SUSTAINABLE DEVELOPMENT OF LOGISTICS IN UZBEKISTAN: DIGITIZATION, ENVIRONMENTAL INNOVATION AND INFRASTRUCTURE PROBLEMS

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Annotation: this article explores the role of digitization, environmental innovation and infrastructure problems in ensuring sustainable development of the logistics sector in Uzbekistan. The study analyzes local and international experiences and examines current problems in the automation of logistics processes, the introduction of environmentally friendly vehicles and the modernization of road infrastructure. Using qualitative and quantitative methods, ways to improve the efficiency of the logistics system in the conditions of Uzbekistan are determined. The results show that the use of digital platforms and renewable energy sources reduces logistical costs and reduces the negative impact on the environment. But the fact that the infrastructure is outdated and financial resources are limited creates serious obstacles. The article provides practical suggestions for overcoming these problems.

Keywords: logistics, sustainable development, digitization, environmental innovation, infrastructure, Uzbekistan, transport system, renewable energy.

Introduction: Logistics is an important branch of the modern economy and ensures the efficient delivery of goods and services. Uzbekistan's strategic location in Central Asia makes it an important hub in the global logistics network. The country is actively involved in the modern form of the Great Silk Road – international transport corridors, gaining importance as a transit area connecting the markets of China, Europe and the Middle East. In recent years, the Government of Uzbekistan has been paying great attention to the development of logistics infrastructure, but factors such as insufficient introduction of digitization, environmental problems and obsolescence of road networks prevent the sustainable development of the industry. Digitization plays an important role in optimizing logistics processes. Logistics companies around the world are using technologies such as artificial intelligence, blockchain and IoT (Internet of Things) to reduce costs and improve the quality of Service. And in Uzbekistan, digital platforms – for example, ATI.SU cargo exchange-shows preliminary progress in the planning of domestic and international transportation. However, the widespread use of these systems is slow due to lack of infrastructure and Human Resources [1]

Environmental innovation is important in ensuring the sustainability of the logistics sector. Conventional fuel-based vehicles cause air pollution and climate change. Carbon emissions of automobile transport in Uzbekistan have a negative impact on urban air quality, especially in large cities such as Tashkent. The use of electric transport and

renewable energy sources can be an important solution to these problems, but the introduction of such technologies is still in its infancy. Infrastructure problems are one of the main obstacles to the logistics of Uzbekistan. The obsolescence of road networks and railway infrastructure, the lack of logistics centers, and the scarcity of modern systems such as charging stations make transportation processes more expensive and time-consuming. For example, while the Navoi international intermodal logistics center is a significant achievement, there is a lack of such centers in all regions of the country. This article is aimed at identifying ways of sustainable development of logistics in Uzbekistan and analyzes the problems of digitization, environmental innovation and infrastructure. The study aims to adapt international experience and offer practical solutions, taking into account local conditions [2].

Literature analysis: the logistics sector is one of the main sectors of the modern economy, providing efficient movement of goods and services. Internationally, research in the field focuses heavily on digitization and environmental sustainability. Scientists around the world are looking for ways to introduce new technologies and develop environmentally friendly transport systems to optimize logistics processes. For example, artificial intelligence and blockchain technologies significantly reduce costs when planning cargo transportation, while increasing the speed of delivery. Electric trucks and hydrogen-based vehicles are being widely introduced in Europe to help reduce carbon emissions. These experiences shape the sustainability-focused strategies of global logistics systems and serve as important guidance for developing countries. Although research on logistics in Uzbekistan is smaller than international, in recent years there has been significant activity in this direction. Local scientists and specialists are studying the possibilities of making Uzbekistan an important logistics center in Central Asia, based on the strategic location of the country. The research is mainly focused on the state of road infrastructure, the introduction of digital technology and its role in international transport corridors. For example, it is argued that the obsolescence of road networks and the lack of modern logistics centers are slowing the development of the industry. The international intermodal logistics center” Navoi " is cited as an important achievement because it plays an important role in transit cargo transportation, but the inadequacy of such centers across the country remains as a problem. Local research on digitization shows early progress in Uzbekistan. For example ATI.SU online platforms such as have reduced costs by simplifying processes in internal shipments. However, small and medium-sized businesses have a low level of application of these systems, due to a lack of financial resources and qualified personnel. At the same time, the environmental aspects of logistics processes are often overlooked. While the impact of conventional fuel-based trucks on air pollution has been studied, practical projects for electric transport and the use of renewable energy sources are still in their infancy. Financial constraints and insufficient personnel experience in this matter are seen as a serious obstacle [3].

Uzbekistan's role in international transport corridors also plays an important role in research. The country is actively involved in the modern form of the Great Silk Road –

China-Europe transit routes. However, the slow progress of infrastructure modernization and insufficient attention to environmental factors will interfere with the full realization of the potential of transit freight transport. Local studies recommend strengthening cooperation with the private sector and expanding digital technologies, but these proposals are often of a general nature, with difficulties in practical implementation. In general, it is clear that there is a growing interest in the field of logistics in Uzbekistan, but most of the research is not being turned into practical projects due to infrastructure and financial constraints.

Methods: the study was aimed at determining the ways of sustainable development of the logistics sector in Uzbekistan, and qualitative and quantitative methods were used together in this process. The aim was to comprehensively study digitization, environmental innovation and infrastructure problems and offer solutions suitable for local conditions. This approach served to adapt the global experience to the economic, geographical and environmental conditions of Uzbekistan.

