

WAYS TO STABILIZE THE CONDITION OF THE TRANSPORTATION OF AGRICULTURAL PRODUCTS IN THE CONDITIONS OF LARGE-SCALE RUSSIAN AGGRESSION

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The issue of transportation of agricultural products from the producer to the buyer is important for our country. Russia's full-scale war against Ukraine emphasized the extreme importance of the transport complex for the economy and society. With the beginning of invasion of Ukrainian land, air communication with the world was completely stopped, and sea ports were also blocked. With the beginning of hostilities on the territory of Ukraine, the routes of transportation of agricultural products were disrupted, a large number of elevators were destroyed, the road surface of warehouses was destroyed, and sea ports were seized.

The purpose of this article was to study the current state of freight transportation in the conditions of martial law, to improve and stabilize the ways of transporting agricultural products. The task was to find ways to improve logistics and ways to protect grain products from missile strikes, as well as possible ways to export this grain from the territory of Ukraine.

The article presents the results of an analytical analysis of the state of transportation of agricultural products, suggests ways to stabilize and solve the problem. The development of logistics and cooperation with foreign partners, the construction of protected hubs for storing grain products, as well as the construction of modern elevators that could accumulate large volumes of products for their further transportation in large batches to consumers. The best option for Ukraine would be the creation of grain hubs in European countries, as well as transport grain by motor vehicle, accumulate grain in large batches, and deliver it to other parts of the world, through the ports of Europe. However, today it is not so easy, because currently European countries are imposing restrictions on the import of our grain products.

Today, despite the difficult military situation, the lost part of the transport infrastructure and logistics, Ukraine is one of the largest grain exporting countries. The restoration of traditional ways of freight transportation and the constant search for new ones is a sign of a healthy and promising policy for the development of the transport industry. The European choice of our state, the support of partners will ensure uninterrupted freight transportation and will give new impetus to the development of river and railway transport.

Key words: logistics, freight transportation, grain elevators, grain agreement, problems in transportation.

Fig. 6. Ref. 7.

1. Problem formulation

During the war, the agrarian sector of the economy became the main source of budget replenishment. Four of the top-five positions of goods that Ukraine sold in 2022 became food and agricultural goods. The issue of transportation of agricultural products from the producer to the buyer is important for our country. Russia's full-scale war against Ukraine highlighted the extreme importance of the transport complex for the economy and society. With the beginning of the invaders' invasion of Ukrainian land, air communication with the world was completely stopped, and sea ports were also blocked. Therefore, all the hard work fell on the shoulders of railway workers and car drivers, who from the first days of the war helped millions of Ukrainians to leave for neighboring countries or safer regions of the Motherland, thus saving many of their lives [2]. The Ukrainian transport system suffered, because the full-scale war almost destroyed all Ukrainian logistics. Grain elevators and ports stopped, a significant number of elevator complexes were destroyed by the occupiers.

Therefore, it is important to find rational ways to export Ukrainian grain, to provide for organizational and institutional measures to stabilize the condition of the transportation of agricultural products.

2. Analysis of recent research and publications

Grain transportation is one of the most important factors in the logistics chain of any country. Ukraine is no exception, as it is one of the largest grain exporters in the world.

Before the full-scale war, in the 2021/2022 marketing year, Ukraine grew and harvested 84.6 million tons of grain and leguminous crops, which is a record harvest. At that time, there were still 19.7 million tons of grain left over from the previous year in granaries and elevators.

The vast majority of grain grown in Ukraine is exported to various countries of the world through sea ports. If you depict the interaction of modes of transport schematically, it will look like in Fig. 1.

