systems that reduce per-unit costs, including the construction of warehouses.
- Creation and promotion of a unified regional brand, consistent with the local development strategy, capable of competing against major retail chains.
- Implementation of modern IT systems that are too expensive for one small or medium-sized enterprise.
- Reduction of risks associated with the business of small and medium-sized trading companies and, consequently, reduction of the cost of financial resources for these enterprises.

The established experience of trade functioning describes various forms of participation of management bodies in the process of promoting goods. Among others, one of the more effective solutions is the creation of a consortium with the participation of local executive control.

In the case of introducing this form of management with the participation of a logistics consortium in the regions, such an association can include local regulatory authorities, existing wholesale trade organizations, facilities selling products at retail, transport companies, banks, insurance companies, etc. The purpose of the logistics consortium is to support and develop retail trade, small businesses in sparsely populated areas. The main task is to form a commodity distribution system for this region. The mechanism of operation is through the formation of a support program subject to a preferential development policy, as well as financial participation in the formation and development of wholesale and small wholesale trade facilities.

Figure 22 shows a modernized form of product deliveries in regions with low density and sparse population, taking into account the organization of the logistics consortium. Registration of organizations in the activities of the consortium can be implemented by direct participation in the formation of the organization by these or other companies as co-founders.

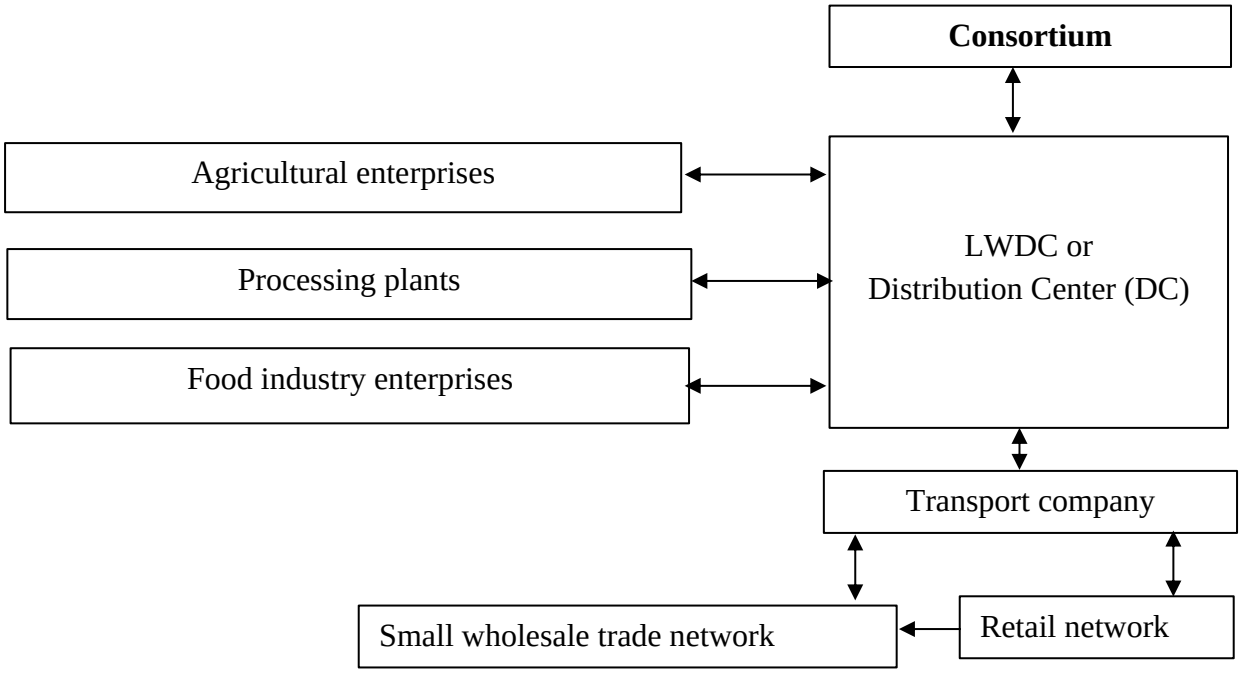


Figure 22 - Form of goods supply within regions of Kazakhstan

Note: developed by the author

This form of interaction takes place in accordance with the conclusion of a cooperation agreement and involves the following work: development of a basis for joint marketing programs; training of highly qualified staff; promotion of products to other regional commodity markets (interregional scale); coordination of advertising activities; organization and integration of transportation and warehousing of goods; implementation of redistribution and maneuvering of goods flows.

In order to coordinate the actions of partners, unified information centers can be created to ensure information integration.

World practice confirms the advantages of distributing goods through distribution logistics systems based on a distribution center. In this case, savings are achieved by reducing the volume of goods in a warehouse outside the consumer and by transport costs through the implementation of a large batch of goods delivered.

When establishing a regional distribution center, several primary organizational, economic, and technical challenges must be addressed:

1. Equipping retail outlets with the necessary technology.
2. Achieving comprehensive customer service.
3. Incorporating additional transportation services.
4. Optimizing settlement structures within the distribution logistics system.
5. Optimizing the workload of transport and logistics infrastructures;
6. Reducing the time of goods in transit by reducing downtime at junctions, as well as using more advanced vehicles and transport equipment.

In the structure of the regional distribution center, it is proposed to create a distribution center, which is divided into five main subsystems, which practically correspond to five departments of the system: regional service department, external

communications department, transport department, warehouse and final analytical department.

Creation and management of information flows will be delegated in the distribution center system to the external communications department, the regional service department - to the final analytical department.

Maintenance of material flows is performed by transport and warehouse subsystems.

Centralized organization can be assigned to a management company included in the work or attracted, having the ability to implement the entire range of infrastructure support. Involved organizations can assume the functions of centralizing planning, coordination and regulation of the process of goods movement.

When choosing a management company, it is advisable to find a supplier who is ready to discuss the needs of the organization's clients, along with their own needs. It is necessary to establish standards for key performance parameters. Professional suppliers can support several quality improvement programs and, in practice, include their implementation in the contract. They should be ready to discuss agreements on the basis of profit sharing in case of excess profits, and ready to pay a fine if they cannot solve the problem.

When creating a consortium, it is necessary to organize the work of a distribution center, as well as a small wholesale trade division with their placement in the regions. It is likely to organize the work of small wholesale centers trading on the principle of cach & carry.

In the course of working with retail operators, it is proposed to use the following type of customer groups:

- retail enterprises,
- wholesale customers - kiosks, pharmacies, gas stations;
- hotel and restaurant business - hotels, restaurants, cafes.

The primary task remains to determine the geography of the distribution of the influence of state support and financing, including by choosing the location of the structural units of the logistics consortium. In the regions that are most attractive for doing business, it is proposed to create a program for the development of trade infrastructure based on state financing.

In moderately attractive regions, forming or repurposing entities into small-scale wholesale centers operating under the “cash and carry” principle is also proposed. As a result, the structure of the logistics system will be characterized by a rational construction of the links of the logistics chain and an optimal organization of the center itself. In accordance with the peculiarity of the geographical location of the regions, it is advisable to place the distribution center in regional centers, since they have a more developed wholesale trade infrastructure.

Regional wholesale distribution centers of food products

A wholesale distribution center (WDC) can take various forms, depending on the entity initiating the project. The legal framework largely depends on the organizational and legal forms of businesses participating in the WDC, along with the intensity of trade turnover. In areas where small businesses predominate among

WDC participants, establishing an agricultural consumer cooperative may be a suitable option.

Such cooperatives may focus on marketing, processing, supplying, and servicing small businesses (i.e., cooperative members). A WDC of this nature could face obstacles including a lack of project champions, insufficient initial capital, scarcity of land parcels for the center, and difficulty in attracting qualified personnel. One feasible approach is to base a consumer cooperative at an existing processing enterprise, small production unit, or warehouse facility, subsequently expanding to provide the full range of services. Alternatively, depending on geographical circumstances, cooperative WDCs may lease local warehouses and outsource processing activities to nearby food industry facilities. Nonetheless, creating such a cooperative requires substantial financial investment, which small enterprises often lack. Government assistance, involving financial support mechanisms, becomes essential for forming a cooperative-based WDC, thereby necessitating clear guidelines on how to subsidize such structures.

According to the State Program for the Development of the Agro-Industrial Complex of the Republic of Kazakhstan for 2017 - 2021, the expansion of opportunities for the sale of agricultural and processed products will be carried out in two directions.

The first is the creation of a wholesale distribution center for the formation of large consignments of food and their distribution to the domestic market and export.

The second is the creation of an electronic trading system for agricultural products. An example of the implementation of digital technologies can be the creation of an electronic platform for trading agricultural products, which will overcome geographical limitations, reduce the costs of maintaining retail space, etc.

In addition, to solve the problem of the shortage of transportation capacities when exporting grain crops and processed products, it is planned to develop a logistics map of the agro-industrial complex and action plans for the construction of terminals, transshipment warehouses, and the renewal of a specialized fleet of equipment.

The existing program should have included an item for subsidizing the costs of building a wholesale distribution center.

In regions with consistently robust demand and supply, WDCs may be founded by development companies if local investment conditions are attractive. These firms handle design, land acquisition, construction, utility deployment, center management, and related operational tasks. However, challenges arise when such development companies set service fees at levels that may be deemed excessive, raising the possibility of government intervention to compensate agricultural producers who rely on the center.

Facilitating the entry of development companies requires establishing a favorable investment climate at the regional level. This may involve providing long-term land leases under preferential conditions, with the option to purchase for the WDC; zero property tax rates for up to seven years; reduced income tax rates for up to eight years; preferential land tax regimes; and assistance in persuading producers to collaborate with the WDC.

In other circumstances, large companies in the sale or processing of agricultural products could establish WDCs. When such enterprises already possess infrastructure and land resources, constructing a new WDC is more straightforward, but requires acknowledgment of existing business constraints for agricultural producers.

Core Functions of a Wholesale Distribution Center

Based on WDC objectives, its primary functions should align with the principle of delivering comprehensive services in a single location:

1. Procurement – purchasing agricultural products.
2. Warehousing – leasing warehouse space; handling acceptance, loading/unloading, and secure storage of farm products.
3. Processing – pre-sale product preparation; processing of agricultural goods (e.g., manufacturing semi-finished and finished products, packaging).
4. Servicing – ensuring agricultural producers can acquire essential goods; providing veterinary and phytosanitary inspection; offering financial services (credit, insurance); and maintaining vehicle parking and servicing.
5. Transport – managing documentation; cargo escort; monitoring cargo movement; planning transport operations.
6. Marketing – selling agricultural goods (maintaining databases of suppliers and buyers); leasing retail space; delivering market information; overseeing turnover management; selling agricultural goods.
7. Social – organizing public canteens; preparing ready-to-eat meals for social institutions; providing public catering (cafés, snack bars); offering lodging services.

The wholesale distribution center model should absorb the best international experience in organizing wholesale markets for agricultural products (Rungis, Mercabarna, Corbas, etc.), which has been deeply revised taking into account the specifics of Kazakhstan's commodity distribution chains (Figure 23).

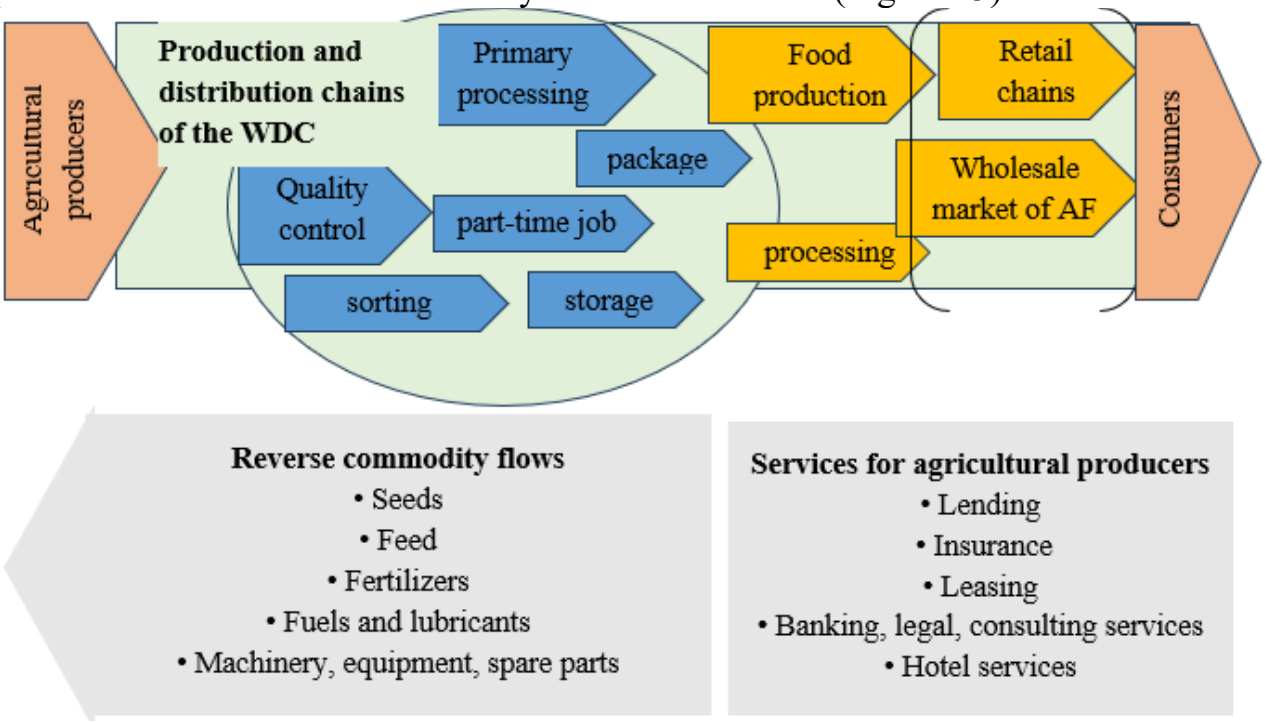


Figure 23 – Model of a wholesale distribution center

Note: developed by the author

Distinctive features of the model:

• Quality and compliance management, traceability;

• Multichannel distribution organization due to a combination of “Push” and “Pull” distribution models;

• Organization of a social nutrition system;

• Offline auctions of agricultural products;

• Fresh logistics (with controlled quality control).

