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## Current State and Prospects of Grain Logistics Development in Ukraine

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► **Abstract.** Considering the lack of elevator capacities and the imbalance in the distribution of commodity flows due to the occupation and blocking of seaports, other modes of transport are currently unable to provide the required volumes of grain for export, and the safety of the harvest is under threat. Therefore, the issue of logistics development in war conditions is urgent, which determines the relevance of the study. The purpose of the study is to analyse the pre-war and current state of the grain logistics system and to identify efficient ways of its development during the war and after its end. The study is based on the following methods: dialectical, historical, monographic, abstract-logical, systematic and classification, analytical forecasting, statistical, economic, economic-mathematical, and graphical. Investigated the length of roads in Ukraine and forecasted the reduction of roads due to military operations. The analysis of export-import logistics was performed, and the advantages of maritime transport were determined, the share of which in exports was 99.5%, and in imports, the majority of transportation was by rail (44.9%). The state of elevator capacities was explored, the lack of which in 2021 amounted to 18.3 million tons (17.4%), the volume of their losses due to hostilities in 2022 was determined – 12.6 million tons (22.2%), the impact of the war on the growth of prices for grain storage services was analysed. A critical analysis of the infrastructure projects of the National Council for the Restoration of Ukraine from the Consequences of the War is performed and identified their disadvantages. The proposed measures to improve logistics will allow for reducing the lack of elevator capacities, increasing grain exports, accelerating the movement of products across the border and reducing logistics costs. The results of the research can be used by public authorities in the establishment of programs for the development of agrarian logistics, business structures – for the development of infrastructure projects and improvement of logistics systems of enterprises, scientists – for further investigation of grain logistics problems and determining the prospects for its development

► **Keywords:** elevator capacities, tariffs, ports, transport, intermodal system

### ► Introduction

The purpose of modern logistics in agriculture is to improve the development and efficient management of commodity, information, and financial flows in the supply, production, and marketing of agricultural products. The achievement of the purpose is based on the eight components of the "logistics mix of 8 P", which include the requirement to deliver the right product of the right quality in the right quantity to the right consumer in the right place at the right time at the right cost [1].

Grain production is the foundation for the development of leading industries in Ukraine's

economy. Therewith, Ukraine has all the necessary conditions for growing grain crops: a favourable climate, fertile soils, rich water resources, extremely favourable geopolitical location, etc. Thus, "the potential capabilities of the domestic agro-industrial complex for the production of high-quality grain are such optimistic that they allow Ukraine to claim a leading position in the world grain market" [2].

At the current stage of development of the agricultural sector of the economy, considering the impact of the war, the key purpose of the development of agricultural logistics, in particular its grain

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sector, in Ukraine is to ensure the most efficient interaction between public authorities, agricultural traders and agricultural producers.

The grain industry of the country occupies a leading position in ensuring food security. In addition, grain exports are one of the main sources of foreign exchange earnings. Thus, in 2021, 50.8 million tons of grain were exported for the amount of 12.3 billion USD, which amounted to 18% of all export earnings.

Transportation, primary processing (cleaning, drying), storage, and loading of vehicles with grain require extensive transport, storage, and information infrastructure: roads, railways, elevators, port grain terminals, and reliable means of communication and information transfer.

Even before the war, the logistics infrastructure had many deficiencies that hurt the conditions of transportation and storage of grain, the information system did not correspond to modern requirements. The roads did not correspond to international standards, resulting in delays in product delivery, and significant losses during transportation, a high degree of physical and moral deterioration of trucks. Rail transport was characterised by a lack of specific wagons for grain transportation, a high degree of wear and tear, and locomotives, insufficient electrification of the railway, high freight tariffs, and long delays in the development of freight trains, etc. In the country, there was a lack of elevator capacities for storage and primary processing of products, a low level of automation of loading and shipment of grain at existing warehouse complexes, and imperfection of access roads caused long queues of vehicles. Insufficient development of inland water transport did not allow increasing the volume of transportation of agricultural products in a cheaper way. The largest river terminals in terms of transshipment volumes are owned by only two companies – “Nubilon” and “Ukrichflot” – more than 75%, although smaller companies have recently invested in the development of river transport.

After the outbreak of the war, the problems of grain logistics intensified primarily due to the blockade of seaports, as sea transport is the most efficient in the transportation of grain for export. The blockade has disrupted logistics chains, significantly increased the load on the least efficient road transport for the transportation of large volumes of grain, and increased the load on rail transport. In general, this did not solve the problem, despite the unblocking of some ports from August 1, 2022. In 2021, out of 50.80 million tons of exported grain, 50.56 million tons, or 99.5% were transported by sea.

To assess the scale of problems in grain logistics during the war and identify ways to solve them, it was necessary to analyse the state of modern logistics systems in Ukraine. The purpose of the study is to develop tasks and identify efficient measures to overcome the crisis that arose in grain logistics as a result of the war based on the analysis, to outline the ways of its development in the post-war period.

The result of the research was scientifically based proposals for improving the functioning of

the grain logistics system during martial law and identifying the main tasks for its development in the postwar period.

### ► Literature Review

The issues of the development of logistics systems in general and in the agricultural sector, in particular, are covered in the works of many Ukrainian and foreign scientists.

Andréa Leda Ramos de Oliveira, Karina Braga Marsola, Ana Paula Milanez, and Sandra Liegê Renner Faretto [3] noted that “the lack of investment in logistics infrastructure limits the growth of its potential”. They identified rail and water transport as the most efficient for long-distance transportation of agricultural products with low added value. They widely used the concept of “intermodal transport” as a combination of at least two modes of transport, where the longest part of the route runs either by rail or by water.

The research of Natalia Wagner [4] is to develop a system of ranking Polish voivodeships by the level of their material and technical potential. Three arrays of variables were used for this purpose. The calculation is based on three areas of research: transport infrastructure (road and rail transport), warehouse capacities, and activities of companies providing the logistics process. The researcher used one of the methods of numerical systematics proposed by Z. Hellwig. The results of the study allow the authorities to determine the logistics potential of the regions by the sustainable transport development strategy of the country.

Lumír Pečenýa, Pavol Meško, Rudolf Kampfb, & Jozef Gašparík [5] in their research defined modern logistics as “an interdisciplinary science that improves the quality of business processes and allows companies to respond to market and customer requirements faster”. The study proposes methods for optimising logistics processes for more efficient use of vehicles in combination with modern technologies and human resources.

In their studies, A. Vorona, L. Istomin, S. Kalmykov, & M. Lyashenko [6] determined the place of customs logistics in ensuring the movement of grain crops as a factor in the growth of foreign trade. To ensure a competitive advantage in the world grain market, the study proposes to establish a technological scheme of interaction between entities, in particular, government agencies, exporters and carriers participating in the world grain market.

The research of M. Grazia Speranza [7] is devoted to solving the problems of interaction between the subjects of the logistics system, in particular transport, to improve the quality of decision-making through using Operational Research (operations research – the application of scientific methods and approaches (mathematics) to solve decision-making problems, particularly in business management and public administration). Determination of modern trends and the place of the latest technologies, in particular IT, in the development of logistics, were the subject of the author’s research.

J. Mehmman, F. Teuteberg [8] investigated the feasibility and efficiency of involving a third-party logistics service provider in the transportation process, defined the functions of the participating parties and the implementation of a modified transportation planning process.

Research results indicate cost savings of up to 38% and a reduction of environmental pollution when using a third-party carrier as a link in the logistics chain. According to the authors, this approach contributes to achieving the purposes of sustainable development of the transport system.

Kamal Lamsal, Philip C. Jones, & Barrett W. Thomas [9] in their research substantiated the optimal logistics system through the establishment of a model that considers two factors: the presence of a specific number of farms and the lack of premises for storing agricultural products.

The objective of the model is to minimise the amount of road transport required to transport harvested crops from the field to storage facilities or processing plants. It is accomplished by reducing vehicle idle time in traffic jams at the destination by optimising the timing of the start of crop harvesting in individual farms. The researchers propose a two-phase approach that divides the problem, first by determining the start of harvesting on farms, and then determining the number of vehicles required to transport the produce.