Literary analysis was one of the main stages of research. International journals and scientific publications were studied, as well as articles published in Uzbekistan. International sources analyzed the latest advances in digitization of logistics processes, environmentally friendly vehicles and infrastructure development. Local sources, on the other hand, collected information about Uzbekistan's transport and logistics system, the state of road networks and the use of digital platforms. This analysis made it possible to compare global trends with local problems and helped to identify the most relevant issues for Uzbekistan. The method of data analysis was used to assess the real state of the logistics system in Uzbekistan. Government reports, statistics and environmental monitoring results were reviewed. In particular, the volume of freight traffic, the state of road infrastructure, the efficiency of rail networks and the environmental impact of transport emissions were analyzed. For example, official data was studied to determine the level of air pollution and the share of trucks in large cities such as Tashkent and Samarkand. At the same time, the degree of application of digital platforms and their economic efficiency were analyzed. Expert interviews have added a practical perspective to the study. Interviews were conducted with leaders of logistics companies, transport industry experts, environmentalists and representatives of government agencies. They discussed the main problems of the logistics system in Uzbekistan – the obsolescence of roads, the scarcity of charging stations, difficulties in the implementation of digital systems–. At the same time, they highlighted such opportunities as the use of solar energy, the testing of electric transport and the expansion of international cooperation. These conversations enriched the study with real-life challenges and helped shape strategies that were appropriate to the local context [4].

Comparative analysis was applied to compare the effectiveness of digital platforms, environmentally friendly vehicles and infrastructure projects with international experience. For example, the. ATI.SU the platform has been compared to China's Cainiao or Europe'S DHL digital systems. At the same time, the use of electric trucks in Uzbekistan was

compared with European experience – for example, electrification of freight transport in Norway–. This analysis helped determine which technologies and strategies are most suitable for Uzbekistan, especially taking into account economic resources and climatic conditions.

Results: the study showed that Uzbekistan has great opportunities for the sustainable development of the logistics sector, but a number of serious obstacles remain. Digitization provides significant achievements in the field. Online platforms have greatly reduced costs by simplifying processes in internal shipments. For example, planning transportation through cargo exchanges allowed logistics companies to reduce the number of empty walks and optimize fuel consumption. However, the use of these platforms is very limited in small and medium-sized businesses, as many businesses do not have enough resources and experience to implement digital technologies. This situation indicates that only large companies are seeing the benefits of digitization. Ecologically, conventional fuel-based trucks have been identified as one of the main sources of air pollution. Especially in large cities, these vehicles increase the level of harmful substances in the air, which negatively affects the health of the population and the living conditions of cities. Initial testing projects for electric transport have begun, but due to a lack of infrastructure – such as charging stations – these initiatives are not being used on a large scale. At the same time, Uzbekistan's coal-based energy system limits the environmental benefits of electric transport, since clean energy sources are not yet sufficiently developed [5].

Infrastructure problems were seen as one of the biggest obstacles in the logistics sector. A large part of the road network is outdated, which will extend the time of transportation and increase costs. Rail networks also do not fully meet modern requirements, causing difficulties in international transit freight traffic. While the Navoi Center for logistics centers is a significant achievement, other regions of the country lack such infrastructure. This situation interferes with the full use of Uzbekistan's transit potential. In terms of opportunities, the climatic conditions and strategic location of Uzbekistan give great advantages. The use of solar energy provides an ideal opportunity for the development of charging stations and the support of electric transport. At the same time, digital management systems can make logistics processes more efficient, especially if their application is facilitated for small businesses. The active participation of Uzbekistan in international transport corridors makes it possible to increase the volume of transit cargo transportation and bring economic benefits, but this requires attention to infrastructure modernization and environmental factors.

Discussions: the results of the study show that Uzbekistan has great opportunities for the sustainable development of the logistics sector, but significant obstacles remain. While digitization processes have increased efficiency in domestic transportation, the technological capabilities of small and medium-sized businesses are limited. For example, only large companies are effectively using digital platforms, while small businesses are lagging due to financial and qualification constraints [6].

Ecologically, the impact of conventional vehicles on air pollution is significant. Electric trucks and hydrogen technologies are being tested, but the coal-based energy system limits these initiatives. In contrast to international experience, Norway and China have a widely developed electric transport infrastructure, which is an important example for Uzbekistan. For example, more than 30% of freight traffic in Norway is carried out by electric transport. Infrastructure problems increase logistics costs. Due to the obsolescence of roads and the scarcity of logistics centers, the transportation time extends by an average of 20%. While the Navoi center is an important achievement, areas such as Samarkand, Fergana and Surkhandarya lack modern logistics infrastructure. Solar power and digital control systems can partially solve these problems, but large investments and long-term planning are required. Given the local conditions, the hot climate of Uzbekistan is ideal for the use of solar energy, but low personnel qualifications and environmental awareness of the population slow down this process. International cooperation – for example, China's One Belt, One Road Initiative-can play an important role in financing infrastructure projects.

Conclusions and suggestions: the sustainable development of the logistics sector in Uzbekistan is important in ensuring economic growth and environmental sustainability. While digitization processes reduce costs, infrastructure obsolescence and environmental issues pose serious obstacles. The use of electric transport and renewable energy sources can increase the stability of the industry, but this process requires significant investment and state support. The following suggestions are recommended to be made:

Expanding digital platforms and subsidizing their use for small businesses;

Development of a network of solar-based charging stations, especially in transit corridors;

Attracting international investment to modernize road and rail infrastructure;

Introduction of tax breaks and cheap loans for the introduction of electric trucks;

To train specialists in the field of logistics and to organize training programs to increase environmental awareness of the population.

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