In Kazakhstan, the **construction of major WDCs** and their integration into a national network is initiated by the state, with the Ministry of Trade and Integration as the supervisory authority. Local governments should facilitate land allocation, utility and transport infrastructure, and deliver tax incentives during WDC construction. Regardless of organizational structure, it is essential to plan for state support—such as subsidized interest rates on investment loans, short-term financing for agricultural processing, and partial reimbursement of WDC construction costs.

In Kazakhstan, the construction of major WDCs and their integration into a national network is initiated by the state, with the Ministry of Trade and Integration as the supervisory authority. Their plans included the construction of 24 WDCs. The main concept of including WDCs into the national network is to unite them under a single management structure with a common information system. This will allow them to operate on the basis of uniform standards and rules, use a single information space, and enable the state to monitor food resources and prices, and organize government procurement of agricultural products.

Local governments should facilitate land allocation, utility and transport infrastructure, and deliver tax incentives during WDC construction. Regardless of organizational structure, it is essential to plan for state support—such as subsidized interest rates on investment loans, short-term financing for agricultural processing, and partial reimbursement of WDC construction costs.

The effectiveness of the WRC depends on the relationship scheme formed between the organizers of the project. To establish a large WDC that will eventually become part of a nationwide network and significantly affect agricultural markets, close collaboration with government bodies is recommended. This joint effort is instrumental for implementing such large-scale projects and sustaining their long-term operations. Where the WDC takes the form of a consumer cooperative, small business entities bear the primary responsibility in both its establishment and activities.

Economic relationships between agricultural producers and the WDC are defined by contractual agreements. When purchasing farm products, either standard purchase-sale contracts or financing contracts tied to monetary claims (factoring) may be used. In case of factoring when delivering products by an agricultural producer to the WRC, the latter receives a short-term loan from the bank to pay the advance. After the sale of the products, the WRC settles with the producer in full minus the advance paid. In case of receiving a large order from processing enterprises for the supply of agricultural raw materials, subcontracting agreements may be concluded with the producers. Contracts related to the performance of specific tasks—such as freight or forwarding services—can be concluded with the transport

firms and processing companies participating in the WDC. The WRC sells its products in accordance with the commission agreement. In case of leasing premises and equipment by agricultural producers, the WRC must conclude a lease agreement or a trust agreement for the property.

Prices for goods sold via the WDC adhere to ex-warehouse terms, making the WDC more appealing to agricultural product buyers, as cargo shipping and loading/unloading costs fall under the center's expenses. Purchase prices for agricultural goods account for production cost and standard profitability sufficient to enable expanded reproduction.

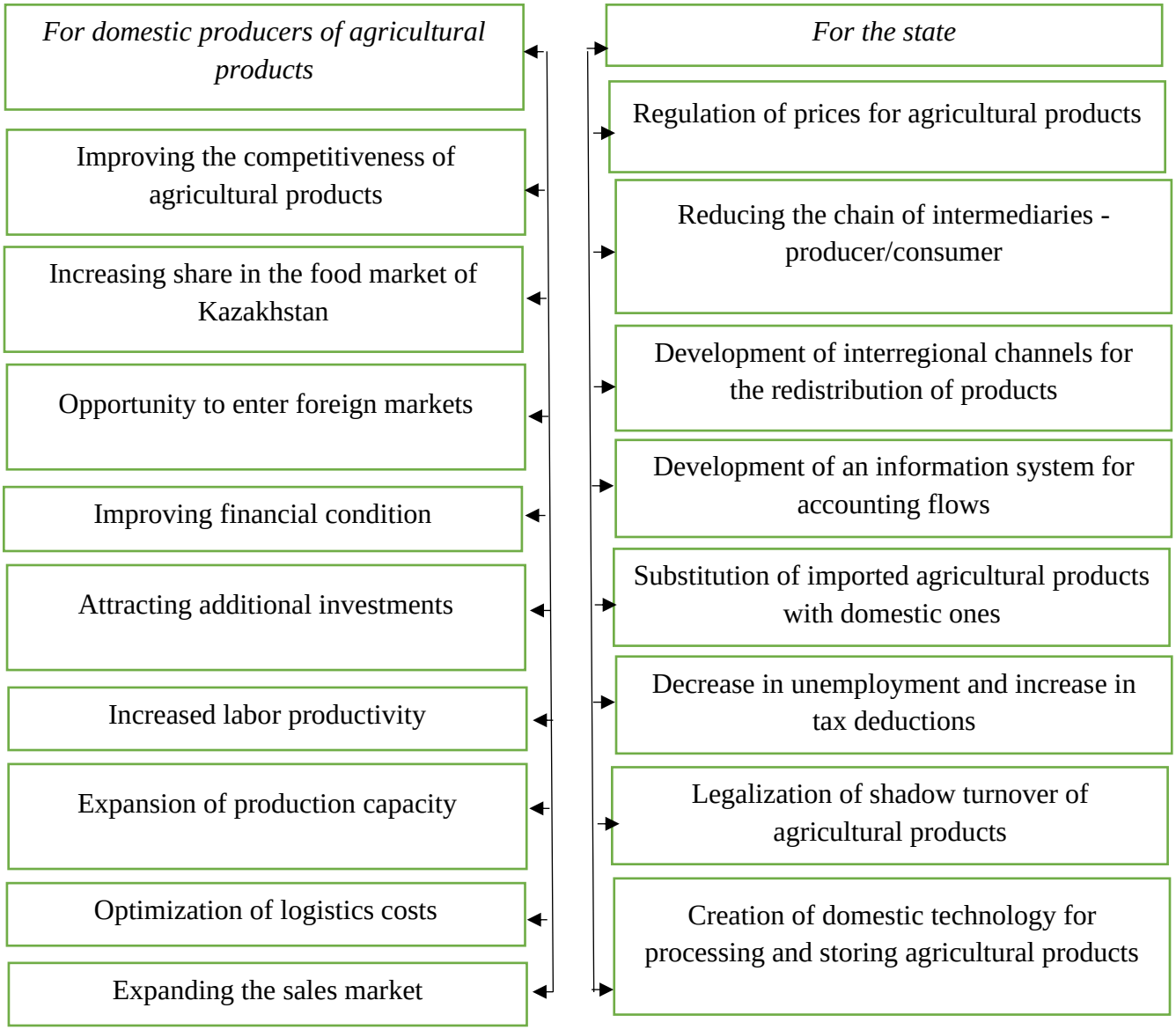


Figure 24 – Main economic problems solved by logistics wholesale distribution centers
of agri-food products

Note: developed by the author

The cost of building a wholesale distribution center varies based on the functions, specialization, and scale of operations.

Commissioning a new WDC not only assists producers in selling their goods but also creates additional employment opportunities in rural localities. From this perspective, establishing logistics WDCs for agricultural products relieves producers from ancillary expenses in preparing goods for market and helps ensure that their products are directly placed on the shelves of prominent chain retailers (Figure 24).

The creation of logistics WDCs will allow domestic producers of agricultural products to: increase the competitiveness of their products; ensure access to foreign markets; attract additional investment; expand production capacity; optimize logistics costs; increase the share of the food market of Kazakhstan; improve financial condition; increase labor productivity; expand sales markets.

Thanks to the functioning of the WDCs in the country, several problems can be solved: stabilize prices for agricultural products; create an integrated information system for accounting of flows and effective interregional channels for the redistribution of agricultural products; reduce the number of unemployed; increase budget revenues, improve the efficiency of the sale of agricultural products by rationalizing economic ties between agricultural producers and wholesale and retail enterprises

Figure 25 illustrates the operating mechanism of a logistics wholesale distribution center**.** At the WDC, goods undergo quality assessment, required documentation, packaging, labeling, and processing. Additionally, the legal organization of transactions—including exchange-based sales, state procurement contracts, and retail chains—is conducted.

In this system, agricultural producers include enterprises, households, and peasant farms that supply raw agricultural materials. Fruit and vegetable industrial processing proceeds in two stages:

-Primary Processing, which encompasses sorting, calibration, washing, peeling, and rinsing.

-Advanced Processing, involving canning, freezing, marinating, juice extraction, and other methods (e.g., dried fruits).

Product distribution paths include wholesale/retail sales and commodity exchanges for deliveries to end users (public procurement, retail outlets, food service establishments). The proposed logistics WDC coordinates interactions across the entire chain—from agricultural production to the consumer—while satisfying economic interests of the stakeholders. It manages incoming shipments, storage, and centralized distribution, enforces quality and safety measures, and integrates exchange transactions using derivative instruments.

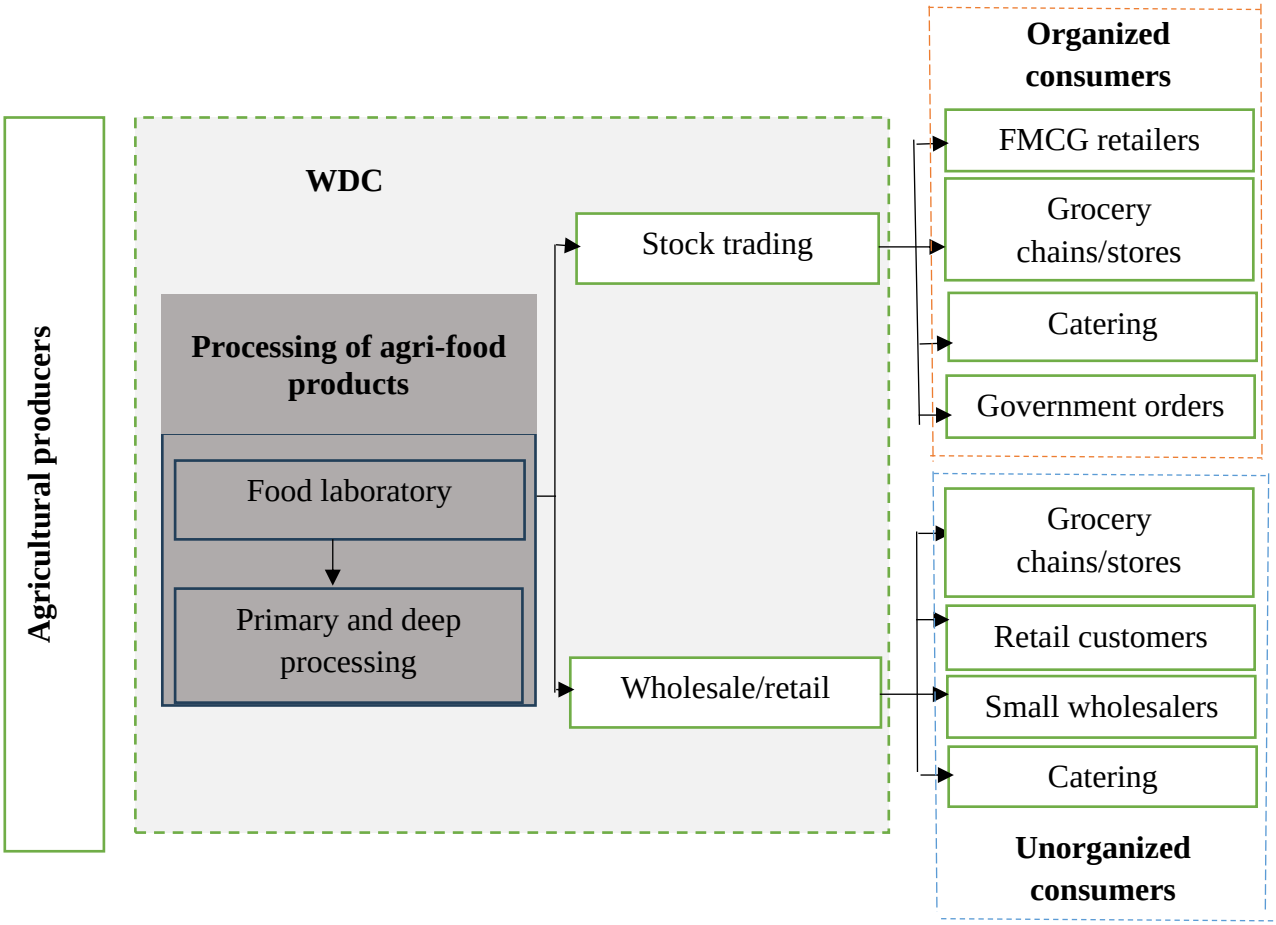


Figure 25 – The mechanism of functioning of the logistics wholesale distribution center of agri-food products

Note: developed by the author

Figure 26 presents a model for forming a logistics wholesale distribution center with agricultural products as the primary flow. Either a public authority or a private investor (via an initiative proposal) may originate the project. Following an assessment of project efficiency within a public–private partnership (PPP) framework—and subsequent endorsement—the concept is finalized, and the techno-economic parameters of the project are calculated, accompanied by comprehensive documentation.