Elham Mardaneh, Ryan Loxton, Shiv Meka, & Luke Gamble [10] in their study defined a decision-making system designed to support farmers in choosing different approaches in the process of harvesting grain and its distribution. One such approach may be the decision to store products in their warehouses or use the warehouses of third-party enterprises located at a considerable distance from the grain producer. The system, which is based on the application of a mathematical model and considers several factors, such as the number of crops, grain moisture, possible crop losses, loss of quality due to adverse weather conditions, etc., is the foundation for the construction of an integrated logistics scheme (fourth-party logistic), which considers all external and internal factors to achieve maximum efficiency. The variables used in the mathematical models are the yield of each crop, harvest time, transport, and storage costs. According to the results of the study, the conclusion is substantiated that storage at own storage facilities is more efficient due to the reduction of harvesting time and losses, the overall yield increases, and, thus, the profits of agricultural producers increase.

Theoretical and practical aspects of logistics development in agriculture of Ukraine, in particular, the introduction of effective logistics approaches in production, are devoted to the works of I.G. Smirnov, T.V. Kosareva [11, 12], O.V. Pavlenko, T.V. Volkova [13, 14]. The prospects for the development of foreign logistics in general and in the context of the agreement with the EU were studied by O.P. Velichko, & S.I. Hrytsenko [15, 16].

A significant contribution to the development of grain logistics, which is the subject of this study,

was provided by: V.A. Kolodiichuk [17], who proposed a model for the efficient development of logistics of the grain subcomplex of the agro-industrial complex of Ukraine, considering its integration into the world logistics systems; O.I. Gutorov [18], who substantiated the theoretical and methodological foundations of using vehicles in the logistics of agricultural production, where a significant place is occupied by the transportation of grain; L.M. Volynets [19], which considered the issue of improving the logistics system for grain exports, including an assessment of the economic efficiency of container transportation. The area of research of I.V. Yehorashchenko [20] was the system of logistics in the grain market, which he proposes to improve through the adoption of a national development program based on the experience of developed countries, reforming the legal mechanism of the logistics system of agriculture, development, and implementation of state financing for the development of grain logistics, development of investment attractiveness of logistics infrastructure through the introduction of a system of tax and customs benefits.

The studies in the field of agricultural logistics that were analyzed by the authors are thorough and valuable in scientific terms, but all of them were performed in peacetime and do not reflect the specific features of the functioning of agricultural logistics systems in a country at war. Thus, the subject of this research, designed to analyse and improve the grain logistics system of Ukraine during and after the war, is extremely relevant and timely.

### ► Materials and Methods

The theoretical and methodological foundation of the research in the study was the dialectical method of scientific cognition, a systematic approach to the study of the economic essence of logistics in general and its features in Ukraine, in particular, structural changes during military operations. Scientific works of domestic and foreign scientists on the development and functioning of logistics infrastructure in general and grain logistics in particular, legislative and regulations of Ukraine have become the theoretical foundation of the research.

To substantiate the theoretical provisions of the study and analysis of the evolution of theoretical approaches to the nature of the concept of logistics and agrarian logistics, in particular, the historical method and the method of theoretical knowledge were applied.

The monographic method was used in the process of processing the literary sources on the defined subject of the research.

Abstract-logical and dialectical methods have become the scientific foundation for the determination of the terminology regarding the definition of the general term "logistics" and the narrow terms "agricultural logistics" and "grain logistics" in the process of studying scientific publications and developing conclusions and proposals.

System and classification methods are used in the research to determine the factors of efficiency

of logistics systems in agriculture, and the development of new approaches to the classification of agricultural logistics entities.

System and classification methods are used in the research to determine the factors of efficiency of logistics systems in agriculture, and the development of new approaches to the classification of agricultural logistics entities. Notably, due to military actions, according to the Law of Ukraine “On the Protection of the Interests of the Subjects of Submission of Reports and Other Documents during the Period of Martial Law or State of War” dated 03/03/2022 No. 2115-IX [21], access to current statistical information for 2022 is limited. Thus, data from Internet sources were widely used for the study.

The economic and mathematical method is used to calculate individual indicators of the functioning of the agrarian logistics system and their forecasting – the volume and proportion of deficit or surplus of grain storage capacities in the regions of Ukraine. The calculation was based on the available capacity for grain storage and gross harvest by region.

The visual representation of individual dynamic series is performed using a graphical method, for example, the dynamics of volumes and changes in the structure of export-import of agricultural products by different modes of transport and the operational length of the routes of Ukraine and the dynamics of grain transportation by mode of transport.

The main stages of the research were:

a) analysis of theoretical studies of Ukrainian and foreign scientists on the development and functioning of logistics systems, in particular in the agricultural sector of the economy;

b) analysis of the state of logistics in Ukraine in general and the grain sector in particular before the war, for example, the length of transport routes and volumes of domestic grain transportation and export-import operations by type of transport;

c) determination of the volume of losses of logistics infrastructure during military operations, in particular losses of elevator capacities and transport;

d) investigation and systematisation of the national policy areas for improvement of grain logistics considering the losses caused by the war and their critical analysis;

e) defining the main tasks and identifying their recommendations for improving the development of grain logistics during the war and after its end.

The initial sources of information used in the research process were: the regulatory framework of the state economic regulation of logistics systems of Ukraine, statistical and analytical data of the Ministry of Agrarian Policy and Food of Ukraine, State Statistics Service of Ukraine, State Customs Service of Ukraine, publications of domestic and foreign scientists and practitioners, operational and annual reports of international organisations, the results of the author’s observations on the functioning of logistics systems in the leading countries of the world, and scientific electronic sources of information on the Internet, personal observations and research.

## ► Results and Discussion

The term “logistics” appeared in the ancient world and meant “the art of reasoning”. Opinions on the essence of logistics have been transformed over the centuries: from the ancient world to the beginning of the Middle Ages, a “philosophical” essence was developed, which consisted in formalising the implementation of calculations and distribution of products. From the Middle Ages to the 60s of the 20<sup>th</sup> century, the essence of logistics was developed under the influence of numerous wars and consisted of the spatial and temporal movement of troops and military cargo. From the 60s to the present day – the “civilian period”, during which logistics competencies have been transformed from the physical movement of goods and phase and functional logistics to enterprise logistics and logistics systems, and finally – supply chain logistics [22]. During this period, “logistics” began to develop as a science. In Ukraine, this science began to develop in 1991 after gaining independence.

The development of logistics and the definition of the term “logistics” have been contributed by several Ukrainian scientists. Thus, in the author’s opinion, a rather extensive, comprehensive concept of “logistics” was given by V.A. Kolodiichuk: “Logistics is a scientific and practical field of relations between market elements, which involves a functional study of material and related information, financial and service flows on the way from the primary source of raw materials to consumers of final products to optimise the properties of a particular system and implement its target function in obtaining a synergistic effect” [23]. Using the integration approach, N.M. Tyurina, I.V. Goy, I.V. Babii interpret logistics as “the science of integrated management of material and related flows in various (including economic) systems” [24]. Consider that this definition is too general, and one-sided and does not explain the essence of the term, the place of its elements in the process of establishing a logistics chain. I.O. Zharska concisely and informatively defined that “logistics is to ensure maximum consistency of all operations related to the movement of resources between different links of the supply chain [25]”. The most precise definition of logistics, in the author’s opinion, was given by E.V. Krykavskiy: “Logistics is the process of planning, controlling and managing the development of material flow, its warehousing, and integrated information from the place of production to the place of consumption to adapt to the consumer’s demands” [22]. Admittedly, all these definitions fully correspond to the essence of the concept of “grain logistics”. But grain logistics, in particular, and logistics in agriculture, in general, have their characteristics, two of them, the author notes. First of all, contrary to, for example, industrial logistics, the beginning of the development of logistics chains is connected with the place of production, and with clear time limits, which are determined by the harvest period. Secondly, the conditions of grain storage are specific, namely: temperature and humidity conditions, the necessity of aeration during long-term storage,

ensuring the absence of pests, rodents, and diseases using chemical protection, a high level of mechanisation, special training of workers servicing the process of storage of products. Thus, the definition of grain logistics developed by the author is the process of planning, development, control, and management of grain logistics chains to achieve the maximum economic effect by all entities at all stages of transportation, storage and delivery of products to the consumer, considering the narrow time frame of the process start and specific storage conditions.