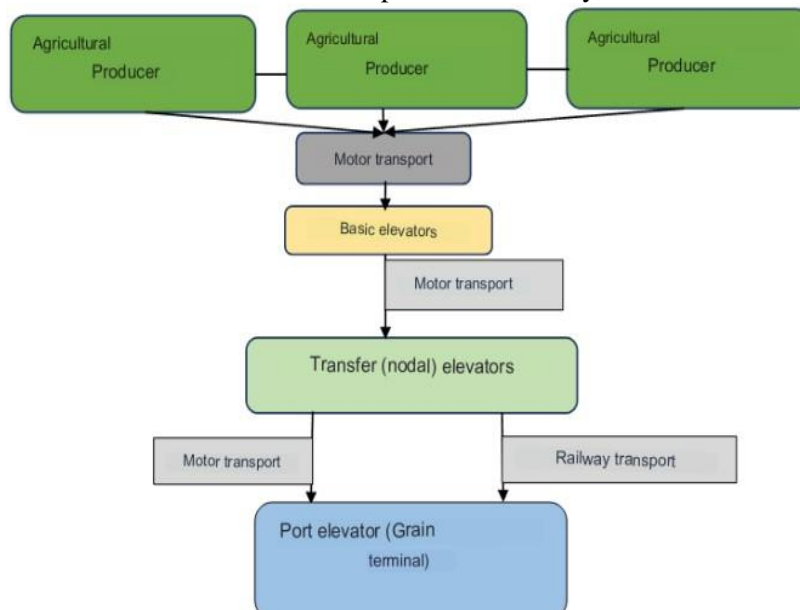


Fig. 1 Scheme of the interaction of modes of transport for the transportation of grain in Ukraine

Source: built by the author based on the data from the Ukrainian transport complex.

According to the Ministry of Agrarian Policy and Food of Ukraine and the State Tax Service of Ukraine, in July-December 2021, Ukraine exported 32.6 million tons of grain, legumes and flour, and this exceeded the export for the period of 2020 by 6.7 million tons.

Most of Ukraine's exports go through seaports (93-95%), to which goods are delivered by rail (55- 60%), road transport (30-35%) and river (7-10%).

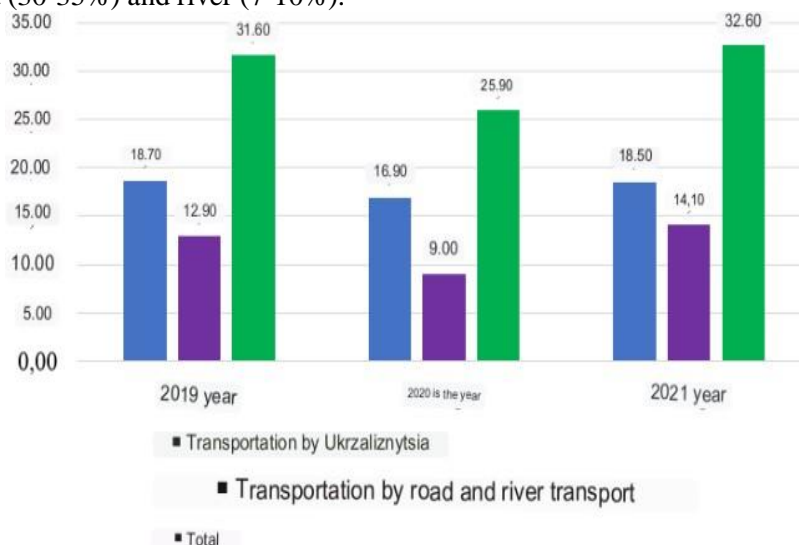
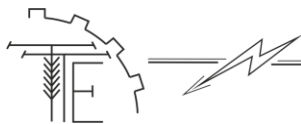


Fig. 2 Grain export schedule for 2019-2021 million tons



If we take statistical data from Ukrzaliznytsia, then in July-December 2021, it transported 18.5 million tons of grain and milling products for export, so it can be concluded that 14.1 million tons were transported by road and river transport [7].

The main market for grain export is the countries of Asia and Africa. The largest importers of domestic grain products are Turkey, Spain, and Egypt.