Once the concept and business plan for the WDC have been approved, decisions concerning implementation are undertaken, along with the identification of participant obligations and cost-revenue arrangements.

The WDC project is put into operation and accepts products from agricultural producers on the basis of a sales contract, while conducting a phytosanitary examination of the products. Then the products are redistributed between production workshops for sorting, processing, packaging of products, etc., then the finished products are shipped to the trade and distribution department.

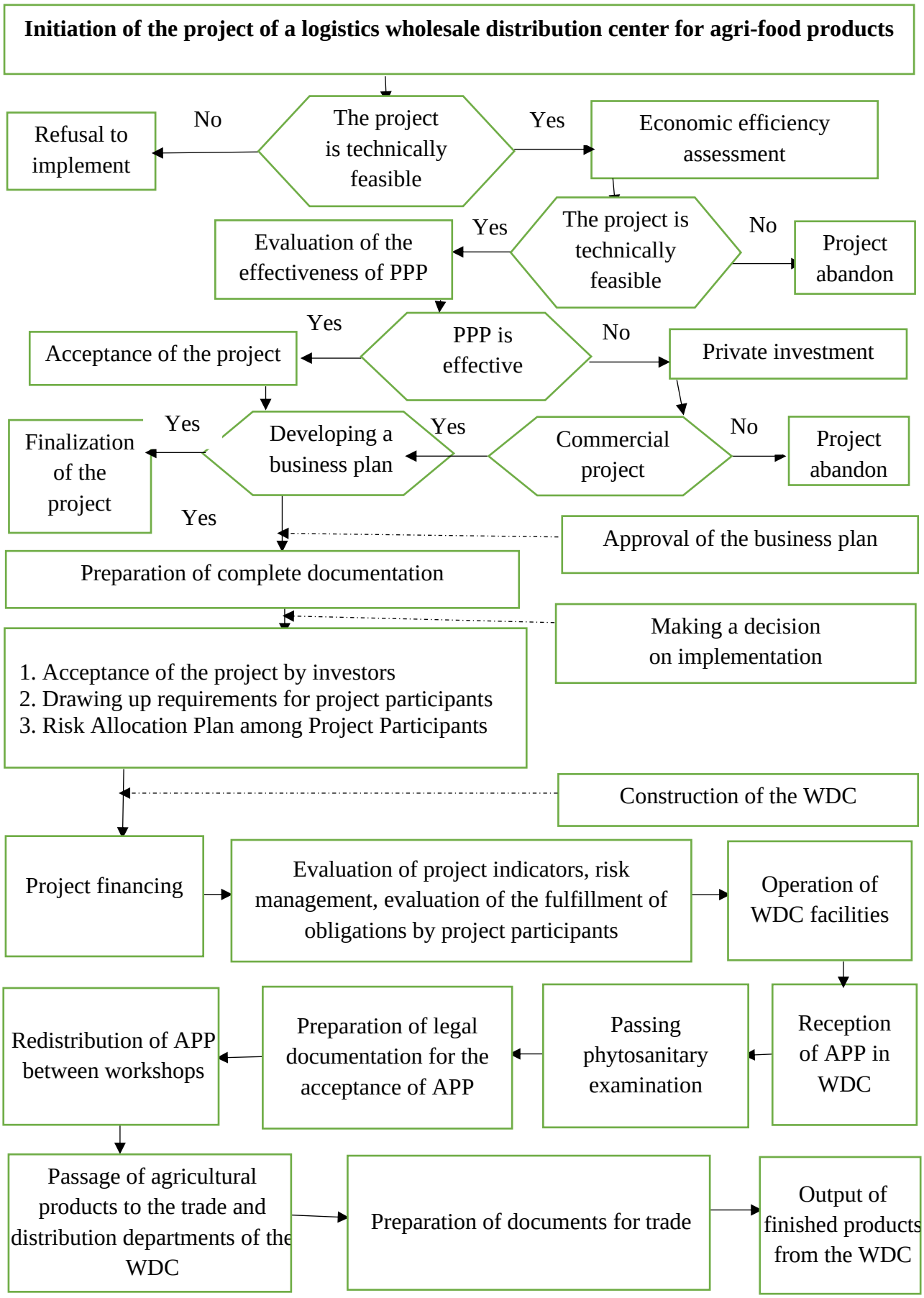


Figure 26 – Model for the formation of a logistics wholesale distribution center for agri-food products (WDC)

Note: developed by the author

The developed organizational and functional structure of the LWDC management and the model of its formation based on the PPP mechanism, combining all logistics, production and technological processes into one chain, as well as the sale and marketing of agricultural products on the commodity exchange, contribute to the formation of organizational and methodological support for the WDC (Figure 26).

Consequently, logistics wholesale distribution centers of agri-food products help to solve the main problems of both local agricultural producers and the state and contribute to increasing the efficiency of the marketing of agri-food products by rationalizing economic ties between agricultural producers and wholesale and retail enterprises.

Drawing on existing models for logistics center development, a public–private partnership mechanism has been adapted to design a logistics WDC for agri-food products. This model integrates all logistics and production processes, including distribution and trade of agri-food products on a commodity exchange. Within this approach, an organizational and functional management structure has been developed, which oversees all infrastructural components, coordinates transport and logistics processes for suppliers through specialized software, and integrates the informational flows essential to the logistics WDC for agri-food products.

The commissioning of WDCs will not only resolve issues with the sale of agricultural products but also create more jobs in rural areas. The functioning of WDCs is timely and essential for implementing import substitution policies, with the support of regional authorities in finding investors and stakeholders for such projects.

3.3 Evaluation of the economic efficiency of wholesale distribution centers

The principal outcomes of the Wholesale Distribution Center (WDC) creation project, which characterize its overall effectiveness, include:

- Increasing the proportion of domestically produced vegetables in the total trade volume;
- Establishing oversight of the entire product logistics cycle, encompassing raw material quality, collection and storage conditions, processing, handling, transportation to consumers, and final sales;
- Forming an integrated system to manage orders, product flows, and financial transactions, thereby consolidating food and nutritional requirements for various population groups.

In order to saturate the domestic market of Kazakhstan with domestic goods and ensure favorable conditions for domestic producers, it was planned to implement a project to create a National Commodity Distribution System (NDS) in the form of an infrastructure of wholesale distribution centers (WDCs). In total, the state planned to build 24 WDCs of various capacities by 2025 with a total funding of 237.5 billion tenge using the PPP mechanism, i.e. the cost of 1 WDC is on average 9.89 billion tenge.

Due to changes in the base rate and borrowing costs in February 2022, the project became more expensive, which led to the need to revise the implementation approaches and the level of state obligations under the PPP agreement. In this regard,

at the end of August 2022, the Ministry of Trade and Integration of the Republic of Kazakhstan (MIT RK) recognized the idea of building a WDC as an ineffective waste of money. The government considered the WDC construction project to be ineffective. The investor, due to the unprofitability of the project due to its optimization, initiated the termination of the PPP agreement, as well as the transfer of already created WDC facilities, which were in state ownership in Astana and Shymkent, to private ownership. Since the project was not implemented, there were no payments from the republican budget.

Instead of building a wholesale distribution center, the Ministry of Agriculture of the Republic of Kazakhstan decided to develop an information system that will unite all networks, storage facilities and trading facilities to collect operational information on the availability and prices of basic food products. Unifying these resources under a single information system will facilitate a comprehensive approach to establishing a food supply chain from producers to consumers, eliminating inefficient intermediaries, reducing market informality, stabilizing prices, expanding commercial infrastructure, and creating export channels. The government is currently evaluating the model for creating this network.

It should be noted that at present, thanks to digitalization in agriculture, conditions are being created for increasing production volumes and increasing the country's export potential. The Ministry of Agriculture of the Republic of Kazakhstan has 4 information systems on its balance sheet, including unified state information system of subsidies, information system "Auyl amanaty", identification of farm animals, unified automated system for managing the branches of the agro-industrial complex "e-Agriculture".

To ensure traceability in animal husbandry, work is underway to automate the entire life cycle (including livestock products), the information systems "Identification of farm animals", "Unified automated system for managing the branches of the agro-industrial complex" are used.

A new information system for traceability of crop production is also being introduced, it will allow tracing the cycle of production and origin of agro-industrial products according to the principle "from field to table", to assess the effect of subsidies on the products manufactured in this industry.

The final stage of digitalization of the agri-industrial complex will be the introduction of the "E-APC" platform.

In order to ensure an integrated approach to the digitalization of agriculture and the creation of a unified digital platform for the agro-industrial complex, it is planned to combine all existing information systems in agriculture as part of the digital transformation of the agricultural sector, through full automation and digitalization of all business processes.

In 2023, there were 9 wholesale distribution centers and 1,171 private vegetable storage warehouses in the country. Their capacity was 3.5 million tons with a need of 12 million tons, which is 4 times less. There is a large deficit of warehouses due to their dispersion.

Thus, the analysis of the development of wholesale distribution centers showed that:

- the idea of developing wholesale distribution centers appeared after 2013;

- all previously set plans for the creation of wholesale distribution centers have not been implemented, funding has been terminated, and the concepts have been abolished;

- the current situation in the field of production and sale of agricultural products indicates the need for wholesale distribution centers as a key element of the national commodity distribution system. Thanks to wholesale distribution centers, it is possible to effectively solve the main tasks of the country: increase the competitiveness of domestic products, regulate food prices, stimulate the development of agriculture, etc.

The WDC system is the best foreign experience in the sale of agricultural products around the world, and so far there are no other better solutions. All over the world, the state economically stimulates the creation and development of WDCs, and participates in management, partially administratively regulating this process until the project reaches self-sufficiency.

However, the results of the study [13, 91] show the great potential and effectiveness of the LWDC or ALC. In this regard, the work assesses the effectiveness of the project to create the WDC based on the following indicators: the coefficient of overall economic efficiency of the investment, the discounted payback period of the investment (DPP), the internal rate of return, the coefficient of return on investment. For this purpose, the data of the conducted forecast of the development of the volume of production, volume of consumption, population of Kazakhstan, purchase and sales prices were used and on their basis the forecast of the capacity of the market of agricultural products and the share of products subject to storage and processing and trade through the wholesale distribution center were determined [13].

To determine the growth of agricultural production and volume of consumption, a forecast was made for the pessimistic and optimistic scenarios using the extrapolation method.

Forecasting for the inertial scenario was carried out on the basis of the analysis of time series characterizing the production of each type of agricultural product for 2003-2022. The optimistic forecast was based on the maximum values of agricultural production achieved in the RK in different years. The achievement of optimal values by year was calculated based on a linear trend.

It is expected that establishing the WDC will stimulate agricultural output by promoting entrepreneurship not only in farming organizations but also in private household operations and peasant (farm) enterprises

In turn, to finance the costs of the Ministry of Transport and Communications of the RK and the Ministry of Agriculture of the RK, all interested private investors (small and large commodity producers, production and marketing cooperatives, processing enterprises, retail chains) should be attracted.

At the end of 2022, taking into account inflation and an increase in the interest rate over 2 years by 21.5%, 288 billion tenge of capital investments will be required for the construction of the ODC network.