The main purpose of the development of modern logistics in the agrarian sector of the Ukrainian economy is to establish the most efficient interaction between public authorities, business organisations (traders), and agricultural enterprises.

The world economy is developing rapidly, currently, economic relations between the subjects of the world market are globalised and establish conditions for the comprehensive integration of

economic sectors. Transport occupies a leading place in the process of sustainable economic development. Transport logistics has a complex multilevel structure, and the established logistics chains are diverse and multifunctional, they involve different types of transport in the process of cargo delivery from the manufacturer to the end consumer. The development of logistics transport systems occurs in a competitive environment in the markets of domestic and international transportation. For domestic transportation of products, an extensive system of roads in Ukraine is used.

By length, the longest routes are highways, the length of which in 2021 was more than 160 thousand km. The second place in terms of the length of routes is occupied by the railway, the length of which was 19.8 thousand km (excluding the occupied territories, the network of which is not currently in operation), of which more than 47.2% is electrified, and the least developed network of river transport routes – only 2 thousand km (Fig. 1).



**Figure 1.** Operational length of Ukrainian railways and dynamics of grain transportation by types of transport  
**Source:** Based on the data of the State Statistics Service of Ukraine [26]

According to the volumes of cargo transportation, which are indicated in the same figure, railway transport undoubtedly dominates, the domestic freight turnover of which over the past 5 years ranged from 33.6 to 40.0 million tons of grain, and in the structure of all transportation, its share ranged from 62.3% to 73%. During the same period, from 12.7 to 19.3 million tons of grain were transported by road, or from 25.9% to 35.8% in the structure of domestic grain

transportation. River transport accounts for the smallest volume of traffic – 0.3-0.6 million tons or 0.4-1.1%.

Considering the war with Russia, which resulted in the loss of a significant part of Ukrainian territories, it can be predicted by the end of 2022 a reduction in the length of roads by 40.9 thousand km compared to 2021, a reduction in the length of railways by 4.9 thousand kilometres, the length of river routes will be reduced by 0.2 thousand km.

Compared to last year, the level of operation of alternative modes of transport to sea in grain logistics has increased: rail – from 33.6 million tons (62.3%) in 2021 to 38.8 million tons (60%) in 2022, road – from 19.3 million tons (35.8%) to 22.75 million tons (35%), river – from 0.5 million tons (0.9%) to 3.25 million tons (5%), respectively [26]. Considering the loss and blocking of the Black Sea and Azov ports, it is expected that the volumes of grain transportation by rail, road and river transport will increase.

Railway transport in Ukraine is the leading industry in the road transport complex of the country, which provides almost 82% of freight and 36% of passenger traffic carried out by all modes of transport.

In terms of freight traffic, Ukrainian railways rank fourth on the Eurasian continent, behind only the railways of China, Russia and India.

One of the most significant problems, according to L.M. Volynets, particularly during traffic peaks, is the low capacity of the port railway infrastructure. Currently, the maximum capacity of port railway stations is about 2,100 wagons with grain. As one of the ways to overcome this adverse situation, she suggests “increasing the number of stations that can develop routes” [19]. However, in the author’s opinion, being in a deep crisis, Ukrzaliznytsia will not be able to invest significant funds in the development of any number of stations to establish the possibility of developing routes. Otherwise, all costs will be covered by the growth of tariffs, which have already become exorbitant for many companies using railway transport services. Consider it quite appropriate for her proposal to establish conditions for increasing the capacity of railway stations, which requires significantly lower costs and is quite an efficient solution to the problem.

Road transport occupies a leading position in transport logistics. Road transport is one of the main instruments of influence on the economic development of the country – more than 100 thousand road carriers serve about 64 per cent of domestic freight turnover.

In grain logistics, it is an indispensable means of delivering products to farm warehouses or elevators, to railway and port terminals or even straight to the customer both inside and outside the country.

In general, the road transport of Ukraine corresponds to the economy’s demands for the transportation of goods, although the structure of the truck fleet is unbalanced, a significant number of vehicles by their technical and economic parameters (ergonomics, body type, environmental friendliness, efficiency, carrying capacity) do not fully comply with modern requirements. The renewal of the fleet is slow, as indicated by about 70% of morally and technically outdated rolling stock.

All over the world, including Ukraine, the demand for inland waterway transportation services

is growing significantly. Considering the deep economic crisis in the country, the constant growth of prices for energy resources, frequent interruptions in the work of road and rail transport due to military operations in the eastern and southern regions of the country, cargo owners, in particular grain traders, are trying to reduce transport costs and optimise logistics flows by transporting products by river transport. Thus, this type of transport is becoming rather relevant in Ukraine. Inland water transport is gradually recovering its lost position and is increasingly competing with other modes of transport.

Based on the data of the Ministry of Infrastructure of Ukraine, it allows increasing the annual volume of cargo transportation up to 45 million tons (including 30 million tons of export products, and 15 million tons of import products). The modernisation of existing gateways may become a condition for such growth. [27].

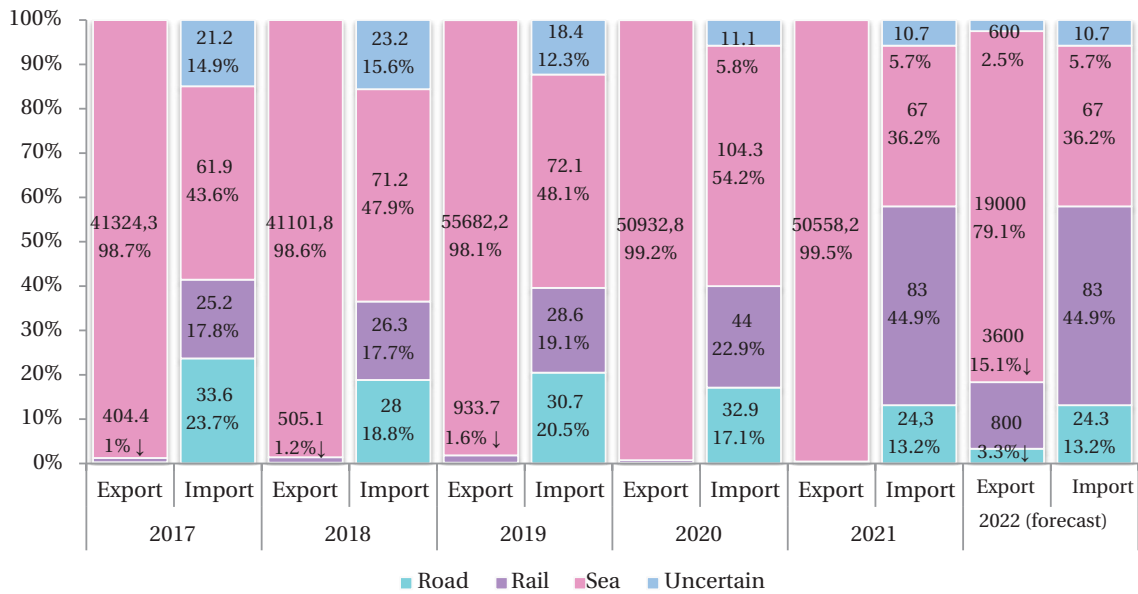
The maritime transport sector of the logistics system of Ukraine is a universal complex that provides the demands of the Ukrainian economy in the transportation of export products.

The domestic port and transport industry have several advantages, particularly significant for grain logistics:

- 1) adaptability for the transshipment of significant volumes of grain products and oilseeds;
- 2) powerful production base, which allows performing cargo handling;
- 3) the favourable location of ports, which allows efficient servicing of the flow of transit cargo;
- 4) a developed regulation framework that facilitates the attraction of both domestic and foreign investments in the development of ports;
- 5) high human resources potential.