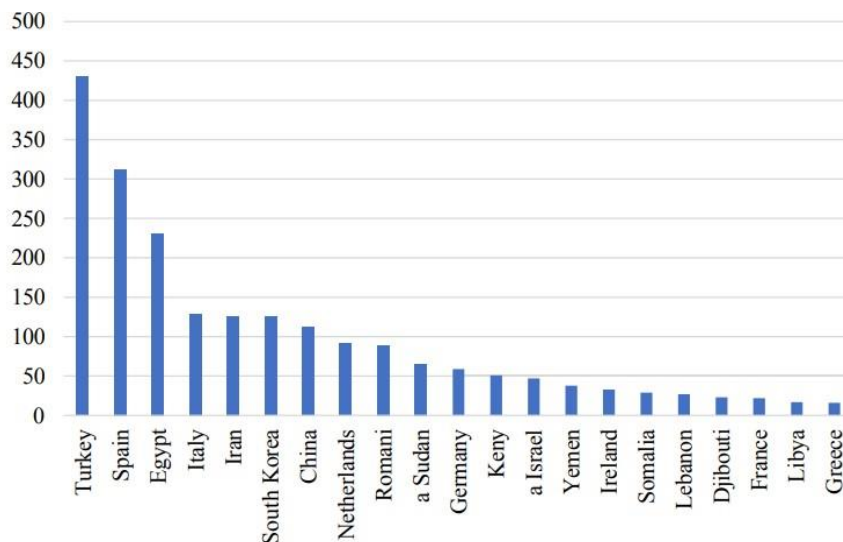


Fig.3 Geography of grain exports from Ukraine

Agricultural producers of Ukraine are represented by enterprises of different production volumes and legal organization, from private personal farms and farms to agroholdings. Therefore, one of the main features of the Ukrainian grain logistics system is elevators of different purposes, types and sizes, which became the primary targets for missile attacks by the Russian invaders. According to various studies, Ukraine has lost 10 to 13 million tons of elevator capacity since the beginning of the full-scale war, which was 17 to 20% of the total capacity. According to the www.elevatorist.com website, from February 24, 2022 to end of December 2022, the number of potentially destroyed or damaged warehouses reached 87 units, 165 elevators were located in the temporarily occupied Luhansk, Donetsk, Zaporizhzhia and Kherson regions - this is more than 10% of the pre-war certified capacities with grain storage [2] .

Also, as of November 2022 year, researchers estimated that the cost of repairing and restoring these destroyed granaries will reach \$1.1 billion.

In general, at the beginning of the full-scale war, it was I think that Russian troops were targeting grain storage and processing enterprises, which is a war crime.

In a study by the American Conflict Observatory, it was calculated that Ukraine lost every sixth elevator, and not only in the territories close to the front. Enterprises in Zhytomyr, Kyiv, and Vinnytsia regions were destroyed and damaged by rocket attacks. Some elevators in Sumy Oblast and Chernihiv Oblast were damaged back in February-March 2022 year during the occupation of these territories. However, the most destroyed enterprises located in the eastern and southern regions: in Donetsk, Luhansk, Kharkiv, Zaporizhzhya, Mykolaiv, Dnipropetrovsk.

One of the oldest elevators in Ukraine, which still worked in the Zaporizhzhia region - "Orikhovsky" - was completely destroyed.

Due to proximity to the front line and artillery shelling in Kherson region, Mykolaiv region, Dnipropetrovsk region and Kharkiv region, many small and medium-sized granaries were destroyed and damaged. In Odesa, silos and premises of a large elevator and a bakery were damaged by a rocket attack. Mykolaiv seaport survived several shellings, there were fires at oil terminals in the port in the summer. The silos of one of the port elevators in Mykolaiv were on fire due to the impact of enemy missiles, another fire was in the warehouses of the port-side enterprise of the Mykolaiv seaport [6].