Taking into account foreign experience, we propose to finance it both from our own funds and from attracted funds of the participants in the commodity distribution

system. Of the 288 billion tenge, own funds account for 86.4 billion tenge (30%) and funds from the republican budget - 201.6 billion tenge (70%). Of these, 30% (86.4 billion tenge) are own funds of commodity producers, cooperatives involved in the processing, marketing and trade of agricultural products. After 20% subsidization by the state, the volume of necessary own funds is 69.12 billion tenge.

The main components of the storage WDC, distribution WDC and trade WDC, as well as the requirements and parameters for them [126] are given in the table in Appendix G, Table G.1.

Warehouses, product processing shops; cold rooms, areas for waiting for unloading and loading of vehicles directly from warehouses or container areas, trading places are the main production facilities of the wholesale distribution center. And administrative buildings, communications and security services, fire service are non-production facilities.

The core production facilities for a WDC comprise warehouses, product-processing facilities, refrigeration units, loading and unloading zones for vehicles, and designated market spaces. Non-production facilities include administrative offices, communications services, security, and fire protection units.

Over the entire period, the number of constructed WDC s will be 24 units. The main indicators of the construction project for 2020-2027 are given in Table G.2, Appendix G. At the end of the period in 2025, the total capacity of all WDC s will be 2.4 million tons of products. The number of employees is 5,000 people.

Terms of lending for the WDC project: 201,600 million tenge (70%) - from the budget and 86.4 million tenge (30%) - own funds of the NTS participants. The loan term is 15 years at 15% per annum (Appendix G, Table G.3).

Forecast calculations incorporate an annual 20–30% rise in fixed costs linked to labor expenses, wage indexation, and increased costs for fuel, lubricants, and electricity, among other factors.

It was planned that from 2022 to 2025, the workload of the wholesale distribution center would amount to 8.5% of the projected values of the total volume of vegetable production. This relatively low initial figure reflects the startup phase of the center’s commercial activities, uncertainties associated with establishing supply contracts, and the existing long-term contracts between larger producers and other centers (e.g., retail chains, processors, intermediaries).

Between 2026 and 2030, the WDC’s throughput is projected to reach about 20% of total vegetable production. During this interval, the primary goals include engaging as many peasant (farm) households and private plots as possible and securing multi-year collaboration agreements.

In the period from 2026 to 2036, the workload will be about 30% of the total gross vegetable harvest across all categories of agricultural enterprises in the country.

In calculating expected profit, the analysis did not factor in the reimbursement of some expenses (20% of construction costs), as stipulated by the State Program for Support of the Agro-Industrial Complex. Therefore, the presented forecast leans toward a pessimistic scenario. Even so, net profit is expected to become positive in 2033 (Figure 27).

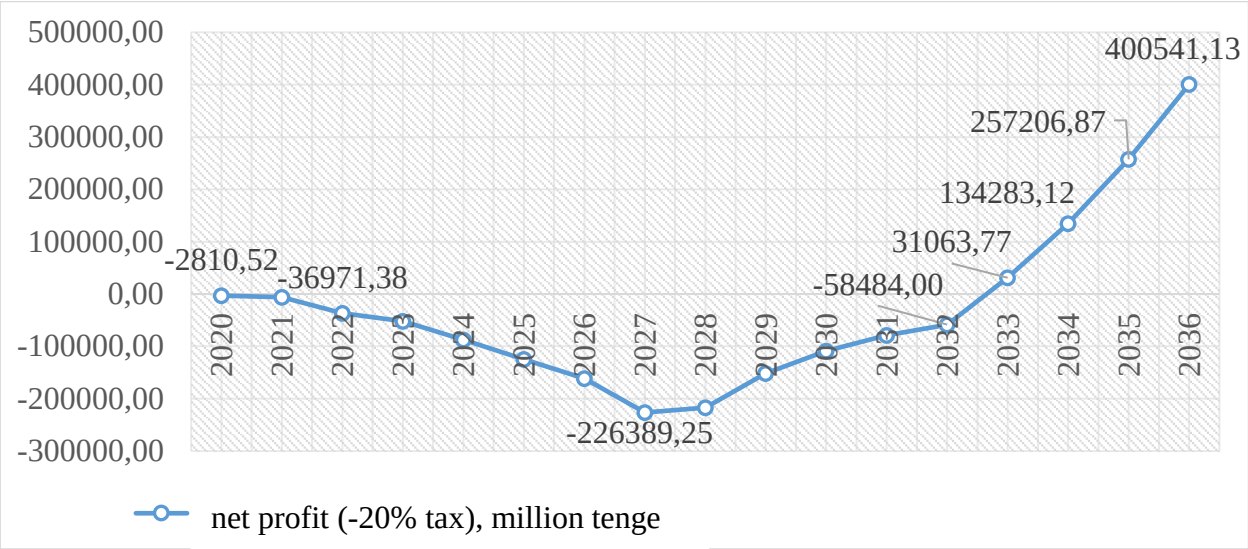


Figure 27 - Dynamics of net profit of the project for construction of the WDC under the pessimistic scenario for the period 2020 - 2036, million tenge

Note: calculated by the author

In the optimistic scenario, a reimbursement of 20% of the construction costs (46,368 million tenge) for the wholesale distribution center is assumed, coupled with a higher utilization rate of the center's capacity—while other parameters remain unchanged (Figure 28).

The return is planned in parts, from 2029 (after the launch of the project and the start of commercial activities).

From 2022 to 2026, the WDC is projected to handle about 10% of the forecast total vegetable production (all farm categories). Between 2027 and 2030, the WDC's throughput would reach approximately 25% of total vegetable production. Between 2030 and 2036, it would reach 35%. As before, the objective is to involve as many peasant farms and private plots as possible through long-term collaboration agreements.

Under the optimistic scenario, the value of net profit also reaches a positive level in 2029, with a value of 153438.9 million tenge, which is 23508 million tenge more than in the pessimistic scenario.

Gross income values also increased, and accordingly, the level of net profit.

The average annual value of net profit will be 127839 million tenge. The trend line on the graph shows a positive trend in terms of profit (Figure 28).

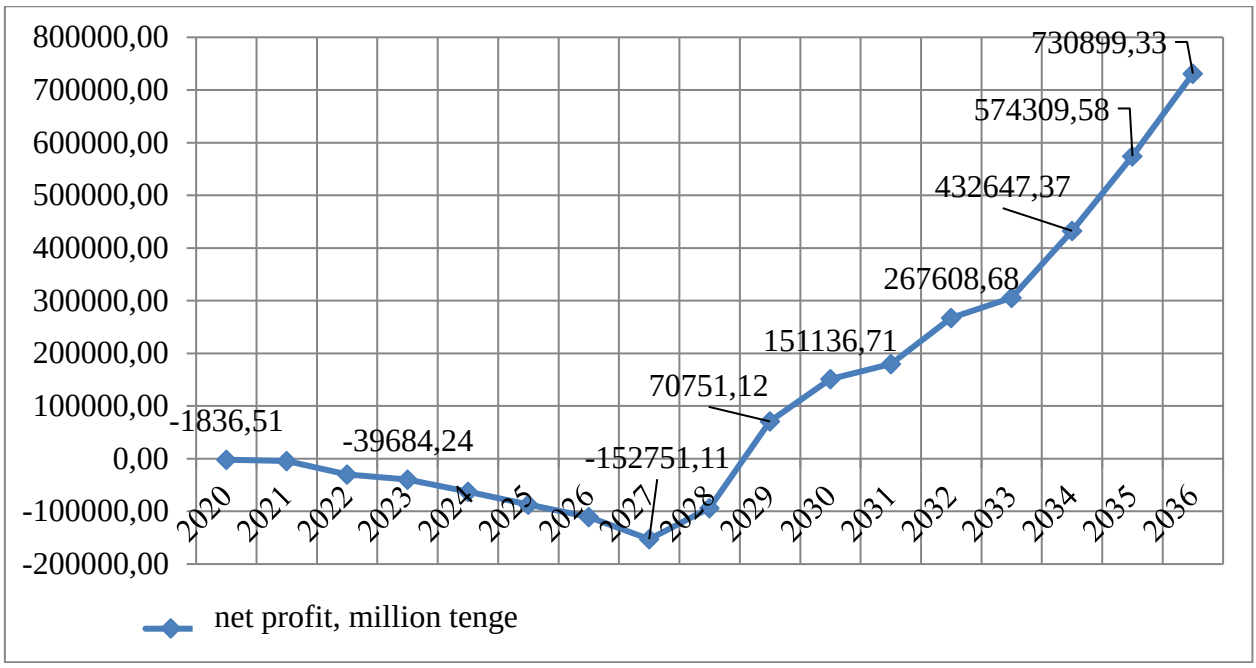


Figure 28 – Dynamics of the project's net profit under the optimistic scenario for the period 2020–2036, million tenge

Note: calculated by the author

The results of the forecast of the investment project's economic efficiency indicators are presented in Table 20.

Table 20 – Results of the forecast of the investment project's economic efficiency indicators for the construction and operation of the logistics WDC

Indicators	Pessimistic forecast	Optimistic forecast
Capital investments, million tenge	288000,0	288000,0
Average annual gross income, million tenge	3933004,2	4899244,0
Average annual net profit, million tenge	18142,0	90147,9
Average annual production volume, thousand tons	3200,7	3765,6
Coefficient of overall economic efficiency of capital investments, %	6,2	31,0
NPV (net present value), at a discount rate of 15%, million tenge	3191,6	12285
IRR (Internal rate of return), %	3,76	25,41
PI (Project investment profitability ratio), %	1,58	6,1
Discounted payback period (DPP), years	15	9
Note: Calculated by the author		

Under the pessimistic and optimistic forecasts, the coefficients of overall economic efficiency of capital investments are 6.2% and 31.0%, respectively.

The discounted payback period (DPP) is 15 years in the pessimistic case and 9 years in the optimistic case, while the internal rate of return (IRR) is 3.76% and 25.41%, respectively, compared to a 15% annual lending rate.

The coefficient of return on investment in the project is 1.5% and 6.1%

The internal rate of return in the pessimistic scenario is 3.76% and in the optimistic one – 25.41%, which means that the developed investment project is profitable and can be taken into consideration.

Thus, the economic efficiency from the creation of the LWDC will be expressed in:

- reduction of product losses and expenses in the distribution system;
- reduction of the difference between the manufacturer's selling price and the retail price;
- increase in the efficiency of the general system of supply and distribution of food in large cities, industrial centers and individual regions of the country;
- expansion of the range of food products and improvement of their quality;
- increase in tax revenues;
- freedom of choice for consumers and the opportunity to increase income for producers of goods.

CONCLUSION

The conducted research on the development of logistics infrastructure and sustainable supply chains for agri-food products, as well as their role in increasing the competitiveness of the economy of Kazakhstan and ensuring sustainable growth, allows us to draw the following conclusions:

1. Based on the conducted study, the essence and content of the key components of logistics infrastructure were revealed. The definition of logistics infrastructure was refined as a set of objects and a complex of interrelated elements that ensure activities related to the procurement, supply, storage, and delivery of products to consumers.

The creation of modern logistics infrastructures for the agri-industrial sector (ALC, WDC, RC, etc.) will help reduce the volatility of food product prices, enable farmers to receive a fair share of the trade markup, which in turn will allow them to generate higher income, reduce post-harvest losses, and improve product quality and safety.

The development and maintenance of reliable logistics infrastructure are crucial for enhancing economic competitiveness, reducing transportation costs, and improving the overall efficiency of product supply chains.

2. In connection with the above, we note the following features of the functioning of the logistics infrastructure and supply chains of agricultural products: it is necessary to use a logistics approach to create an effective system of goods movement in the Kazakhstani market of agricultural products. This system should be built on the conjugation, integration and cooperation of all elements involved in the movement of goods and include:

- material base for production (farmer production and sales cooperatives);
- warehouse base (modern network of cold storage facilities, storage facilities, hangars);
- transport component (refrigerated trucks, grain carriers, etc.);
- trade infrastructure (distribution centers and exchanges).

3. The implementation of conceptual provisions for the functioning of the agri-food product market requires changing traditional approaches to assessing its selection and placement. At the regional level, the criteria for optimality and efficiency of placement should be measured using an integral multiplicative indicator. The methodology for its calculation involves forming a system of indicators that characterize the optimality and efficiency of using distribution infrastructure elements, determining indices that show their changes over time, and calculating an aggregated indicator that represents the average value of the indices. The contribution of this research lies in the combined use of different methods at various stages of the study. The application of standardization, cluster analysis, regression analysis, factor analysis, center of gravity method, and ranking of regions by the criteria we developed for selecting WDC types allowed us to develop a more practical method for determining the number of WDCs, considering regional demand factors for WDCs. This method, considering the proposed factors, will help to avoid the construction of underutilized WDCs.

