

Statistical Examination of Social Infrastructure in Ukraine's Border Regions

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Abstract: In this paper, we examine Ukraine's post-war reconstruction and the critical need for modernizing social infrastructure to preserve and develop human capital, facilitate the integration of displaced persons, and enhance regional competitiveness, particularly in border areas with the EU where such infrastructure is essential for cross-border cooperation and European integration. Utilizing methods including system analysis, structural-functional and comparative analysis, territorial analysis, and generalization, we classify types of social infrastructure, outline objectives for modernization, and identify key implementation stages in Ukraine's border regions. Our findings reveal that effective modernization is vital for preserving human capital, curbing depopulation and youth outflow, integrating internally displaced persons and veterans, attracting investments, and fostering regional economic development. Key elements include rehabilitation centers, modern educational institutions, housing and digital infrastructure, and improved transport systems for cross-border communication. Ultimately, this paper concludes that the modernization of social infrastructure is crucial for Ukraine's post-war economic recovery, human capital preservation, and integration into the European space, with a comprehensive approach that considers social, economic, and institutional factors essential for sustainable territorial development and enhancing their strategic significance for the state.

Keywords: social infrastructure, modernization, post-war reconstruction, border regions of Ukraine, human capital, European integration, cross-border cooperation.

1 Introduction

The post-war reconstruction of Ukraine highlights the need to form a modern model of social infrastructure that is capable of ensuring the reproduction and development of human capital as a key resource for economic growth. In scientific literature, social infrastructure is considered not only as a set of objects and institutions that satisfy the basic social needs of the population, but also as a system-forming factor in increasing the competitiveness of the national economy and strengthening the social cohesion of society.

One of the critical challenges for Ukraine is the massive outflow of human capital, which complicates the processes of restoring economic potential and integrating progressive management and technological practices. The preservation of the population, its social adaptation and reintegration of war-affected persons are the determining prerequisites for the reconstruction of the country. In this regard, the modernization of social infrastructure covers not only traditional areas (education, healthcare, culture, sports), but also the development of specialized rehabilitation infrastructure, including medical and rehabilitation centers, veteran hubs, and social services.

The problem is of particular importance in the border regions of Ukraine with the EU, which act as a space for active socio-economic, cultural, and humanitarian exchanges. These regions have the potential to become «pilot sites» for the implementation of modern models of social infrastructure integrated into the European space. The modernization of social infrastructure in border areas can not only improve the quality of life of local communities, but also strengthen cross-border cooperation, contribute to the preservation of human capital, and create the prerequisites for sustainable development in the post-war period.

2 Materials and Methods

The following scientific methods were used in the research: the method of system analysis and synthesis, which made it possible to reveal the essence of the concept of "social infrastructure" in the context of post-war reconstruction and determine its role in the preservation and reproduction of human capital; the structural-functional method, which made it possible to

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identify the main directions and elements of the modernization of social infrastructure in the border regions of Ukraine, as well as the arguments and tasks of the modernization of the social infrastructure of the region; the method of territorial analysis, which provided a study of the features of the border regions of Ukraine as a space for cross-border cooperation; the generalization method, which was used to formulate conclusions and determine strategic guidelines and stages of the modernization of social infrastructure in the post-war period.

3 Results

The post-war recovery of the Ukrainian economy requires various types of resource provision, and in particular, the main one is human resources. From the perspective of infrastructure modernization, the development of human resources in the EU border regions depends on many factors, including the modernization of social infrastructure, because social infrastructure plays a key role in creating conditions for living, working and integrating the population.

In general, social infrastructure is a set of facilities, institutions and services that ensure the satisfaction of social needs of the population, such as education, healthcare, culture, transport, housing, etc. It is a basic element of social development, as it determines the quality of life, social stability and economic potential of the region.

Onikienko V., Voloshyn O. emphasize that social infrastructure contributes to increased labor productivity, increased employment, and reduced social inequality. For example, access to quality medical care and educational services directly affects the quality of human capital [1].

Baranova O. studied how the construction of new schools and clinics in rural areas reduces the migration of youth to cities and improves the demographic situation [2].