Before the war, the seaport system of Ukraine had 18 ports, 5 of which are located in the temporarily occupied Crimea. The total capacity of ports and terminals located on the continental part was 313.3 million tons. In 2021, more than 50 million tons of grain were transhipped through seaports – 4.1% more than in 2020. The largest volumes of grain processing were performed in the following ports: Chornomorsk – 14.55 million tons (an increase of 9.2 % compared to the previous year), Mykolaiv seaport – 12.9 million tons (a decrease of 2.1 %) and “Pivdennyi” – 9.7 million tons (+7.2 %) [27].

The maritime transport complex is a multifunctional structure that satisfies the national economy’s requirements for transport support of export transportation (Fig. 2). By 2022, almost 100% of the export cargo was shipped by sea. The developed infrastructure of ports and port elevators allows the shipping of significant volumes of grain by sea. The share of other modes of transport in grain exports is not significant.



**Figure 2.** Export-import of grain by different types of transportation

**Notes:** without air transport and postal transportation due to insignificant volumes

**Source:** developed by the authors based on the data of the State Customs Service of Ukraine [28]

Considering the imbalance between sea and other modes of transport in the export of grain products until 2022, believe that the logistics system has developed inefficiently and one-sidedly. After all, during the blocking of ports by Russia, the volume of grain exports sharply decreased precisely due to the lack of adaptation of road, rail and river transport to respond quickly to the threats that have arisen and compensate for a load of maritime transport.

According to the forecasts of the Ministry of Agrarian Policy, in 2022, the harvest of grains, legumes, and oilseeds is expected to be about 65 million tons, including about 48 million tons of grains. About 30 million tons are planned to be exported [29]. According to estimates, about 50% (24 million tons) of the new grain harvest will be exported.

In March 2022, 1.16 million tons of grains were exported, which is 3 times less than in March 2021 (3.48 million tons), of which only 370 tons were exported by road, which is 26.6 times less than in March 2021 (9,874 tons), and 1.07 million tons by sea, which is 3.2 times less than in March 2021 (3.46 million tons). Export transportation by rail in March 2022 increased 12.1 times and amounted to 90.9 thousand tons (in March 2021 – only 7.5 thousand tons). In March 2021, only 2 tons of grain were exported by air [28]. The structure of grain exports by modes of transport in March 2022 changed radically compared to the same period of 2021 and became as follows: road transport – 0.03%, rail transport – 7.8%, sea transport – 92.1%. Considering the unblocking of some of the Black Sea ports from August 1, 2022, it allows calculating the approximate volumes and structure of exports and imports by mode of transport. Road transport will account for 3.3% of exports, rail transport – 15.1%, maritime transport will

remain the key for exports, with a share of 79.1%, and the share of uncertain transport will be 2.5% (Fig. 2).

Considering the insignificant volumes of grain imports and the relatively small share of maritime transport in the transportation of imported products, it is believed that the structure of transportation will not undergo significant changes neither will the volumes.

The structural difference between the volumes of imported and exported grain transportation is influenced by the following factors:

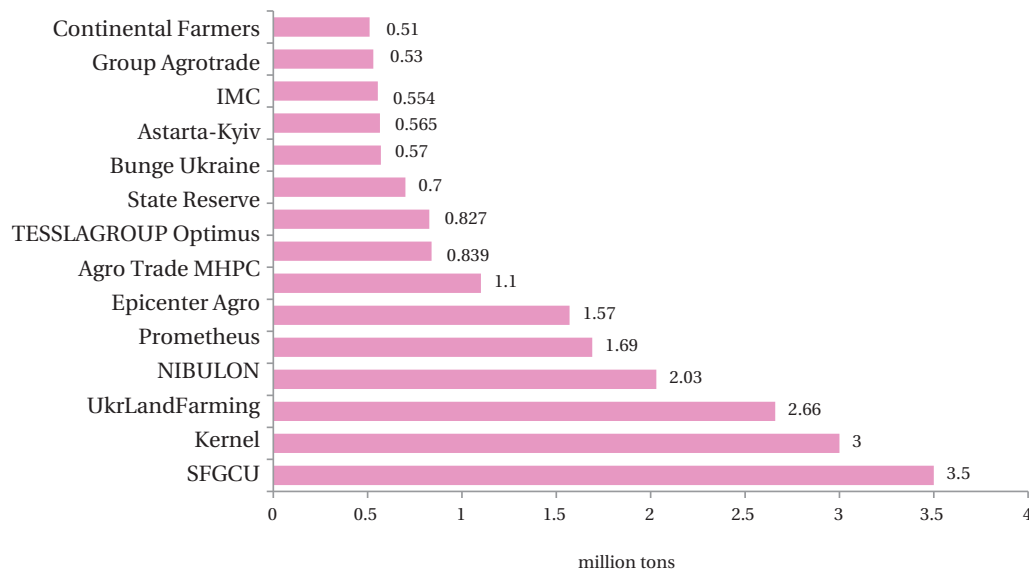
1) insignificant volumes of grain imports compared to exports allow more efficient use of land transport (road and rail);

2) the reduction in the volume of grain transportation by road in 2020-2021 is caused by stricter quarantine restrictions for this particular type of transport.

In general, summarising the analysis of export-import operations by modes of transport, it can be concluded that the increase in railway tariffs, fuel, and quarantine restrictions at customs due to the COVID-19 epidemic have restricted the use of land transport, and sea transport is the most efficient in the transportation of large volumes of products.

The crop storage system is one of the most crucial links in logistics. Currently, the largest agro-industrial companies by elevator capacities in 2021 were placed on the Black Sea coast in Odesa, Chornomorsk, Mykolaiv, and other cities.

The State Food Grain Corporation (SFGCU) has one of the largest elevator capacities of 3.5 million tons (Fig. 3). Elevator capacities of over 2 million tons are owned by some of the largest agricultural holdings in Ukraine: Kernel, UkrLandFarming, and Nibulon.



**Figure 3.** Top 15 companies by elevator capacities in 2021

**Source:** calculated based on the data of the main elevator site of Ukraine [30]

The smallest elevator capacities from this list are owned by Continental Farmers Group in the Western region of the country.

The cost of grain storage services provided by certified elevators is quite an influential factor in the

development of the cost of this product. The leading operator in the grain storage services market is currently JSC “SFGCU”. The cost of services of JSC “SFGCU” branches for the 2021/2022 marketing year is presented in Table 1.

**Table 1.** Cost of services of JSC “SFGCU” branches for 2021/2022 MY, UAH (including VAT)

Region	Reception		Drying, UAH/t-%	Purification, UAH/t-%	Storage, UAH/t-day	Shipment	
	Car, UAH/t	Railway, UAH/t				Car, UAH/t	Railway, UAH/t
Grains (wheat, barley, millet, rye, buckwheat, oats, rice, sorghum)							
Northern	18-25	20-25	55-77	18-33	1.7-2.4	110-156	110-156
Southern	15-27	27	57-80	16-28	1.8-2.7	108-176*	130-154*
Eastern	11-20	21-40	60-126	12-23	1.8-2.3	126-170	133-174
Central	10-17	10	60-76	15-24	1.7-2.5	142-168	144-207
Western	17-44	34-60	60-140	18-35	1.8-2.8	75-195	93-202
Grains (corn)							
Northern	18-24	–	85-170	18-33	2-2.3	110-156	110-156
Southern	18-27	–	77-117	18-24	2-2.3	109-160	124-154*
Eastern	15-25	–	75-168	18-25	1.8-2.3	126-166	132-166
Central	10-21	–	75-170	18-25	1.9-2.5	141-175	141-190
Western	19-43	–	80-165	18-34	1.8-2.8	75-150	93-157
Oilseeds (sunflower)							
Northern	19-27	–	95-127	21-40	2.1-2.7	132-150	132-155
Southern	18-30	–	77-139	24-33	2-2.7	130-182*	135-182*
Eastern	25-42	–	84-150	17-30	1.8-2.5	125-170	133-174
Central	13-32	–	89-225	21-33	2.1-3.0	150-200	157-210
Western	20-39	–	92-227	28-39	2-2.8	90-160	93-160
Oilseeds (rape, flax, mustard)							
Northern	18-23	–	67-78	22-32	2.1-2.4	140-150	139-155
Southern	21-28	–	74-114	24-31	2-2.5	124-184	124-182