Despite the active combat operations at the front and rocket attacks on the entire territory of Ukraine, elevator construction did not stop, and the significant volumes of the previous year's harvest pushed farmers to expand storage capacities even more. We have 32 ready and 44 new grain storage facilities under construction. As manufacturers of elevator equipment said, some projects on the frontline and occupied

territories have been put on hold, while the grain infrastructure continues to develop throughout the rest of Ukraine. Thus, the company "Volyn-Zerno-Produkt" increased its own capacities by 100,000 tons and built 2 new silos and warehouses. The company "Epicentr K" continued to complete the construction of two elevators in the Khmelnytskyi region. The total storage capacity of the completed granaries will reach 180,000 tons. It is also known about the construction of new granaries and the increase of the capacities of already existing elevators for medium and small farms. Installation of equipment and completion of projects in Lviv, Volyn, Ivano-Frankivsk, Ternopil, Khmelnytskyi regions were reported by the companies KMZ Industries, Lubnymash, and Zernova stolitsia [7].



Fig. 4 Attacks on Ukrainian elevators

The loss of the ability to use sea freight has become a critical challenge for grain exports, so the "grain deal" has become an opportunity for us. The opening of the "grain corridors" at the UN level was initiated at the end of April 2022 year, when the Secretary General of the organization Antonio Guterres visited Kyiv, Ankara and Moscow. The initiative belongs to the UN, and Turkey actively contributed to its implementation. But the triumph of the signing was short-lived - in less than a day, Russia hit the Odesa port with missiles. At the same time, they decided not to abandon the implementation of the agreement, which is beneficial to all parties [2].

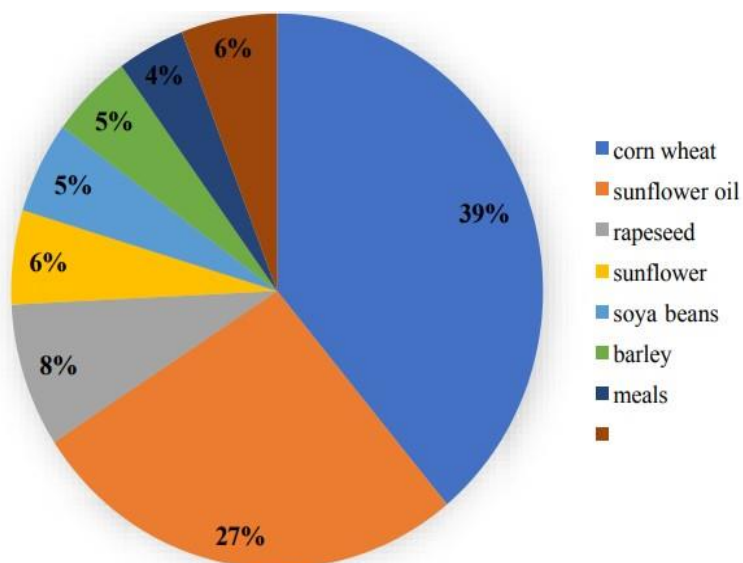


Fig. 5 Exported agricultural products through the grain corridor as of the beginning of February 2023

The implementation of the "Istanbul plan" became possible primarily due to the release from the temporary occupation of Zmiiny Island and the restoration of Ukraine's control in the northwestern part of the Black Sea. The sea export of agricultural products through the "grain corridor" was resumed on August 1. According to the terms of the signed agreement, grain shipment from Ukraine is carried out in three ports of "Great Odesa": Odesa, Chornomorsk and Pivdenny (Odesa region). A caravan is formed from bulk carriers loaded in Ukrainian ports. He, together with the leading ship, is going to Turkey for an inspection check. Ships that successfully pass it will be able to continue moving on the agreed course. The grain corridor in Ukraine works in a two-way direction: as many ships entered our ports to load grain, the same number left for the ports of destination. During 45 days of work, Ukrainian Black Sea ports handled 134 ships. 3.1 million tons of various agricultural products were loaded on board: corn, wheat, barley, rapeseed, soybeans and oil. Food is exported to the following countries: Asia - 71 ships with 1.4 million tons of agricultural products were sent; Europe - 44 ships, 1.1 million tons; Africa - 19 ships, 0.6 million tons [6].