Another feature of the proposed methodological approach is the construction of an interconnected transport and logistics infrastructure within the region. The proposed approach will significantly improve the efficiency of using transport and logistics infrastructure in regions according to their needs, based on socio-economic, geographic, ecological, and production factors and requirements.

Fulfillment of these requirements will dramatically improve the process of creating and implementing the consumer value of the wholesale distribution center: systematically providing the client with exactly what he wants, at the time he needs and in a place convenient for him.

4. The research showed that Kazakhstan lacks a centralized state body responsible for addressing the issues of cold chain supply for perishable food products (PFP). This leads to a number of problems, including insufficient attention from government bodies to PFP issues, difficulties with monitoring and traceability of supply chains, and weak organization of product collection, transportation, storage, and sales processes. Eliminating these deficiencies requires:

- Organizing statistical accounting for cold chain activities and infrastructure.
- Continuous training of specialists in cold chain management.
- Establishing a special government body for regulating and planning cold chain operations for PFP supply. To improve transparency and traceability of supply chains, it is necessary to:
- Implement vertical integration of farmers and other logistics chain participants.
- Use modern technologies such as the Internet of Things (IoT), blockchain, and remote monitoring systems for temperature conditions. A comprehensive approach to modernizing and developing the cold chain will reduce product losses, improve quality, and ensure the resilience of PFP supply chains in Kazakhstan.

5. The proposed methodological approach consists of three stages. At the first stage, regions (districts and urban agglomerations) are identified where the placement of key logistics infrastructure objects is advisable. To solve this task, an approach based on the cumulative potential of two-stage cluster analysis, factor analysis, and a ranking method is proposed. The consistency of the results from the combined use of these methods was demonstrated using the example of Kazakhstan. At the second stage, the geographical placement of logistics infrastructure objects is determined. The center of gravity method is used to find the optimal locations for infrastructure based on transport time and distance. Corresponding optimization tasks are solved to minimize the cost of advancing the material flow from suppliers to consumers. At the third stage, the service zones of WDCs are determined based on minimizing the service costs for each district.

The distinguishing feature of the proposed methodology is that, when forming logistics infrastructure, the target purpose and type of commodity carrier (storage, distribution, trade) can be taken into account simultaneously. This makes it possible to choose the required capacities, types of refrigeration and ventilation equipment, specialized transport (refrigerated trucks, isothermal vans), etc. The methodology for selecting WDC locations for storage, distribution, and trade is recommended for use in state planning for the development of regional logistics

infrastructure, as well as by large companies when deciding on investments in the logistics sector.

Using this methodology allows state bodies or private investors to calculate possible options for optimal placement of WDCs before making decisions about designing or modernizing existing distribution networks, based on factors such as population density, transport and logistics infrastructure, and the economic and physical availability of food products, which enhances the efficiency of production, sales, and supply chain sustainability for agri-food products.

6. The analysis revealed factors, environments, and conditions that influence the development of logistics infrastructure and product supply chains. The main limiting factors include technological, financial, economic, social, epidemiological, and geographic factors.

It is necessary to ensure the efficient functioning of food supply chains with minimal or no intermediaries, due to the close proximity of production and consumers.

The study showed that Kazakhstan's high international trade intensity is associated with existing economic ties, huge economic potential and the country's geographical location. High intensity of trade turnover in various directions and low logistics efficiency (below the world average) emphasize the need for dynamic development of logistics infrastructure, reduction of customs barriers and costs, improvement of the quality of training and service, which will affect greater scalability of transport and logistics and increase their contribution to the economy.

7. The main directions for the development of logistics infrastructure and agri-food supply chains should be:

- Institutional support,
- State regulation of logistics infrastructure,
- Formation of national logistics infrastructure,
- Formation of logistics systems at different levels,
- Creation of marketing and logistics information systems and research,
- Improvement of domestic and foreign trade and trade infrastructure for key agricultural products,
- Participation in the development of logistics infrastructure for product promotion within the EAEU,
- Improving the efficiency, development, and use of logistics infrastructure and agri-food supply chains.

8. Drawing on existing models for logistics center development, a public–private partnership mechanism has been adapted to design a logistics WDC for agri-food products. This model integrates all logistics and production processes, including distribution and trade of agri-food products on a commodity exchange. Within this approach, an organizational and functional management structure has been developed, which oversees all infrastructural components, coordinates transport and logistics processes for suppliers through specialized software, and integrates the informational flows essential to the logistics WDC for agri-food products.

The commissioning of WDCs will not only resolve issues with the sale of agricultural products but also create more jobs in rural areas. The functioning of

WDCs is timely and essential for implementing import substitution policies, with the support of regional authorities in finding investors and stakeholders for such projects.

9. Overall, the economic benefits derived from establishing logistics-oriented wholesale distribution centers (WDCs) include:

- Decreasing product losses and expenses in the distribution system;
- Narrowing the gap between producers' selling prices and retail prices;
- Increase in the efficiency of the general system of supply and distribution of food in large cities, industrial centers and individual regions of the country;
- Increase in tax revenues;
- Providing consumers with broader choices and enhancing producers' income.

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APPENDIX A

Implementation acts of the research results

УТВЕРЖДАЮ
Член Правления-
проректор по академическим вопросам
НАО «Восточно-Казахстанский
университет имени Сарсена Аманжолова»
_____Алимбекова Н.Б.
_____2024г.

Акт внедрения в учебный процесс результатов работы

Мы, нижеподписавшиеся, Директор департамента академической политики и управления образовательными программами, руководитель отдела по организации учебно-методической работы, декан Высшей школы бизнеса и права, и.о. заведующий кафедрой экономики, менеджмента и финансов и А.А.Рахметулина составили настоящий акт о том, что результаты научного проекта «Развитие транспортно-логистической системы Казахстана» (свидетельство Министерства юстиции Республики Казахстан о внесении сведений в государственный реестр прав на объекты, охраняемые авторским правом № 42478 от 30.01.2024г.), имеют теоретическое и практическое значение для учебного процесса.

Настоящим актом подтверждается, что результаты научного проекта «Развитие транспортно-логистической системы Казахстана» были использованы и внедрены в учебный процесс в лекционные и практические занятия для образовательных программ по направлению подготовки кадров «Бизнес и управление» НАО «Восточно-Казахстанский университет имени Сарсена Аманжолова».

Директор департамента академической политики и управления образовательными программами — **Домалатов Е.Б.**

Руководитель отдела по организации учебно-методической работы — **Хамитова З.К.**

Декан Высшей школы бизнеса и права — **Апышева А.А.**

И.о. зав. кафедрой экономики, менеджмента и финансов — **Конуспаев Р.К.**

Автор разработки — **Рахметулина А.А.**

Проректор по академическим вопросам
НАО Кокшетауский университет
им. Ш. Уалиханова
Медетов Н.А.
2024г.

Акт внедрения в учебный процесс результатов работы

Мы, нижеподписавшиеся, директор Высшей школы бизнеса и права, заведующий кафедрой «Бизнеса и услуг» и А.А. Рахметулина составили настоящий акт о том, что результаты научного проекта «Развитие транспортно-логистической системы Казахстана» (свидетельство Министерства юстиции Республики Казахстан о внесении сведений в государственный реестр прав на объекты, охраняемые авторским правом № 42478 от 30.01.2024г.), имеют теоретическое и практическое значение для учебного процесса.

Настоящим актом подтверждается, что результаты научного проекта использованы и внедрены в учебный процесс в лекционные и практические занятия для образовательных программ по направлению подготовки кадров «Бизнес и управление» НАО Кокшетауский университет им. Ш. Уалиханова.

Директор Высшей школы бизнеса и права **Искаков А.Ж.**

Заведующий кафедрой «Бизнеса и услуг» **Утегенова Ж.С.**

Автор разработки **Рахметулина А.А.**

в Диссертационный совет по группе специальностей /образовательных программ 6D050600, 8D04102 – Экономика, 6D051000, 8D04103 – Государственное и местное управление, 6D051700, 8D04105 – Инновационный менеджмент, 6D051800, 8D04107 – Управление проектами, 6D050800, 8D04108 – Учет и аудит, 6D050900, 8D04110 – Финансы, 6D051100, 8D04111 – Маркетинг, 6D051300, 8D04101 – Мировая экономика, 6D090900, 8D11301 – Логистика
050400, г.Алматы, пр. аль-Фараби, 71

АКТ

о практическом применении результатов диссертационного исследования

Результаты диссертационного исследования Рахметулиной А.А. «**Development of logistics infrastructure and supply chains of agri-food products in the Republic of Kazakhstan**» представляют практическую значимость для нашей компании ТОО «SMART Trade Solutions». Разработанные меры в рамках исследования позволяют повысить эффективность работы логистической инфраструктуры и создания устойчивых цепей поставок продукции.

Директор Төлеуғазынов Б . Б .

09 декабря 2024 года

Акт внедрения результатов научно-исследовательских работ по теме AP19677634 «Развитие логистической инфраструктуры и устойчивых цепей поставок скоропортящейся продовольственной продукции на территории Казахстана»

(научный руководитель д.э.н, профессор Раимбеков Ж.С.
Исполнители: д.э.н., профессор Сыздыкбаева Б.У., к.э.н., доцент Баймбетова А.Б., к.э.н., доцент Дулатбекова Ж.А., докторант Рахметулина А.А.)

Настоящим подтверждается, что ряд положений и выводов, разработанных в рамках научного исследования по проекту AP19677634, а также предложенные практические рекомендации имеют высокую актуальность для нашей компании.

Рекомендации по развитию и поддержке транспортно-логистических услуг и инфраструктуры в условиях современной экономики, а также оценка уровня их развития представляют значительный практический интерес. Эти идеи могут быть успешно использованы при разработке стратегических планов по совершенствованию транспортно-логистических систем компании.

Применение предложенных моделей и механизмов функционирования логистической инфраструктуры для скоропортящейся продукции, а также построение эффективных и устойчивых цепей поставок создадут возможности для оптимизации процессов транспортировки агропромышленной продукции. Это, в свою очередь, повысит общую эффективность и надежность логистических операций ТОО «SMART Trade Solutions».

Директор Төлеуғазынов Б . Б .

в Диссертационный совет по группе специальностей /образовательных программ 6D050600, 8D04102 – Экономика, 6D051000, 8D04103 – Государственное и местное управление, 6D051700, 8D04105 – Инновационный менеджмент, 6D051800, 8D04107 – Управление проектами, 6D050800, 8D04108 – Учет и аудит, 6D050900, 8D04110 – Финансы, 6D051100, 8D04111 – Маркетинг, 6D051300, 8D04101 – Мировая экономика, 6D090900, 8D11301 – Логистика
050400, г.Алматы, пр. аль-Фараби, 71

АКТ

о практическом применении результатов диссертационного исследования

Настоящим подтверждаем, что результаты диссертационного исследования Рахметулиной А.А. «**Development of logistics infrastructure and supply chains of agri-food products in the Republic of Kazakhstan**» являются актуальными в современных условиях.

В частности, практические рекомендации по построению взаимоувязанной транспортной и логистической инфраструктуры на территории региона будут применены в дальнейшей деятельности ТОО «Новый Шелковый Путь».

Практическая значимость диссертации определена тем, что разработанные меры в рамках исследования позволяют существенно повысить эффективность использования транспортно-логистической инфраструктуры в регионах в соответствии их потребностям на основе учета социально-экономических, географических, экологических, производственных факторов и требований.

Директор ТОО «Новый Шелковый Путь» Кравченко Г.А.



Акт внедрения результатов научно-исследовательских работ по теме AP19677634 «Развитие логистической инфраструктуры и устойчивых цепей поставок скоропортящейся продовольственной продукции на территории Казахстана»

(научный руководитель д.э.н, профессор Раимбеков Ж.С.
Исполнители: д.э.н., профессор Сыздыкбаева Б.У., к.э.н., доцент Баймбетова А.Б., к.э.н., доцент Дулатбекова Ж.А., докторант Рахметулина А.А.)

Настоящим актом подтверждается, что ряд положений и выводов научных исследований по проекту AP19677634, оценка состояния и выявленные проблемы существующей транспортно-логистической инфраструктуры; факторы, влияющие на формирование, эффективное и устойчивое развитие транспортно-логистической инфраструктуры; модели и механизм развития транспортно-логистической инфраструктуры и предложеные практические рекомендации по их развитию представляют актуальность для компании.

Предложенные рекомендации по развитию и поддержке транспортно-логистических услуг скоропортящейся продукции и ее инфраструктуры в условиях цифровизации и оценка уровня их развития представляют практический интерес и могут быть внедрены при разработке стратегических планов развития транспортно-логистических систем компании.