Table 1, Continued

Region	Reception		Drying, UAH/t-%	Purification, UAH/t-%	Storage, UAH/t-day	Shipment	
	Car, UAH/t	Railway, UAH/t				Car, UAH/t	Railway, UAH/t
Eastern	19-26	–	65-82	20-21	1.8-2.3	150-166	133-166
Central	6-30	–	60-104	21-30	2-3	150-200	150-214
Western	20-45	–	74-167	18-34	2-2.8	75-160	93-160
Legumes (peas, soybeans)							
Northern	17-29	–	82-99	21-33	2-2.5	132-156	132-156
Southern	18-27	–	52-140	19-33	1.8-2.3	124-170	124-170*
Eastern	18-26	39	84-212	20-25	1.8-2.5	150-166	133-166
Central	12-27	–	58-120	21-30	1.9-2.7	142-190	142-190
Western	20-43	–	140-203	18-34	1.8-2.8	75-150	93-156

**Note:** with the possibility of shipment on water

**Source:** Based on the data of the State Food and Grain Corporation of Ukraine [31]

Services as of today have increased by 2-3 times for agricultural enterprises from different regions of Ukraine due to the rise in the price of gasoline and diesel fuel and other factors.

Due to the blockade of the Azov and Black Sea ports by Russia, grain sellers are forced to use land and river transport to export grain and oilseeds to European countries to reload the products on ships in the Baltic and Black Sea ports. Before the war, Ukrainian seaports could provide monthly transshipment of grain for export in the amount of 6-7 million tons. Currently, due to the limited capacity of land and river cargo crossings, only 1.5 million tons were exported by rail, road, and river in May 2022 [32].

Currently, Ukraine can export agricultural products only by water through the Danube ports. Due to the insufficient number of barges, grain terminals and berths, their throughput capacity is very limited. In the past, these ports were hardly used for the export of Ukrainian products, which is why the investment attractiveness for their development

was low. Prolonged downtime of port infrastructure led to tens of billions of losses. Ukraine's loss of export revenues amounted to one and a half billion US dollars in the first month of the war alone. Thus, it is planned to increase the annual throughput capacity of the Danube ports to 25 million tons or 1.7 times [33].

In 2021, farmers harvested 85 million tons of grain. Because domestic consumption in Ukraine is less than 20 million tons, about 55-60 million tons of the harvest could be exported, which would provide foreign exchange earnings. During the 2021-2022 marketing year, about 40.0 million tons of grain were exported.

The availability of granaries in the regions of Ukraine is presented in Table 2. The provision of elevator capacities at the end of 2021 amounted to 56.6 million tons, in addition to the storage facilities of agricultural enterprises (about 30.0 million tons). Last year, the deficit of warehouses was 17.4%. Only 3 regions had a surplus of warehouses, these are Mykolaiv (9.6%), Odesa (15.9%) and Poltava (2.9%).

Table 2. Provision of granaries in the regions of Ukraine

No.	Region	Quantity, units.	Simultaneous storage volumes, million tons	Gross harvest in 2021, million tons	Deficit/surplus of elevator capacities, +/- million tons	Deficit/surplus of elevator capacities, +/- %
1	Vinnitsia	85	6.4	7.7	-1.3	-16.9
2	Volyn	24	1.4	1.8	-0.4	-22.2
3	Dnipropetrovsk	78	5.1	6.5	-1.4	-21.5
4	Donetsk	30	2.0	3	-1.0	-33.3
5	Zhytomyr	38	2.4	3.8	-1.4	-36.8
6	Zakarpattia	10	0.2	0.4	-0.2	-50.0
7	Zaporizhzhia	52	3.7	5.1	-1.4	-27.5
8	Ivano-Frankivsk	18	0.9	1.2	-0.3	-25.0
9	Kyiv	52	4.2	5.3	-1.1	-20.8
10	Kirovohrad	57	5.5	6.6	-1.1	-16.7
11	Luhansk	25	1.5	2.2	-0.7	-31.8
12	Lviv	30	1.7	2.1	-0.4	-19.0
13	Mikolaivska	56	5.7	5.2	0.5	9.6

Table 2, Continued

No.	Region	Quantity, units.	Simultaneous storage volumes, million tons	Gross harvest in 2021, million tons	Deficit/surplus of elevator capacities, +/- million tons	Deficit/surplus of elevator capacities, +/- %
14	Odesa	81	7.3	6.3	1.0	15.9
15	Poltava	72	7.2	7	0.2	2.9
16	Rivne	22	1.5	1.9	-0.4	-21.1
17	Sumy	53	4.4	5.1	-0.7	-13.7
18	Ternopil	50	2.9	3.8	-0.9	-23.7
19	Kharkiv	75	4.8	6.4	-1.6	-25.0
20	Kherson	57	3.1	4.4	-1.3	-29.5
21	Khmelnysky	65	4.7	5.6	-0.9	-16.1
22	Cherkasy	55	4.6	6	-1.4	-23.3
23	Chernivtsi	16	0.4	0.8	-0.4	-50.0
24	Chernihiv	63	5.1	6.8	-1.7	-25.0
	<b>Total</b>	<b>1164</b>	<b>86.7</b>	<b>105.0</b>	<b>-18.3</b>	<b>-17.4</b>

Source: developed by the authors based on the data of the State Statistics Service of Ukraine [26]

The lowest provision with granaries (50% and more of the deficit) is observed in the Western region – Transcarpathian (50%), and Chernivtsi (50.0%) regions.

The smallest deficit of grain storage capacities (less than 20%) was observed in Vinnytsia (16.9%), Kirovograd (16.7%), Lviv (19.0%), Sumy (13.7%) and Khmelnytsky (16.1%) regions. In general, the deficit of elevator capacities in Ukraine amounted to 18.3 million tons or 17.4%. The decisive role in the deficit or surplus of storage capacities is played by the volume of harvesting, which constantly fluctuates under the influence of both objective factors, such as the level of technological and logistical support of production, and subjective factors, such as weather and climatic conditions.

The author of the study can agree with V.A. Kolodychuk, who argues that “ambitious strategic programs

to increase annual grain production in Ukraine to 90-100 million tons, and in some strategies – up to 120 million tons will remain a populist call if we do not systematically approach the development of the grain subcomplex of the agro-industrial complex” [23]. It was the systematic approach and favourable weather conditions that allowed obtaining the largest ever gross harvest of grains and oilseeds in the amount of 105 mln tonnes in 2021, while the problem of grain storage deficit remained, which amounted to 17.4% with significant differentiation by regions.

Since the beginning of the war, some of the elevator capacities have been damaged or destroyed, some remained in the occupied territories. In general, today, the national economy has lost more than 12.5 million tons of elevator capacity out of 56.6 million tons available as of January 1, 2022 (Table 3).

**Table 3.** Availability and losses of elevator capacities as a result of military operations by regions

No. n/a	Region	Elevator capacity by 02/24/2022 (thousand tons)	Elevator capacity after 02/24/2022 (thousand tons)	Destroyed, occupied, blocked sea and river vessels (thousand tons)	Proportion of destroyed, occupied, blocked sea and river vessels, %
1	Vinnytsia	4212.5	4150.0	62.5	1.5
2	Volyn	927.0	927.0	0.0	0.0
3	Dnipropetrovsk	3190.0	3100.0	90.0	2.8
4	Donetsk	1127.2	0.0	1127.2	100.0
5	Zhytomyr	1303.0	1205.0	98.0	7.5
6	Zakarpattia	111.5	111.5	0.0	0.0
7	Zaporizhzhia	2170.0	264.0	1906.0	87.8
8	Ivano-Frankivsk	552.0	552.0	0.0	0.0
9	Kyiv	2688.0	2688.0	0.0	0.0
10	Kirovohrad	3565.0	3565.0	0.0	0.0
11	Luhansk	880.0	0.0	880.0	100.0
12	Lviv	1095.0	1095.0	0.0	0.0
13	Mikolaivska	4221.0	2080.0	2141.0	50.7