3. The purpose and tasks of research

The purpose of the article is to study the current state of freight transportation in the conditions of martial law, improvement and stabilization of the ways of transportation of agricultural products. The task of the article: to find ways to improve logistics and ways to protect grain products from missile strikes, as well as possible ways to export this grain from the territory of Ukraine.

4. Results of the researches

Despite the existing agreements on the "grain corridor", we understand that it is necessary to urgently look for other options for the transportation of grain products. River transport is getting a new wave. So, Odesa region has become another place of active construction of new grain infrastructure and expansion of already operating enterprises on the Danube. Granting the Danube River the status of inland waterway E-80-09 will make possible the implementation of the European Agreement on the most important inland waterways of international importance. Such actions will help reduce the burden on seaports and attract additional investments for the development of the infrastructure of river ports and berthing facilities. Perhaps this will become a starting point for the restoration of the river fleet.

Another step towards the stabilization of cargo transportation of export grain products can be the increase of railway transport capacity through the creation of dry ports. The scheme of operation of which is shown in fig. 6

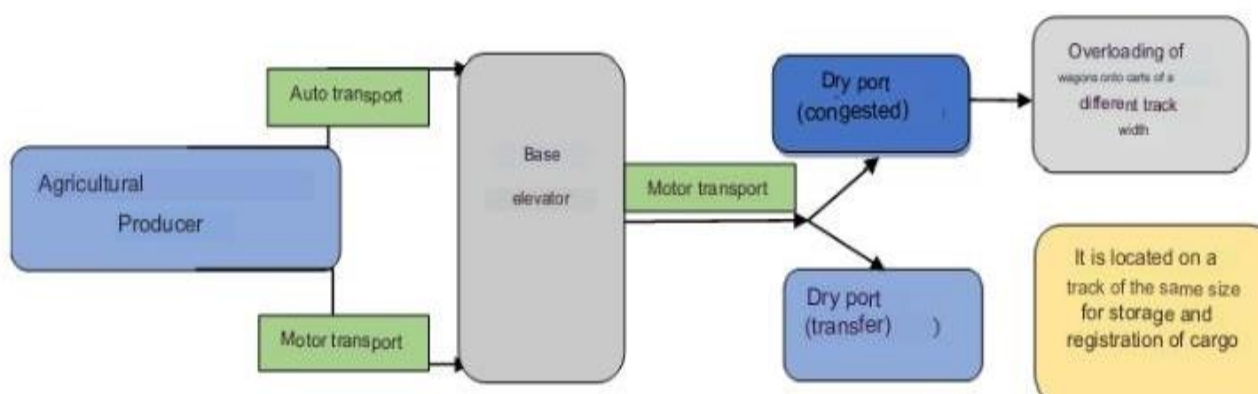
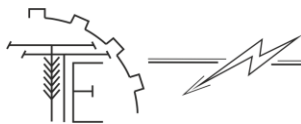


Fig. 6 Scheme of operation of the dry port

At the Chop railway station, such a "logistics hub" with wide and narrow tracks for transshipment of any agricultural products and processed products has already started operating. The activities of the logistics hub "CHOP" include transshipment from broad gauge to narrow gauge and vice versa, as well as from any type of wagons to motor vehicles and vice versa: covered wagons; half-cars; containers on platforms; hoppers (grain trucks); tanks.

Ukrzaliznytsia and the German VTG agreed on the development of intermodal connections with European countries. Such cooperation will ensure rhythmic, predictable and economical transportation of goods.

At the beginning of 2023, Ukrzaliznytsia announced the introduction of an intermodal service that will combine the transportation of container, trailer and combined transport trains to Poland, Romania, Austria and



Turkey. Today, the possibilities of using the technological solutions of the French engineering company Alstom and the Spanish company Tria regarding the purchase of wagons with a sliding system for the transition from a track width of 1435 mm to a track of 1520 mm are being considered.