Использование представленных модели и механизма функционирования логистической инфраструктуры для скоропортящейся продукции и эффективных цепей поставок позволит построить эффективные и устойчивые цепи поставок при транспортировке агропромышленной продукции.

Директор ТОО «Новый Шелковый Путь» Кравченко Г.А.



APPENDIX B

Participation in an applied research project under the grant funding of the Ministry of Education and Science of the Republic of Kazakhstan

«Л.Н. ГУМИЛЕВ АТЫНДАҒЫ ЕУРАЗИЯ ҰЛТТЫҚ УНИВЕРСИТЕТІ» КЕАҚ
ҒЫЛЫМ ЖӘНЕ КОММЕРЦИАЛИЗАЦИЯ ДЕПАРТАМЕНТІ
ҒЫЛЫМИ ЖОБАЛАР ЖӘНЕ БАСЫЛЫМДАР БАСҚАРМАСЫ
ҒЫЛЫМИ ЖОБАЛАРДЫ ҚОЛДАУ СЕКТОРЫ
«30» 05 2024 ж.
№ 33

СПРАВКА

Дана **Рахметулиной Айгерим Абаевне** в том, что она действительно с «03» января 2024 года является младшим научным сотрудником проекта AP19677634 «Развитие логистической инфраструктуры и устойчивых цепей поставок скоропортящейся продовольственной продукции на территории Казахстана», в рамках государственного заказа на реализацию научного и (или) научно-технического проекта по бюджетной программе 217 «Развитие науки», по приоритету «Исследования в области социальных и гуманитарных наук», (договор № 269-23-25 от «03» августа 2023 г.).

Научный руководитель проекта: Раимбеков Жанарыс Сабирович.

Справка дана по месту требования.

И.о. директора департамента науки **А. Молдахметова**

«Л.Н. ГУМИЛЕВ АТЫНДАҒЫ ЕУРАЗИЯ ҰЛТТЫҚ УНИВЕРСИТЕТІ» КЕАҚ ҒЫЛЫМ ЖӘНЕ КОММЕРЦИАЛИЗАЦИЯ ДЕПАРТАМЕНТІ ҒЫЛЫМИ ЖОБАЛАРДЫ ҚОЛДАУ СЕКТОРЫ

Исп. А. Атызова
Тел. 70-94-87, вн.31-293

APPENDIX C

Copyright certificate from the Ministry of Justice of the Republic of Kazakhstan



ҚАЗАҚСТАН РЕСПУБЛИКАСЫ

РЕСПУБЛИКА КАЗАХСТАН

АВТОРЛЫҚ ҚҰҚЫҚПЕН ҚОРҒАЛАТЫН ОБЪЕКТІЛЕРГЕ ҚҰҚЫҚТАРДЫҢ МЕМЛЕКЕТТІК ТІЗІЛІМГЕ МӘЛІМЕТТЕРДІ ЕНГІЗУ ТУРАЛЫ

КУӘЛІК

2024 жылғы «30» қаңтар № 42478

Автордың (лардың) жөні, аты, әкесінің аты (егер ол жеке басын куәландыратын құжатта көрсетілсе): **РАХМЕТУЛИНА АЙГЕРИМ АБАЕВНА, Раимбеков Жанарыс Сабирович**

Авторлық құқық объектісі: **ЭЕМ-ге арналған бағдарлама**

Объектінің атауы: **Научный проект «Развитие транспортно-логистической системы Казахстана»**

Объектіні жасаған күні: **27.01.2024**

ҚР ӘМ «Ұлттық зияткерлік меншік институты» РМК РГП «Национальный институт интеллектуальной собственности» МЮ РК

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РЕСПУБЛИКА КАЗАХСТАН

СВИДЕТЕЛЬСТВО

О ВНЕСЕНИИ СВЕДЕНИЙ В ГОСУДАРСТВЕННЫЙ РЕЕСТР ПРАВ НА ОБЪЕКТЫ, ОХРАНЯЕМЫЕ АВТОРСКИМ ПРАВОМ

№ 42478 от «30» января 2024 года

Фамилия, имя, отчество, (если оно указано в документе, удостоверяющем личность) автора (ов):
РАХМЕТУЛИНА АЙГЕРИМ АБАЕВНА, Раимбеков Жанарыс Сабирович

Вид объекта авторского права: **программа для ЭВМ**

Название объекта: **Научный проект «Развитие транспортно-логистической системы Казахстана»**

Дата создания объекта: **27.01.2024**

РГП «Ұлттық зияткерлік меншік институты» ҚР Ұлттық зияткерлік меншік институты РГП «Национальный институт интеллектуальной собственности» МЮ РК

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Подписано ЭЦП

Е. Оспанов

APPENDIX D

Criteria influencing the selection and placement of logistics infrastructure for storage, distribution and trade

System of indicators	Justification of the choice of criterion
Social factors	
Population size, people	Characterizes the volume of purchase and consumption of products
Income per capita, thousand tenge	Characterizes the level of income of the population in the region
Purchasing power of the district population, thousand tenge	Characterizes the level of purchasing power of the population
Volume of food consumption per capita, kg/year	Characterizes the level of consumption of products
Level of satisfaction of the population with services	Characterizes access to infrastructure facilities, completeness of information, quality of service
Economic factors	
Number of agricultural producers	Characterizes the volume of favorable business environment in agricultural business, reflecting how much agricultural organizations have increased (decreased)
Volumes of sales of agricultural products, million tenge	Determines the volume of growth in sales of products, the level of agricultural production, and an assessment of the state of the investment climate in agriculture.
Volumes of production in the food industry	Characterizes the assessment of the state of production of finished food products
Volume of wholesale turnover of food products, million tenge	Determines the volume of wholesale sales of food products
Volume of retail turnover of food products, million tenge	Determines the volume of retail sales of food products
Volume of cargo transportation of agricultural and food products, thousand tenge	Characterizes the volume of transportation of agricultural products
Share of the number of food market workers in the total number of employed in the economy of the country (region) of the working-age population, %;	Characterizes the number of people employed in the food sector out of the total number of people employed in the economy
Level of profitability of the TPS	An indicator that determines the efficiency of the TPS
Cost of sales of 1 tenge	Costs of selling a unit of production
Selling price of 1 tenge of sold products	Purchase costs
Profit from sales of 1 tenge of products	Income remaining at the disposal of the distribution network (TPS)
Regional (Infrastructure-geographical) factors	
Number of enterprises and workshops for processing and production of agricultural products	An indicator that determines the level of concentration of enterprises in the processing industry

Availability of storage facilities for products, in tons	Characterizes the storage capacity
Number of storage facilities for agricultural products per 1000 residents, places	The value that determines the actual capacity for storing products
Distance from the district center to the regional center by road, km	Determines the distance and cost of transportation
Time of transportation of products by road, hours	An indicator that determines the speed of delivery of products to the destination
Trading area of grocery stores, per thousand square meters	Determines the degree of development of the retail space
Number of retail chains, units	Characterizes the level of development of retail chains
Warehouse area, thousand square meters	Determines the level of development of the warehouse space
Density of highways, km per 100 square meters	Shows the degree of provision of the territory with a motorway
Length of highways, km	Characterizes the total length (length) of motorways
Availability of railways in the district (0 - no, 1 - yes, 0.5 - partially)	Shows the level of provision with a railway network
Number of marketing, information and consulting centers per 10 thousand people	Characterizes the density of service centers
Production factors	
Volumes of agricultural production in physical quantities (grain, potatoes, fruits and berries, vegetables and melons, meat and milk in tons, eggs in thousands of units)	Determines the volume of agricultural production
Trade assortment	Gives an idea of the range of products available
Ecological factors	
Volume of solid waste from product sales	The amount of waste during the sale of products based on statistics https://stat.gov.kz
Emissions of pollutants into the atmosphere	Emissions into the atmosphere are determined based on statistics https://stat.gov.kz
Note: developed by the author	

APPENDIX E

Questionnaire Survey

Акиму города Астана

Уважаемый !

Просим Вас оказать содействие в сборе материалов, имеющихся в руководимом Вами регионе, сотрудникам Евразийского национального университета имени Л.Н. Гумилева для выполнения научного проекта на тему AP19677634 «Развитие логистической инфраструктуры и устойчивых цепей поставок скоропортящейся продовольственной продукции (СПП) на территории Казахстана».

Исследование осуществляется в целях выявления проблем и потребности в логистической инфраструктуре для СПП, рекомендаций по разработке оптимальных цепей поставок СПП и перспективах развития современных логистических инфраструктур.

Исходя из этого, просим Вас оказать содействие в предоставлении нам информации по холодовой цепи логистической инфраструктуры для хранения, перевозки (транспортирования) и реализации скоропортящейся продукции сельского хозяйства, АПК и пищевой промышленности (овощи, фрукты, молоко, мясо, рыба и т.д.) за последние 3-5 лет по всей области (городам, районам, сельской местности) следующего содержание:

- наименование, год эксплуатации, количество, мощность, площадь, емкость, вместимость, наличие климатических складов, процент потерь (убыль) продукции, уровень регулирования температурного режима, наличие транспортной инфраструктуры - доступа к автомобильным или железным дорогам и т.д.) *в регионе, включая районы и сельские местности.*

По следующим объектам исследования:

а) по хранению и распределению:

-овощехранилища, картофелехранилища, фрукто-/ягодохранилища и хранилища иной пищевой продукции;

- оптово-распределительные центры, логистические центры, оптовые рынки, крупные торговые центры (количество, мощность, площадь и т.д.);

-холодильные склады (хранения, распределения), морозильные и холодовые камеры, холодильное оборудование;

-сортировочные и упаковочные цеха (линии) скоропортящейся продукции;

-центры сбора (агрегирования) скоропортящихся продуктов;

-теплицы с регулируемыми температурами для созревания продукции;

б) по транспортировке: рефрижераторный транспорт, специальные рефрижераторные контейнеры с системами охлаждения, авто- и железнодорожные рефрижераторы (наименование, количество, вместимость, мощности и другие характеристики);

в) объемы инвестиций в логистическую инфраструктуру для хранения, транспортировки и реализации СПП;

г) объемы производства и продаж в натуральном и в стоимостном выражении (импорт, экспорт, внутреннее потребление) по рынку скоропортящейся продукции (за последние 3-5 лет).

Со своей стороны гарантируем Вам, что данная информация будет использована только в рамках исследования вышеобозначенного научного проекта и не будет предоставлена иным юридическим и физическим лицам.

С уважением исполнители научного проекта кафедры экономики и предпринимательства ЕНУ имени Л.Н. Гумилева

научный руководитель, д.э.н., профессор **Раимбеков Ж.С.**
тел. 87017303714, эл.почта: zh_raimbekov@mail.ru

Анкетный опрос участников поставки скоропортящейся продукции для оценки состояния логистической инфраструктуры и цепей поставок в регионах Казахстана

Анкетный опрос участников поставки скоропортящейся продукции для оценки состояния логистической инфраструктуры и цепей поставок в регионах Казахстана

Уважаемый респондент, благодарим Вас за участие в опросе!

Просим внимательно ознакомиться с представленными вопросами и возможными вариантами ответов к ним

Убедительная просьба, если вопрос не касается Вашей деятельности, то пропустите ответ на него

Ваши ответы будут строго конфиденциальными, а имена участников и их принадлежность не будут разглашаться

Цель исследования - оценка текущего состояния и проблем логистической инфраструктуры и логистических цепей поставок скоропортящейся сельскохозяйственной и агропродовольственной продукции для выработки рекомендации по их дальнейшему развитию..

Опрос проводит коллектив исследователей *Евразийского национального университета имени Л.Н. Гумилева в рамках научного проекта.*

Чтобы сохранить изменения, войдите в аккаунт Google. Подробнее...

Блок 1 - Общая информация

1. Название предприятия:

Укажите название организации, которую вы представляете

Мой ответ

2. Должность

Укажите вашу текущую должность

Мой ответ

3. Стаж работы в бизнесе (выберите нужное)

Выбрать

4. Укажите основной регион ведения вашего бизнеса

Выбрать

5. К какой категории субъекта предпринимательства вы относитесь?