Table 3, Continued

No. n/a	Region	Elevator capacity by 02/24/2022 (thousand tons)	Elevator capacity after 02/24/2022 (thousand tons)	Destroyed, occupied, blocked sea and river vessels (thousand tons)	Proportion of destroyed, occupied, blocked sea and river vessels, %
14	Odesa	5500.0	2400.0	3100.0	56.4
15	Poltava	5150.0	5150.0	0.0	0.0
16	Rivne	1010.0	1010.0	0.0	0.0
17	Sumy	2901.0	2877.0	24.0	0.8
18	Ternopil	1800.0	1800.0	0.0	0.0
19	Kharkiv	3007.0	1670.0	1337.0	44.5
20	Kherson	1817.0	0.0	1817.0	100.0
21	Khmelnysky	3060.0	3060.0	0.0	0.0
22	Cherkasy	2850.0	2850.0	0.0	0.0
23	Chernivtsi	234.0	234.0	0.0	0.0
24	Chernihiv	3185.0	3185.0	0.0	0.0
	<b>Total</b>	<b>56556.2</b>	<b>43973.5</b>	<b>12582.7</b>	<b>22.2</b>

Source: Developed by the authors based on [34]

After the beginning of the war with Russia, Ukraine completely lost grain storage capacities in Donetsk (1127.2 thousand tons), Luhansk (880.0 thousand tons), and Kherson (1817.0 thousand tons) regions. Elevators in Zaporizhzhya (1906.0 thousand tons or 87.8%), Odesa (3100.0 thousand tons, 56.4%), Mykolaiv (2141.0 thousand tons, 50.7%), and Kharkiv (1337.0 thousand tons or 44.5%) regions were largely destroyed, occupied and blocked in sea and river ports. Insignificant losses are observed in Zhytomyr (98.0 thousand tons, 7.5%), Dnipropetrovsk (90.0 thousand tons or 2.8%), Vinnytsia (62.5 thousand tons, 1.5%), and the smallest – in Sumy region (24.0 thousand tons or 0.8%) of the available capacities in the region. In total, 12582.7 thousand tons (22.2%) of grain storage capacities were lost in Ukraine.

As of the beginning of 2022, the total capacity of grain storage facilities was 85-87 million tons, including 28-30 million tons of warehouses located on the farms of agricultural producers. Considering the elevator capacities in the regions where the hostilities are occurring, only 70.0 million tons of grain storage capacity is available. Thus, about 23% of the available grain storage capacities are required to preserve the last season's carryover stocks (20.0 mln tonnes).

Considering that this year it is planned to harvest at least 50 million tons of grain and 15 million tons of oilseeds, considering the transitional stocks, the shortage of storage capacities is expected in the range of 15-20 million tons. It can result in significant, 5-7%, losses due to the lack of appropriate conditions for crop preservation. The lack of elevator capacities

during peak periods in early and late autumn will be particularly painful for the agricultural market.

Diversification of logistics infrastructure is one of the most significant areas of development of the agricultural sector of Ukraine, the problems of which are dealt with by the government. Currently, UAH 4.0 billion is required only to provide farmers with temporary storage facilities. An alternative to stationary elevators can be using polymer sleeves for grain storage.

The adverse consequence of Russia's war against Ukraine was the fall in prices of agricultural producers for grain and oilseeds. The blockade of ports has resulted in significant surpluses in the domestic market of these products and an almost fivefold increase in the cost of export logistics. Therefore, domestic prices for major crops intended for export lost more than 30%, for example, the price of grains fell to 4.0-5.0 thousand UAH per ton. Indirect losses of agricultural enterprises from the decline in prices for major export crops, such as corn, wheat, barley, and sunflower, increased to 11.9 billion USD.

The most acute problem for agriculture nowadays is the high tariffs for transporting crops and the cost of storage. In 2022, railway tariffs increased twice: in January-February – by 15-20% compared to January-February 2021 and from June 29, 2022 – by 70%. As a result, the additional annual expenses of agricultural producers amounted to 120 million USD [35].

The cost of international road transportation of grains and oilseeds in July 2022 almost doubled, for domestic transportation, it averaged UAH 3.33 per ton-kilometer (Table 4).

Table 4. Cost of domestic transportation of grains and oilseeds in July 2022

Cargo	Transport	Distance (km)	UAH/t	UAH t/km
Wheat in bulk	dump truck	797	2300	2.89
Wheat	dump truck	310	1450	4.68
Sunflower	dump truck	750	2500	3.33
Wheat	dump truck	310	1280	4.13

Table 4, Continued

Cargo	Transport	Distance (km)	UAH/t	UAH t/km
Sunflower	container ship	620	1900	3.06
Sunflower	dump truck	620	2100	3.39
Grain in bulk	grain carrier	721	2500	3.47
Corn	dump truck	360	1150	3.19
Corn	dump truck	754	1950	2.59
Corn	dump truck	799	1950	2.44
Rape	grain carrier	585	2300	3.93
Soybeans in bulk	dump truck	882	2400	2.72
Rape	grain carrier	511	2000	3.91
Rape	grain carrier	944	3200	3.39
Sunflower in bulk	dump truck	942	3100	3.29
Corn	grain carrier	596	2100	3.52
Soybeans in bulk	dump truck	710	2300	3.24
Sunflower	grain carrier	620	2200	3.55
Soybean	grain carrier	556	2500	4.50
Soybean	grain carrier	994	2700	2.72
Soybean	grain carrier	500	2900	5.80
Corn	grain carrier	840	1850	2.20
Corn in bulk	grain carrier	1100	2200	2.00
Soybean	grain carrier	841	2900	3.45
Corn	grain carrier	930	2050	2.20
Corn	grain carrier	596	2100	3.52
Corn in bulk	grain carrier	744	2100	2.82
Average cost, t/km				3.33

Source: developed by the authors based on the data of DELLA™ transport company [36]

The cost of transportation depends on many factors: type of body, cargo, distance, region of delivery, etc. One of the key factors is the distance of transportation, in Table 4, the author can observe an inversely proportional relationship between the distance and the cost

of transportation (ton-kilometre). The author notes a similar trend in international road transportation of grains and oilseeds. The cost of grain transportation for export increased and, in July 2022, averaged EUR 0.17 or UAH 6.33 per tonne/km in hryvnia equivalent (Table 5).

Table 5. Cost of international transportation of grains and oilseeds, July 2022

Country	Cargo	Transport	Distance, km	EUR/t	UAH t/km
Romania	grain	grain carrier	313	65	0.21
Romania	sunflower in bulk	grain carrier	1450	170	0.12
Romania	grain	grain carrier	1182	150	0.13
Romania	corn in bulk	grain carrier	508	100	0.20
Romania	rape in bulk	grain carrier	847	159	0.19
Poland	soybeans in bulk	grain carrier	509	83.3	0.16
Poland	rape in bulk	grain carrier	1134	96	0.08
Greece	grain in bulk	grain carrier	2104	172	0.08
Bulgaria	sunflower	grain carrier	1413	166	0.12
Average cost t/km		x	x	X	0.17

Source: developed by the authors based on the data of DELLA™ transport company [36]

Due to the blockade of ports, logistics costs in the structure of export costs increased 5-7 times and amounted to 180 USD per ton of grain. Considering this situation, grain producers have to sell products well below cost, on average about 90 USD per ton of

grain in the field, in Europe, its production cost is not lower than 160 USD per ton.

In most regions, there is a deficit of own elevator capacities. Prices for their services have increased significantly. Unloading a ton of grain costs 70 UAH,

storing a ton – 70 UAH per month, and loading one ton – 70 UAH. Storage during the year increases the actual cost of grain by almost 1 thousand UAH. Thus, it is unprofitable to store the harvest currently.