Interesting are the proposals of countries such as Oman and Egypt, which offer Ukraine to create a grain or grain-food hub on its territory for uninterrupted supplies of Ukrainian grain to countries in the Horn of Africa, primarily to countries such as Tanzania, Kenya, Somalia, Uganda, Rwanda, Ethiopia. However, Oman, a country characterized by political instability, cannot be considered a reliable partner today. At the same time, Egypt, for example, after learning about Ukraine's plans, also showed interest in discussing the possibility of creating a similar logistics center on its territory. It is this country that has access to the sea and the ocean, which makes it attractive for the creation of a grain hub. Here you can accumulate grain in large batches and deliver it through the Arabian Sea and the Indian Ocean to China and the countries of the Far East. It is also possible to deliver grain from Egypt to African countries using vehicles

If we consider the countries to which Ukraine exports grain, we can come to the conclusion that it is most expedient to create grain hubs in such countries that have access to the sea.

However, the best option for Ukraine would be the creation of grain hubs in European countries. To transport grain by motor vehicle, to accumulate grain in large batches, and to deliver it to other parts of the world, through the ports of Europe. But, unfortunately, not everything is so simple, because currently European countries are imposing restrictions on the import of our grain products. Basing this decision on the fact that our grain prevents the sale of their farmers' grain [4].

5. Conclusion

Today, despite the difficult military situation, the lost part of the transport infrastructure and logistics, Ukraine is one of the largest grain exporting countries. The restoration of traditional ways of freight transportation and the constant search for new ones is a sign of a healthy and promising policy for the development of the transport industry. The European choice of our state, the support of partners will ensure uninterrupted freight transportation and will give new impetus to the development of river and railway transport.

References

- [1] Kisliy, V.M., Bilovodska, O.A., Olefirenko, O.M., Solyanyk, O.M. (2010). *Logistics: Theory and practice: Education. Manual*. K: Center for Educational Literature. [in Ukrainian].
- [2] *How domestic transport helped the Ukrainian economy and its citizens to survive during the war*. <https://www.unian.ua/economics/transport/yakvitchiznyaniy-transport-dopomig-vizhiti-ukrajinskiy-ekonomici-ta-jijigromadyanam-pid-chas-viyni-12105600.html>. (access date 06/20/23). [in Ukrainian].
- [3] *Project of the Recovery Plan of Ukraine Materials of the working group "Restoration and development of infrastructure"*. URL: <https://www.kmu.gov.ua/storage/app/sites/1/recoveryrada/ua/restoration-anddevelopment-of-infrastructure.pdf> (date of application 05/14/23). [in Ukrainian].
- [4] *Ukraine and Ghana are discussing the creation of a grain storage hub* URL: <https://www.epravda.com.ua/news/2023/01/13/695933/> (access date 04/23/23). [in Ukrainian].
- [5] *Path of Ukrainian grain*. URL: <https://www.ukrinform.ua/rubriceconomy/3537063-slah-ukrainskogo-zerna.html#:~:text=%D0%A3%20%D0%BF%D0%BE%D1%80%D1%82%D0%B0%D1%85%20%D0%A3%D0%BA%D1%80%D0%B0%D1%97%D0%BD%D0%B8%20%D0%BD%D0%B0%20%D0%B2%D0%B8%D0%B2%D0%B5%D0%B7%D0%B5%D0%BD%D0%BD%D1%8F,%D1%8F%D0%BA%D0%B8%D1%85%20%D0%BF%D1%96%D0%B4%D0%B5%20%D0%B2%20%D0%B1%D1%8E%D0%B4%D0%B6%D0%B5%D1%82%20%D0%A3%D0%BA%D1%80%D0%B0%D1%97%D0%BD%D0%B8> (date of application 05.24.23). [in Ukrainian].
- [6] *A new logistics hub for transshipment of grain and oil was launched for farmers*. URL: <https://kurkul.com/news/31124-dlya-fermeriv-zapratsyuvav-noviylogistichniy-hab-dlya-perevalki-zernovih-ta-oliynih> (date of application 05.24.23). [in Ukrainian].
- [7] *Results 2022: destruction and construction of elevators*. URL: <https://elevatorist.com/spetsproekt/185-pidsumki-2022-ruynuvannya-ibudivnitstvo-elevatoriv#:~:text=%D0%A0%D1%83%D0%B9%D0%BD%D1%83%D0%B2%D0%B0%D0%BD%D0%BD%D1%8F%20%D0%B7%D0%B5%D1%80%D0%BD%D0%BE%D1%81%D1%85%D0%BE%D0%B2%D0%B8%D1%89%20%D1%82%D0%B0%20%D1%82%D0%B5%D1%80%D0%> (date appeal dated 05.24.23). [in Ukrainian].