- ◯ Субъект микро предпринимательства
- ◯ Субъект малого предпринимательства
- ◯ Субъект среднего предпринимательства
- ◯ Субъект крупного предпринимательства
- ◯ Другое:

6. Основная сфера Вашего бизнеса

- ◯ 1)Сельское хозяйство
- ◯ 2)Обрабатывающая промышленность (переработка и производство)
- ◯ 3)Перевозка (транспорт и логистика)
- ◯ 4)Образование и наука
- ◯ 5)Инфраструктура складирование, хранения и информация (упаковка, складирование, IT)
- ◯ 6)Торговля скоропортящейся продукцией и продуктами питания
- ◯ 7)Государственный орган и/или негосударственная организация
- ◯ Другое: _____

7. Какую продукцию производите или реализуете (отметить одно или несколько)

- ◯ -молоко и молочные продукты (сыры, мороженое, сливочное масло и т.д.)
- ◯ -растительные продукты: фрукты, ягоды, овощи и грибы свежие
- ◯ -мясо и мясопродукты
- ◯ -рыба, рыбопродукты, раки живые, мороженные, копченые
- ◯ -живые растения для дальнейшей посадки, цветы живые и срезанные
- ◯ -переработанные продукты питания (колбасы и мясопродукты, консервы, масла, жиры, сыры, молочные продукты, мороженое и замороженные полуфабрикаты
- ◯ -мучные и кремово-кондитерские изделия
- ◯ -жиросодержащие продукты, напитки, полуфабрикаты, замороженные готовые блюда и т.п.
- ◯ -соки, маринованные продукты
- ◯ -лекарственные и медицинские препараты
- ◯ -цветы и/или другие растений.
- ◯ Другое: _____

Блок 2 – Логистическая инфраструктура

8.Имеется ли у Вас логистическая инфраструктура хранения, сортировки, транспортировки и распределения

Выбрать

9.Какой температурный режим используется для Вашей продукции:

Выбрать

10.В каком состоянии находится логистическая инфраструктура в Вашем регионе или у Вас, где вас обслуживают (здания и сооружения, склады, холодильные камеры, хранилища и т.д.) для скоропортящейся продукции:

Выбрать

11. Пожалуйста, оцените как часто используете логистические услуги / процессы для оборота скоропортящиеся продукции (выберите нужный ответ: 1- очень часто, 2-часто, 3-иногда, 4-редко, 5- никогда)

	Очень часто	Часто (2-3 раза в неделю)	Иногда (1-3 раза в месяц)	Редко	Никогда
1)сбор и агрегирование продукций в одном месте (пункт приема, или хранения) (СА);	◯	◯	◯	◯	◯
2) обработка после уборки (мойка от грязи, очистка)	◯	◯	◯	◯	◯
3)сортировка, калибровка	◯	◯	◯	◯	◯

13.Насколько близко расположена логистическая инфраструктура к месту производства вашей продукций?

Выбрать

14.Насколько близко расположена логистическая инфраструктура к месту потребления вашей продукций?

- ◯ рядом (до 20 км.)
- ◯ близко (20-50 км.)
- ◯ среднее (50-100км)
- ◯ далеко (свыше 100 км.)

15.Насколько доступна мощность или емкость логистической инфраструктуры в вашем регионе:

Выбрать

16.Оцените, на сколько загружены имеющиеся в вашем регионе/или у вашей организаций мощности по хранению и распределению

- ◯ 1) до 20%
- ◯ 2) 20-30%;
- ◯ 3) 30-40%;
- ◯ 4) 40-50%;
- ◯ 5) 50-70%;
- ◯ 6) 70-90%;
- ◯ 7) 95-100%.

17. Оцените, достаточны ли навыки и компетенции логистической инфраструктуры для выполнения передовой практики

	да	не всегда	нет
-транспортировки	◯	◯	◯
-хранения	◯	◯	◯
-складирования	◯	◯	◯
-контроля качество продукций	◯	◯	◯
-соблюдение санитарно-гигиенических нормы в холодильных складах и камерах	◯	◯	◯
-документирование и ведения учета движения продукций	◯	◯	◯
-калибровке измерительных приборов	◯	◯	◯
-торговле	◯	◯	◯

18.Оцените, какие проблемы препятствуют качественному обеспечению холодовой цепи поставок свежей продукций

Холодовая цепь *– это комплекс логистических мер по обеспечению постоянной температуры и других параметров (влажность, давление), необходимых для надлежащего содержания товара на всей цепи его движения — от производства до потребителя.*

	да	иногда/ не часто	нет
1.Персонал плохо обучен (не контролирует и не мотивирован);	◯	◯	◯

19. Оцените сильные стороны логистической инфраструктуры поставок скоропортящейся продукции в Вашем регионе, (по пятибалльной системе: *1-неразвитая, 2-слаборазвитая, 3-среднее развитие, 4- достаточно развитая, 5-хорошо развитая)*

	1	2	3	4	5
1.Развитость транспортной инфраструктуры: дороги, ТЛЦ, специализированный транспорт, контейнеры и т.д.	◯	◯	◯	◯	◯
2.Развитость логистической инфраструктуры: склады, хранилище, холодовые камеры, распределительные центры	◯	◯	◯	◯	◯
3.Развитость торговой инфраструктуры: торговые центры, магазины, палатки, киоски и т.д.	◯	◯	◯	◯	◯
4.Развитость применение систем непрерывного контроля температуры каждой партии с помощью датчиков	◯	◯	◯	◯	◯
4.Высокий профессионализм и компетенция в холодовой цепи	◯	◯	◯	◯	◯
5.Высокий уровень сервиса в цепях поставок	◯	◯	◯	◯	◯
6.Наличие складских помещений и хранение нестандартной	◯	◯	◯	◯	◯

Блок 3 – Логистика цепей поставок

20.Выберите логистическую цепь поставок Вашей скоропортящейся продукции (выберите нужное):

Логистическая цепь *– это линейно упорядоченная совокупность физических и/или юридических лиц, задействованных в доведении необходимой продукций до конкретного получателя.*

- ◯ без посредника (напрямую)
- ◯ с одним посредником
- ◯ с двумя посредниками
- ◯ с тремя посредниками
- ◯ 4 и более посредников
- ◯ Другое: _____

21.Устойчивость связи с Вашими поставщиками и посредниками:

- ◯ неустойчивая (частый изменения и перебои)
- ◯ относительно устойчивые (сбои случается)
- ◯ устойчивая на длительный период

22.Соблюдаете ли (отслеживаете) температурный режим в холодовых цепях поставок скоропортящейся продукции и условий хранения, транспортировки и реализации (выберите нужное)

	да	частично соблюдаю	редко соблюдаю	не соблюдаю
1.При сборе и агрегировании в места отправки	◯	◯	◯	◯
2.При погрузке и разгрузке в подвижный состав или	◯	◯	◯	◯

25.На сколько логистическая цепь способны обеспечить требуемое качество Вашей продукций

	низкое	среднее	высокое
качество товаров для длительного хранения	◯	◯	◯
количество отходов	◯	◯	◯
количество потерь продукции в логистических цепях (% от первоначальной суммы)	◯	◯	◯
количество рекламации	◯	◯	◯
наличие внедренной системы менеджмента качества на предприятии, удовлетворяющей ряду требований	◯	◯	◯

26. Как решаются задачи организации и управлении закупками скоропортящейся продукции (оцените по пяти балльной системе: 1-худшее, 5 - самое лучшее)

	1	2	3	4	5
1.Поиск и выбор поставщика	◯	◯	◯	◯	◯
2.Заключение договора по поставкам	◯	◯	◯	◯	◯
3.Планирование сезонности и периодичности	◯	◯	◯	◯	◯

28.Проводится ли совместная работа с производителями, дистрибьюторами, логистическими и транспортными операторами по вопросам прогнозирования, планирования, закупки, производства, складирования, управления ценами

	да	нет	не предусмотрено
1.Маркетинг (изучение рынка, потребителей, поставщиков и т.д.)	◯	◯	◯
2.Производство	◯	◯	◯
3.Переработка	◯	◯	◯
4.Информация	◯	◯	◯
5.Хранение	◯	◯	◯
6.Складирование	◯	◯	◯
7.Упаковка	◯	◯	◯
8.Транспортировка	◯	◯	◯
9.Управление заказами и закупками	◯	◯	◯
10.Управление ценами на логистические услуги	◯	◯	◯
11.Торговля	◯	◯	◯

29.Назовите факторы, влияющие (препятствующие) на развитие эффективной и устойчивой цепи поставок скоропортящейся продукции

34.Выберите тип информационно-консультационной поддержки, который поможет вам улучшить логистику поставок скоропортящейся продукции

- ◯ -пояснения законодательства в Вашей сфере деятельности
- ◯ -информация о возможных видах поддержки
- ◯ -консультации по получению разрешений и сертификатов (фитосанитарных, экологических, налоговых, сертификационных и пр.)
- ◯ -обучение с методическими рекомендациями по логистике хранению продукций с соблюдением требований
- ◯ -информация о государственных закупках и условиях участия в них
- ◯ Другое: _____

35.По каким вопросам вы испытываете потребность в обучении? (Выберите 3 наиболее важных ответов)

- ☐ -планирование и прогнозирование цепей поставок
- ☐ -учет и налог в цепях поставок
- ☐ -методы продвижение товаров/услуг
- ☐ -методы складирование и хранения
- ☐ -упаковка
- ☐ -управление холодовым / морозильным оборудованием
- ☐ -взаимодействие с участниками рынка и поставщиками: транспортные логистические, информационные, маркетинговые, складские и пр.
- ☐ Другое: _____

36.Что на ваш взгляд нужно для развития устойчивых цепей поставок скоропортящейся продукции? (Выберите 5 наиболее важных ответов)

Форвардные закупки *- закуп у сельхозпроизводителей продукции на условиях предварительной оплаты после предоставления обеспечения и доплатой после поставки сельскохозяйственной продукции в осенний период*

- ☐ 1)принятие закона «О скоропортящейся продукции» против мошенничества в

36.Что на ваш взгляд нужно для развития устойчивых цепей поставок скоропортящейся продукции?
(Выберите 5 наиболее важных ответов)

Форвардные закупки *- закуп у сельхозпроизводителей продукции на условиях предварительной оплаты после предоставления обеспечения и доплатой после поставки сельскохозяйственной продукции в осенний период*

- [ ] 1)принятие закона «О скоропортящейся продукции» против мошенничества в торговле скоропортящимися сельскохозяйственными продукциями
- [ ] 2)разработка и принятие закона «О поддержке холодильной цепи» (холодовой цепи) с целью обеспечения продовольственной безопасности
- [ ] 3)планирование и оптимальное (близкое) размещения логистической инфраструктуры в местах массового производство и скопления потребителей;
- [ ] 4)меры по снижению количество посредников в цепях поставок;
- [ ] 5)разработка четкого и понятного механизма взаимодействия сельскохозяйственных производителей продукций с другими участниками рынка: транспортники, складские хозяйство и др.;
- [ ] 6)цифровизация бизнес-процессов в логистике цепей поставок от производителя до потребителя;
- [ ] 7)планирование и прогнозирование производства и продаж продукций с

- [ ] логистической инфраструктуры (складов, распределительных центров, формирование автопарков);
- [ ] 12)контроль и оптимизация производственных и транспортно-логистических затрат
- [ ] 13)контроль и регулирование цен на свежую продукцию;
- [ ] 14)внедрение системы автоматизированного управления потребности в товарах, запасах и ресурсах (SCM, ERP, WMS, TMS и др.)
- [ ] 15)увеличение количества лабораторий по сертификации и контролю качества продукций;
- [ ] 16)разработка стандартов качества менеджмента по управлению цепями поставок.
- [ ] 17)Предоставлять все необходимые условия и услуги в одном месте: торговля, хранение, обработка, сертификация безопасности пищевых продуктов, таможенное оформление, транспорт, доставка, маркетинговые консультативные услуги
- [ ] 18)Содействие в «сглаживании» проблемы сезонности культур и улучшить динамику и стабильность цен для мелких производителей, а также для малых и средних предприятий агробизнеса.
- [ ] 19)расширение объема и наименование скоропортящейся продукции с использованием механизма форвардных закупок

APPENDIX F

Correlation coefficients and possible locations of wholesale distribution centers

Table F.1. Correlation coefficients reflecting the relationship between the indicators

	X1	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*	*X9*	*X10*	*X11*	*X12*	*X13*	*X14*	*X15*	*X16*	*X17*	*X18*	*X19*
X1	1																		
X2	0,070	1																	
X3	0,051	-0,003	1																
X4	-0,049	0,009	0,630**	1															
X5	-0,062	0,195*	0,654**	0,895***	1														
X6	0,859***	0,215*	-0,080	-0,103*	-0,133*	1													
X7	-0,072	0,057	0,178*	0,552**	0,585**	-0,075	1												
X8	-0,064	0,052	-0,070	0,150*	0,111*	-0,047	0,214*	1											
X9	-0,070	0,051	0,026	0,220*	0,184*	-0,060	0,238*	0,903***	1										
X10	-0,168*	-0,074	-0,146	0,135*	-0,115*	-0,046	-0,237*	-0,079	-0,032	1									
X11	-0,381*	-0,055	-0,068	-0,055	-0,033	-0,336*	-0,169*	-0,052	-0,083	0,795***	1								
X12	-0,320*	-0,068	0,351*	-0,037	0,314*	0,186*	-0,163*	0,346**	0,175*	0,695***	1,000	1							
X13	0,092	-0,030	0,549**	0,658**	0,450**	0,626**	0,042	0,432**	0,108*	0,014	0,024	0,0281	1						
X14	0,123*	0,030	0,574 **	0,426**	0,429**	0,545**	0,063	0,346**	0,218*	-0,097	-0,085	-0,084	0,248*	1					
X15	-0,190*	0,036	0,490**	0,569**	0,559**	0,698**	0,651	0,473**	0,480**	-0,120*	-0,041	-0,024	-0,078	0,005	1				
X16	0,117*	0,041	0,151*	0,154*	0,247*	0,506 **	0,215	0,532**	0,250*	-0,172*	-0,166*	-0,071	0,037	0,016	0,076	1			
X17	0,026	0,080	0,385**	0,518**	0,545**	0,481**	0,347	0,230*	0,317*	-0,205*	-0,181*	-0,016	0,021	0,022	0,065	0,014	1		
X18	0,760***	0,128*	-0,144*	-0,093	-0,074	0,778***	0,021	0,262*	0,017	0,126*	0,086	0,103*	0,115*	0,248*	0,130*	0,310*	0,493*	1	
X19	0,651**	0,043	-0,135*	-0,148*	-0,174*	0,586**	0,069	0,315*	0,021	0,398*	-0,103*	-0,191*	-0,053	-0,035	-0,058	0,023	0,032	0,562**	1

Note: Calculated by the authors on the basis of data from the Bureau of National Statistics of the Republic of Kazakhstan (2022), the correlation coefficient is reliable at: *p<0.05; **p<0.01; ***p<0.001.