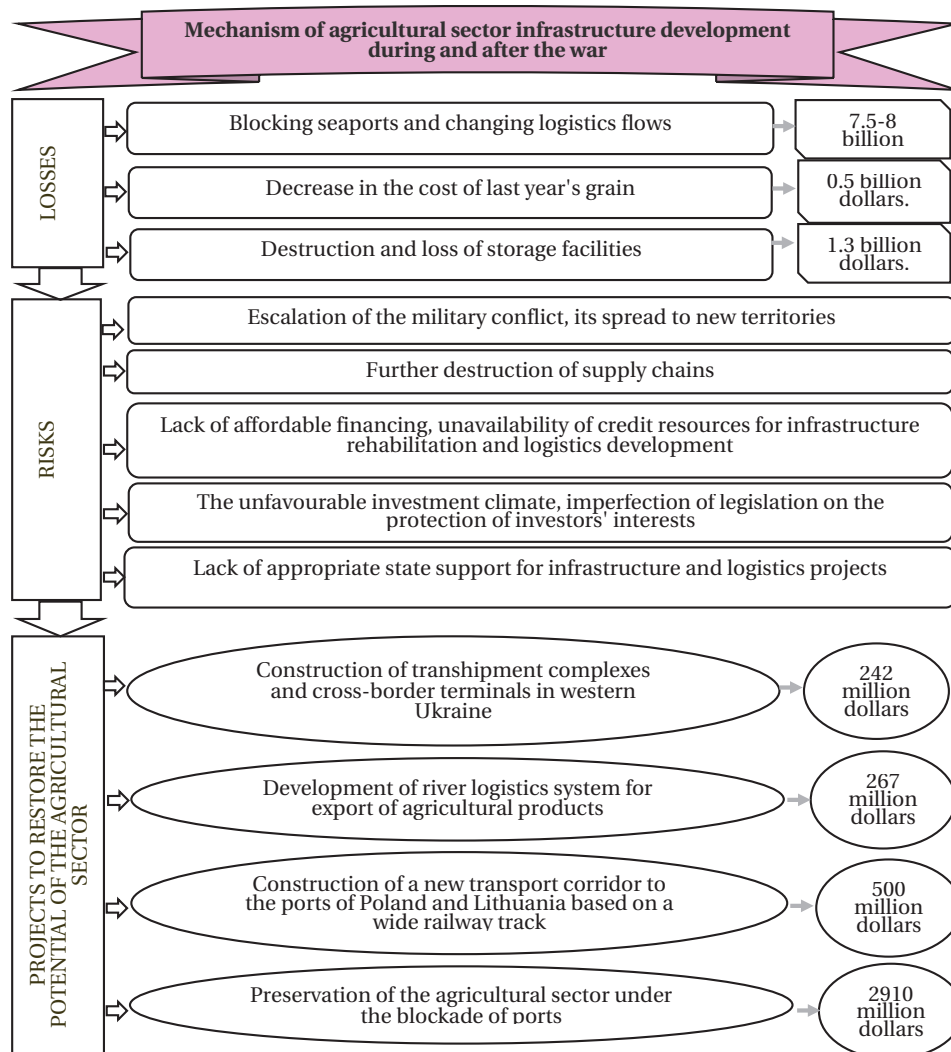
According to the Decree of the President of Ukraine “Issues of the National Council for the Recovery of Ukraine from the Consequences of War” of 04/21/2022 No. 266/2022, the National Council for the Recovery of Ukraine from the Consequences of War was established [37]. The working group “New Agrarian Policy” of this Council has developed several projects [38] to restore Ukraine from the consequences of the war, including several logistics projects.

The calculations performed by the group and our calculations demonstrate that this year the agricultural sector of Ukraine may lose USD 7.5-8.0 billion only due to the blocking of seaports and changes in the logistics of export transportation. The cost of

unsold last year’s grain is USD 0.5 billion, and the cost of destroyed or occupied elevator warehouses is USD 1.3 billion. In total, this will amount to USD 9.3-9.8 billion, or almost two years of profits received by agricultural enterprises in 2020 and 2021 (Fig. 4).

The author considers that in the future the main risks that will adversely affect the development of infrastructure and the efficient functioning of logistics chains will be:

- the spread of the military conflict to new territories and its aggravation;
- the destruction of logistics chains;
- curtailment of lending to infrastructure and logistics projects;
- sharp deterioration of the investment climate, imperfect legal protection of investors’ interests;
- insufficient state support for infrastructure and logistics development.



**Figure 4.** Economic mechanism of infrastructure development during and after the war

**Source:** developed by the authors based on data from [38]

Critically assessing the proposed projects, consider it necessary to provide several remarks. The project of construction of a new transport corridor

to the ports of Poland and Lithuania based on a wide railway track raises doubts about the feasibility and efficiency of its implementation. Since the

implementation of this project is planned for the period 2023-2025, as a result of the potential end of the war, the unblocking of the Black Sea ports (from August 1, 2022, they have already been unblocked for 120 days with the possibility of extending this period), the need for a wide-gauge transport corridor will disappear. In the case of implementation of this project, there is an additional necessity to pay for the transit of goods through the territory of Ukraine's partners Poland and Lithuania. When unblocking their ports, their terminals will be unloaded, which will result in job losses and loss of customs payments. In addition, there is a risk of increasing the cost of the project due to the necessity to pay compensation to the owners of the land through which the track will run. Such significant investments are designed for a long-term payback period, and in the case of forwarding cargoes to domestic ports shortly, the significance of the transport corridor will be offset, which will require foreign currency to be used for its maintenance.

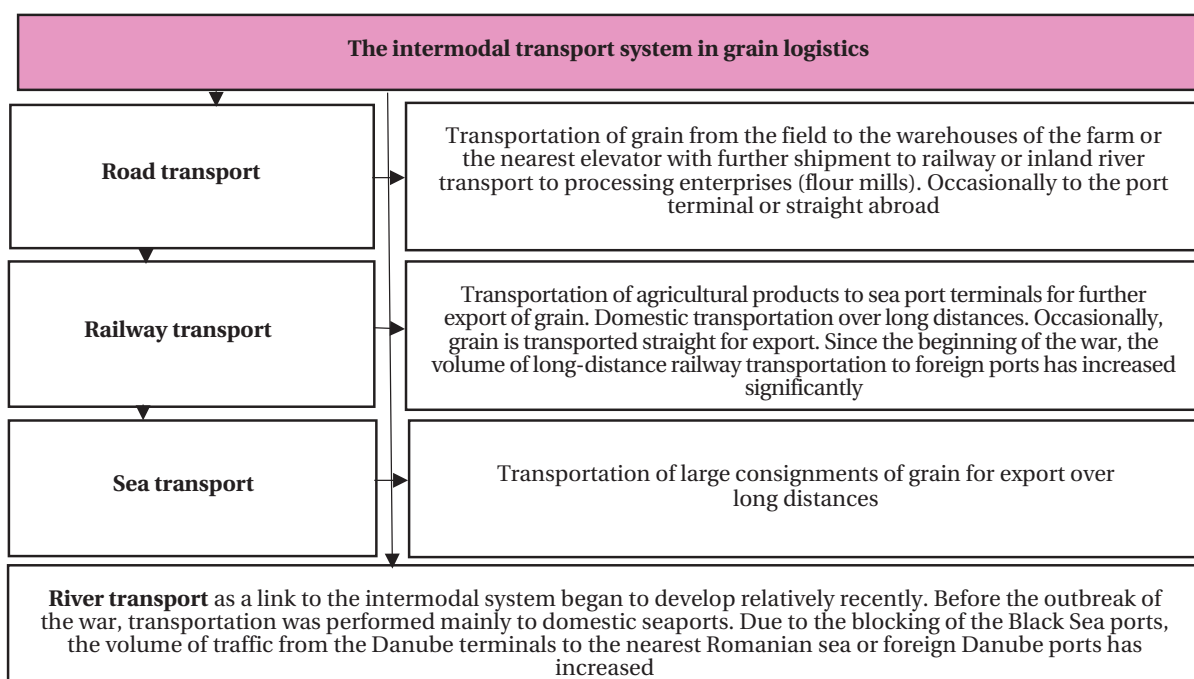
The project of construction of transshipment complexes and cross-border terminals in western Ukraine raises questions about the efficiency of its implementation. Based on the fact that domestic ports are already gradually resuming their work (as of August 20, 2022, 25 vessels with 630 thousand tons of agricultural products were shipped to three ports of Greater Odesa [39]), the importance of powerful grain transshipment terminals will significantly decrease, which will result in idle storage facilities in the western regions of Ukraine and additional costs for their maintenance and conservation.