Список використаних джерел

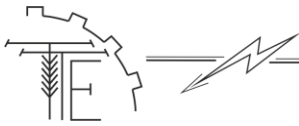
1. Логістика: Теорія і практика: Навч. посібник / Кислий В.М., Біловодська О.А., Олефіренко О.М., Соляник О.М.. К.: Центр учбової літератури, 2010. 360 с.
2. Як внутрішній транспорт допоміг економіці України та її громадянам вижити під час війни. URL: <https://www.unian.ua/economics/transport/yakvitchiznyaniy-transport-dopomig-vizhiti-ukrajinskiy-ekonomici-ta-jijigromadyanam-pid-chas-viyni-12105600.html> (дата звернення 20.06.23)
3. Проект Плану відновлення України. Матеріали робочої групи "Відновлення та розвиток інфраструктури". URL: [https://www.kmu.gov.ua/storage/app/sites/1/recoveryrada/ua/restoration-anddevelopment-of-infrastructure .pdf](https://www.kmu.gov.ua/storage/app/sites/1/recoveryrada/ua/restoration-anddevelopment-of-infrastructure.pdf) (дата звернення 14.05.23)
4. Україна та Гана обговорюють створення зернового хабу. URL: <https://www.epravda.com.ua/news/2023/01/13/695933/> (дата звернення 23.04.23).
5. Шлях українського зерна. URL: [zerna.html#:~:text=%D0%A3%20%D0%BF%D0%BE%D1%80%D1%82%D0%B0%D1%85%20%D0%A3%D0%BA%D1%80%D0%B0%D1%97%D0%BD%D0%B8%20%D0%BD%D0%B0%20%D0%B2%D0%B8%D0%B2%D0%B5%D0%B7%D0%B5%D0%BD%D0%BD%D1%8F,%D1%8F%D0%BA%D0%B8%D1%85%20%D0%BF%D1%96%D0%B4%D0%B5%20%D0%B2%20%D0%B1%D1%8E%D0%B4%D0%B6%D0%B5%D1%82%20%D0%A3%D0%BA%D1%80%D0%B0%D1%97%D0%BD%D0%B8](https://www.ukrinform.ua/rubriceconomy/3537063-slah-ukrainskogo-zerna.html#:~:text=%D0%A3%20%D0%BF%D0%BE%D1%80%D1%82%D0%B0%D1%85%20%D0%A3%D0%BA%D1%80%D0%B0%D1%97%D0%BD%D0%B8%20%D0%BD%D0%B0%20%D0%B2%D0%B8%D0%B2%D0%B5%D0%B7%D0%B5%D0%BD%D0%BD%D1%8F,%D1%8F%D0%BA%D0%B8%D1%85%20%D0%BF%D1%96%D0%B4%D0%B5%20%D0%B2%20%D0%B1%D1%8E%D0%B4%D0%B6%D0%B5%D1%82%20%D0%A3%D0%BA%D1%80%D0%B0%D1%97%D0%BD%D0%B8) (дата звернення 24.05.23).
6. Для аграріїв запущено новий логістичний хаб з перевалки зерна та олії. URL: <https://kurkul.com/news/31124-dlya-fermeriv-zapratsyuuvav-noviylogistichniy-hab-dlya-perevalki-zernovih-ta-oliynih> (дата звернення від 24.05.23).
7. Результати 2022: знищення та будівництво елеваторів. URL: <https://elevatorist.com/spetsproekt/185-pidsumki-2022-ruynuvannya-ibudivnitstvo-elevatoriv#:~:text=%D0%A0%D1%83%D0%B9%D0%BD%D1%83%D0%B2%D0%B0%D0%BD%D0%BD%D1%8F%20%D0%B7%D0%B5%D1%80%D0%BD%D0%BE%D1%81%D1%85%D0%BE%D0%B2%D0%B8%D1%89%20%D1%82%D0%B0%20%D1%82%D0%B5%D1%80%D0%> (дата звернення 10.06.23)