The list value N=204

Table F.2 - Potential locations and center of gravity for selecting the radius of action of the WDC

Regions/district or city agglomeration	Average rating by factor loads (F1-F5)	The volume of transportation from the district center to the proposed WDC, t	WDC storage				WDC distribution		WDC trade	
			Center of gravity, thousand tons km	Sum of center of gravity, km	Rating* by (F1+F3+F5)/3	Quantity	Rating* by (F2+F4)/2	Quantity	Rating* by F2	Quantity
Almaty:	**1,425**	**4054,0**	**1447523,4**	**357,0**	**6,177**					
Alakolsky	0,942	153,7	156,7				1,244	1		
Enbekshikazakh	1,127	800,8	161504,2		2,286	1				
Karasai	0,879	254,7	12312,8		1,281	1				
Ili	0,661	406,5	77243,9		1,159	1				
Akmola	**0,665**	**3085,5**	**1308932,6**	**424,2**	**6,635**					
Aktobe	**2,019**	**716,4**	**177641,3**	**248,0**	**-4,410**					
Aktobe city	0,981	81,4	135,6		0,430				1,112	1
Zhambyl	**1,271**	**2578,0**	**1002831,3**	**388,9**	**0,475**					
Korday region	-0,543	410,5	225767,1		1,010	1				
Shu district	0,584	833,6	362622,7		1,047	1				
Karaganda	**3,325**	**1377,2**	**443908,3**	**322,3**	**-2,667**					
Karaganda city agglomeration	0,662	35,0	58,3		-0,470				1,678	1
Zhezgazkan city agglomeration	0,187				0,345		1,2083	1		
Abai	0,863	207,7	26652,7		1,129	1				
Bukhar-Zhyrau	0,615	204,8	38573,2		1,105	1				
Kostanay	**3,497**	**2514,1**	**665015,2**	**264,5**	**3,306**					
Karasu	0,111	317,5	101056,2		1,406	1				
Kostanay city agglomeration	-0,487	305,7	3566,6		1,521	1				
Mangistau	**-1,304**	**25,2**	**8567,1**	**340,6**	**-4,770**					
Beineu	0,089						1,1295	1		
North	**-1,503**	**3678,7**	**1138718,5**	**309,5**	**6,694**					

Kazakhstan										
Kyzylzhar	0,648	360,7	32460,0		1,388	1				
Taiynshinsky	-0,649	481,9	145361,3		1,613	1				
Turkestan	**0,976**	**3952,8**	**1553670,8**	**393,0**	**2,033**					
Sairam	0,436	417,0	130665,9		1,118	1				
Saryagash	-0,798	481,8	203146,8		1,281	1				
East Kazakhstan	**-1,242**	**3077,7**	**1397588,3**	**454,1**	**-0,391**					
Ayaguz	0,451	215,3	21354,3		0,345		1,5782	1		
Kurchumsky	0,649	312,7	34572,6		0,451		1,6607	1		
Astana city agglomeration	0,979				-0,601		1,738	1	4,417	1
Almaty city agglomeration	0,571				-0,204		6,574	1	12,638	1
Shymkentskaya city agglomeration	0,611				0,238				2,611	1
Total: 25						**13**		**7**		**5**

Note: *ratings are determined based on the ranking of average F1-F5 indicators, ** potential placements are selected if the estimated value of ratings is greater than one

APPENDIX G

Wholesale Distribution Center Construction Project Performance Indicators

Table G.1 - Main requirements and parameters for wholesale distribution center projects

Parameters	Characteristic		
	WDC storage	WDC distribution	WDC trade
appointment	a real estate object intended for storage and performance of procurement, preparatory, distribution and (or) other operations with food products, primarily located near the places of production of fruit and vegetable products and crop products and providing domestic agricultural producers, participants in foreign trade activities and entities of domestic trade with services for the acceptance, storage and primary processing (cleaning, calibration, sorting, packaging and other services) of agricultural products for subsequent sale on the domestic and foreign markets	A wholesale distribution center is a real estate object intended for temporary storage (up to 14 days) and distribution of food and non-food products to sales facilities and provision of logistics services for temporary storage and reloading (transshipment) of goods for the needs of retail facilities	a wholesale and distribution center for trade is a real estate object that provides participants in foreign trade activities and (or) entities in domestic trade with unimpeded access to retail space, storage areas and other premises within the infrastructure trade and logistics complex for the period of trade activities;
Requirements for the WDC			
1) Main zones of the WDC	1) terminal; 2) control; 3) warehouse; 5) technological; 6) administrative.	1) terminal; 2) control; 3) warehouse; 5) technological; 6) administrative. Additionally, the following is required: 1) cross-docking; 2) trade and exhibition area	1) terminal; 2) control; 3) warehouse; 5) technological; 6) administrative. Additionally, the following is required: 1) cross-docking; 2) temperature box; 3) trade and exhibition area; 4) trade area; 5) customs control area (if necessary)
2) Technical equipment of the WDC	1) controlled temperature conditions in the warehouse area and pavilions; 2) availability of places for inspection of goods; 3) availability of loading and unloading equipment, certified weighing equipment;		

	4) availability of modern means of mechanization of loading and unloading operations; 5) availability of a ramp-awning for trucks; 6) maximum intensity lighting at inspection areas, entrances and exits, vehicle reloading areas; 7) availability of a video surveillance system that provides the ability to monitor objects (territory) in real time with data storage for the last thirty calendar days, located in buildings, on sites, as well as along the entire perimeter; 8) availability of access roads for vehicles; 9) availability of areas for parking and maneuvering heavy vehicles; 10) the presence of a territory with a hard surface along the entire perimeter, closed from the adjacent territory by a fence; 11) the presence of an automated system for accounting of goods; 12) the presence of a fire alarm system and an automatic fire extinguishing system, a security alarm system; 13) the presence of a backup power supply system; 14) in cases provided for by technological specialization, the WDC are additionally equipped with chambers for shock and pre-shock freezing of products		
3) Main components of the WDC	Administrative and utility rooms; terminals with warehouses, refrigerated areas; access roads; loading and unloading areas; workshops for processing milk, meat, vegetables, fruits and berries; workshops for finishing vegetable products, fruits and berries; laboratories for checking product quality; service facilities (hotel, parking lot, auto repair shop)	Administrative and utility premises; terminals with warehouses, refrigerated areas; access roads; loading and unloading areas; wholesale and retail trade pavilions for the sale of agricultural products; laboratories for product quality testing; service facilities (hotel, parking lot, auto repair shop);	Administrative and utility premises; terminals with warehouses, refrigeration areas; access roads; loading and unloading areas; wholesale and retail trade pavilions for the sale of agricultural products; laboratories for product quality testing; service facilities (hotel, parking lot, auto repair shop); Cash & Carry store; customs terminal
Quantity	14	5	5
Area of land plot per 1 (total) WDC on average, ha	15 (210)	20 (100)	10 (50)
Area of complex per 1 WDC (total), sq.m	15 000,0 (210000)	50 000,0 (250000)	10 000,0 (50000)

Average annual volume of raw material processing or transshipment capacity per 1 WDC (total), tons	20 000,0 (280000)	500 000 (2500000)	30 000,0 (150000)
Product range	5-10	5-10	More than 10
Suppliers	large, medium-sized enterprises, individual entrepreneurs, peasant farms, households		
Consumers	retail network, wholesale markets	retail facilities (chains, shopping malls, supermarkets, stores)	
Location	near the production sites of fruit and vegetable products and plant products	within the city limits or in the suburbs	near consumers (within or inside cities)

Table G.2 - Key indicators of the WDC construction project

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Investments million tenge			14 656,3	29 312,6	43 968,9	58 625,2	73 281,6	87 937,9	102 594,2	117 250,5	131 906,8	146 563,2	161 219,5	190 532,1	205 188,4	219 844,8
Total volume of products passing through the WDC, t	85 450,4	168 076,6	485 089,4	720 182,7	1133 797,7	1507 891,3	1779 494,0	2183 465,6	2412 854	2725 059	3037 264	3349 469	3661 674	3973 879	4286 084	4598 289
Capacity	35 000	40 000	50 000	60 000	70 000	80 000	90 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000
1st WDC, t	2	4	9	11	16	18	19	24	24	24	24	24	24	24	24	24
Number of WDC s	70 000	160 000	450 000	660 000	1120 000	1440 000	1710 000	2400 000	2400 000	2400 000	2400 000	2400 000	2400 000	2400 000	2400 000	2400 000
Capacity of all WDC s, t	1800	2000	2500	3000	3600	4000	4500	5000	5000	5000	5000	5000	5000	5000	5000	5000

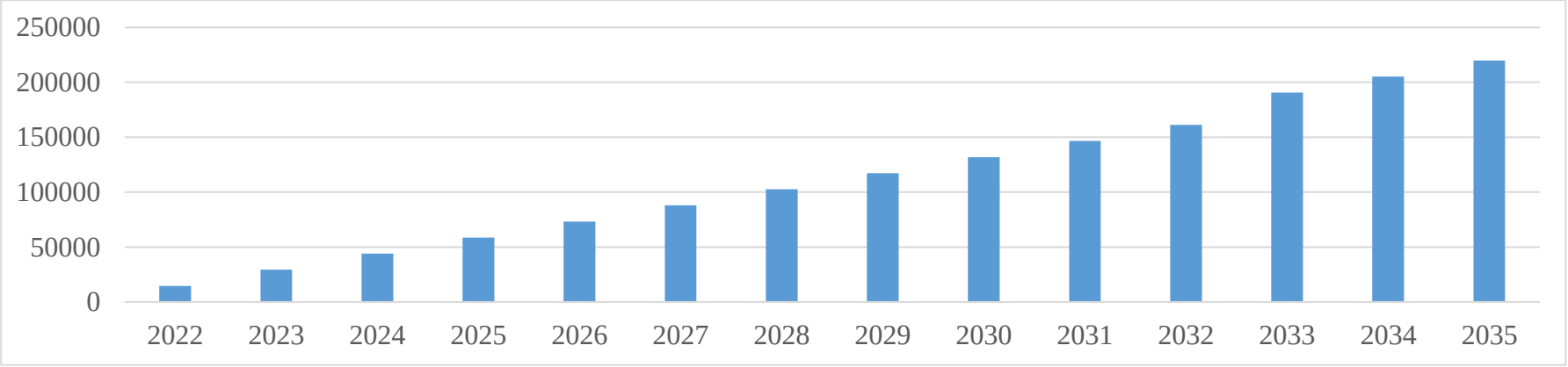


Figure G.1 - Investments under the state program for the development of the WDC network, million tenge

Table G.3 - Conditions for lending to the WDC project

№	Project name	Parameter characteristic
1	Loan amount, million tenge	201,600.0
2	Loan rate, % per annum	15.0
3	Loan term, years	15
4	Monthly payment amount, million tenge	1,221.32
5	Total payment amount, million tenge	219,844.8
6	Loan overpayment, tenge (%)	18,244.0 (9.0%)
7	Start of payments	January 2022
8	End of payments	December 2035