The project of development of the river logistics system for the export of agricultural products

has a long-term perspective and is highly efficient for the export of agricultural products both during the war and after its end. After all, currently, almost a third of Ukrainian exports are exported through the Danube ports. From them, the products are delivered by the river to the port of Constanta in Romania and then go by sea to other countries of the world. The turnover of river transport is gradually growing. During April 2022, it increased 4 times to 850 thousand tons, which is 15% of the pre-war trade turnover. According to experts, the volume of traffic may increase to 1 million tons per month [40]. Thus, in the author's opinion, the investment of USD 242 million in the project is fully justified.

The project of preserving the agricultural sector under the blockade of ports assists agricultural enterprises in providing their production with the necessary resources for sowing and harvesting. In addition, the project provides for the purchase and/or construction of temporary facilities for crop storage. Evidently, the implementation of the project is necessary for the country's economy, but, in the author's opinion, its high cost (2910 million USD) requires more detail, in addition, the project objectives somewhat overlap with the objectives of the project for the construction of transshipment complexes in western Ukraine.

It can be agreed with the scientists A.L.R. de Oliveira, C.B. Marsola, A.P. Milanese and S.L.R. Fatorretto [3], who determined the most efficient sea and rail transport. The concept of "intermodal transport" used by them was completely appropriate to apply to grain transport logistics in Ukraine. The scheme of intermodal transport in grain logistics is presented in Figure 5.



**Figure 5.** Scheme of the intermodal transport system in grain logistics

**Source:** developed by the authors based on data from [3]

Currently, the intermodal system is frequently violated. Though some Black Sea ports have been unblocked since August 1, the volume of maritime traffic is much lower than before the war. Thus, this type of transport, which was the most efficient in the system, often began to disappear from the system. More and more often, despite the high price of fuel, grain is transported by road over long distances, in particular for export. In addition, the volume of transportation outside the state by rail has increased. But in this situation, there are several problems with grain exports:

- 1) insufficient number of border crossings, narrow access roads, lack of modern scanners at customs crossings, which does not allow trucks to quickly pass customs control, resulting in long queues;
- 2) different gauges in Ukraine and European countries, insufficient number of European railcars. The low capacity of the railway at the border does not allow a significant increase in the volume of grain transportation;
- 3) the small number of vessels adapted to work in the Danube ports restrains the increase of cargo turnover through them;
- 4) an imperfect system of logistics flow management results in the slowdown of freight traffic;
- 5) high tariffs for domestic rail transportation and transit, and rising fuel prices significantly reduce the efficiency of road and rail transport.

In the author's opinion, it is expedient to implement cheaper and more efficient projects to develop infrastructure:

- 1) construction of modular grain storage facilities that can be easily assembled and dismantled, the introduction of grain storage technologies in polymer sleeves, rather than the construction of large grain terminals on the western border, the economic significance of which will fall after the unblocking and return of the Azov and Black Sea ports;
- 2) construction of new and reconstruction of existing customs crossings together with European partners in the field of expanding access roads to them, equipping them with powerful X-ray scanners and establishing domestic infrastructure;
- 3) establishment of own production, purchase and lease of vessels for transportation of cargoes, in particular grain products, from the Danube ports;
- 4) repair and reconstruction of the only European railway track in Ukraine from Kovel to Poland, construction of a grain terminal in Kovel, reconstruction of wagons based on the Kovel depot to European standards;
- 5) re-profiling of facilities for the production of wheelsets of freight car bogies for the European gauge;
- 6) improvement of the information flow management system, establishment of conditions for efficient coordination of cargo movement with European partners, and training of management personnel in the field of logistics.

These measures will largely offset the adverse

effects of the loss and blocking of seaports and increase the volume of grain exports with minimal costs and will contribute to the preservation of jobs and the establishment of new ones.

### ► Conclusions

As a result of the research, the author proposed a definition of the term "grain logistics", which includes the specific features of the beginning of the establishment of the logistics chain and the features of grain storage, attention is devoted to the conditions for obtaining the effect for all subjects of the logistics process.

A forecast was made regarding changes in the structure of domestic grain transportation by type of transport due to the blocking of seaports and the development of river transport infrastructure as more economically profitable. The volume of transportation by river transport compared to 2021 will increase by 2.75 million tons or from 0.9% to 5% in 2022, the volume of transportation by road will increase by 3.45 million tons, but the structure of transportation volumes will decrease by 0.8%, the volume of transportation by rail will increase by 5.2 million tons, in the structure of transportation there will be a drop of 62.3% to 60%.

Considering the forecast of harvest volumes and the partial unblocking of seaports, the author has made an indicative forecast of the structure of exports by mode of transport in 2022. The largest share of transportation will remain for maritime transport – 79.1%, 15.1% of grain will be exported by rail, 3.3% by road and only 2.5% of transportation will be indeterminate.

The restriction of using railway and road transport was caused by the increase in railway tariffs and fuel prices, and anti-epidemic quarantine measures at border crossings, particularly for road transport. Sea transport remains the most efficient in the transportation of large volumes of grain.

As a result of hostilities, Ukraine lost a significant part of elevator capacities – 12.6 million tons or 22.2%. Comparing the forecasted harvest and the available elevator capacities in 2022, there may be significant losses of harvested grain due to the shortage of storage facilities for its storage – 5-7%.

Considering several problems that have arisen in grain logistics, some proposals have been developed to overcome them. First of all, it is the introduction of relatively inexpensive technologies for storing grain products, increasing the number and reconstruction of road freight customs crossings to increase the efficiency of road transport for the transportation of grain for export, increasing the export cargo flow through the Danube ports, construction of a grain terminal and repair of the European railway track in Kovel, clear coordination of cargo flows with European partners. The implementation of these proposals will overcome the crisis in grain logistics and significantly increase domestic and export-import cargo turnover.

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## Сучасний стан та перспективи розвитку зернової логістики в Україні

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► **Анотація.** Враховуючи нестачу елеваторних потужностей та диспропорцію у розподілі товарних потоків через захоплення та блокування морських портів, інші види транспорту сьогодні не в змозі забезпечити перевезення необхідних обсягів зерна на експорт, а збереження врожаю знаходиться під загрозою. Тому нагальним є питання розвитку логістики в умовах війни, що визначає актуальність дослідження. Метою статті є аналіз довоєнного та сучасного стану зернової логістичної системи і визначення ефективних шляхів її розвитку під час війни та після її закінчення. Дослідження ґрунтується на наступних методах: діалектичному, історичному, монографічному, абстрактно-логічному, системному та класифікаційному, методі аналітичного прогнозування, статистико-економічному, економіко-математичному, графічному. Досліджено протяжність доріг в Україні та здійснено прогноз щодо скорочення шляхів через військові дії. Проведено аналіз експортно-імпоротної логістики, визначено переваги морського транспорту, питома вага якого при експорті складала 99,5 %, а при імпорті більшість перевезень припадала на залізничний транспорт (44,9 %). Досліджено стан елеваторних потужностей, дефіцит яких у 2021 році складав 18,3 млн тонн (17,4 %), визначено обсяги їх втрат через військові дії у 2022 році – 12,6 млн тонн (22,2 %), проаналізовано вплив війни на зростання цін на послуги зберігання зерна. Здійснено критичний аналіз інфраструктурних проєктів Національної ради з відновлення України від наслідків війни та вказано їх недоліки. Запропоновані заходи щодо удосконалення логістики допоможуть частково знівелювати дефіцит елеваторних потужностей, наростити обсяги експорту зернових, сприятимуть пришвидшенню переміщення продукції через кордон та зменшенню логістичних витрат. Результати досліджень можуть бути використані органами державної влади при створенні програм розвитку аграрної логістики, бізнес структурами – для розробки інфраструктурних проєктів та удосконалення логістичних систем підприємств, науковцями – для подальшого вивчення проблем зернової логістики та визначення перспектив її розвитку

► **Ключові слова:** елеваторні потужності, тарифи, порти, транспорт, інтермодальна система