ШЛЯХИ СТАБІЛІЗАЦІЇ СТАНУ ВАНТАЖОПЕРЕВЕЗЕННЯ СІЛЬСЬКОГОСПОДВРСЬКОЇ ПРОДУКЦІЇ В УМОВАХ ШИРОКОМАСШТАБНОЇ АГРЕСІЇ

3 початком військових дій на території України, шляхи транспортування сільськогосподарської продукції було порушено, знищено велику кількість елеваторів, складів зруйновано дорожнє покриття, захоплені морські порти. Метою даної статті було дослідження сучасного стану вантажоперевезення під час військового стану та вдосконалення і стабілізація шляхів перевезення сільськогосподарської продукції. Завданням було знайти шляхи покращення логістики та шляхи захисту зернової продукції від ракетних ударів, а також можливі маршрути для вивезення цього зерна з території України. В статті наведено результати аналітичного аналізу стану вантажоперевезення сільськогосподарської продукції, запропоновано шляхи стабілізації та вирішення проблеми. Розвиток логістики та співпраця із закордонними партнерами, побудова захищених хабів для збереження зернової продукції, також побудова сучасних елеваторів, які могли б накопичувати великі обсяги продукції, для подальшого її транспортування великими партіями до замовників.

Важливим для нашої країни є питання транспортування сільськогосподарської продукції від виробника до покупця. Повномасштабна війна Росії проти України підкреслила надзвичайну важливість транспортного комплексу для економіки та суспільства. З початком вторгнення на українську землю було повністю припинено повітряне сполучення зі світом, а також заблоковано морські порти. З початком бойових дій на території України були порушені маршрути транспортування сільськогосподарської продукції, зруйновано велику кількість елеваторів, зруйновано дорожнє покриття складів, захоплено морські порти.

Метою даної статті було дослідження сучасного стану вантажних перевезень в умовах воєнного стану, вдосконалення та стабілізації шляхів транспортування сільськогосподарської продукції. Завдання полягало в тому, щоб знайти шляхи покращення логістики та шляхи захисту



зернових продуктів від ракетних ударів, а також можливі шляхи вивезення цього зерна з території України.

У статті наведено результати аналітичного аналізу стану перевезень сільськогосподарської продукції, запропоновано шляхи стабілізації та вирішення проблеми. Розвиток логістики та співробітництво з іноземними партнерами, будівництво захищених хабів для зберігання зернових продуктів, а також будівництво сучасних елеваторів, які могли б накопичувати великі обсяги продукції для подальшого її транспортування великими партіями до споживачів. Оптимальним варіантом для України було б створення зернових хабів у європейських країнах, а також транспортування зерна автотранспортом, накопичення зерна великими партіями та доставлення його в інші частини світу через порти Європи. Однак сьогодні це не так просто, адже нині європейські країни вводять обмеження на імпорт нашої зернової продукції.

Сьогодні, незважаючи на складну військову ситуацію, втрачену частину транспортної інфраструктури та логістики, Україна є однією з найбільших країн-експортерів зерна. Відновлення традиційних шляхів перевезення вантажів і постійний пошук нових є ознакою здорової та перспективної політики розвитку транспортної галузі. Європейський вибір нашої держави, підтримка партнерів забезпечать безперервність вантажних перевезень та дадуть новий поштовх розвитку річкового та залізничного транспорту.

Ключові слова: логістика, вантажні перевезення, зерноелеватори, зернова угода, проблеми в транспортуванні.

Рис. 6. Літ. 7.

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