Kachura T. analyzed the effectiveness of using subventions for the construction of medical and educational institutions in territorial communities. As a result of the research, the author substantiated the conclusion that investments in social infrastructure contribute to increasing the attractiveness of regions for investors [3].

Vasylytsiv T., Bil M., Bachynska M. determined the expected results of implementing social infrastructure development tools in the context of improving the quality of life of the population of the Carpathian region in the following areas: effective use of the health and recreational potential of the Ukrainian Carpathians; development of cross-border cooperation in the field of improving social infrastructure and environmental protection; transition to smart-oriented development of housing and communal services; improvement of the transit potential of the territories of the Carpathian region; preservation and improvement of the cultural environment [4].

The examples given demonstrate the theoretical and practical importance of social infrastructure as an important element of the development of society and the economy. In general, the main types of social infrastructure are (Fig. 1.):

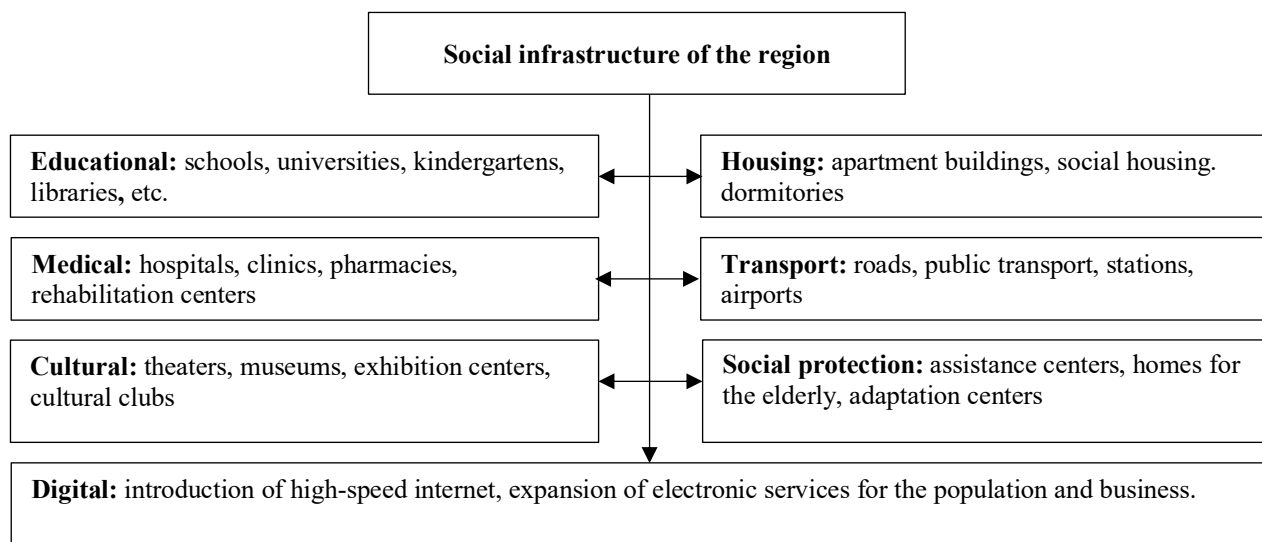


Fig. 1: Types of social infrastructure

The types of social infrastructure are: educational, medical, cultural, housing, transport, social protection, digital. At the same time, digital has been gaining importance over the past decades and has become a basic social infrastructure need of the population.

In the context of post-war recovery, the main task of modernizing social infrastructure is to stimulate the return of the population to Ukraine and ensure proper living conditions for the population in accordance with European quality standards. Therefore, considering the social infrastructure of the border regions with the EU from the position of its modernization in the post-war period for the rapid recovery and stability of the economy, attention should be paid to its updating according to European standards in all areas.

The priority here is ensuring quality. In particular, transport infrastructure requires the development of modern roads, bridges and border crossings, ensuring logistical connections with EU regions to facilitate trade; educational infrastructure - the restoration of schools, universities and vocational schools to train qualified personnel, the integration of European education standards to increase the competitiveness of graduates; medical infrastructure involves the reconstruction of hospitals and the creation of modern rehabilitation centers for war veterans, expanding access to quality medical services for residents of remote areas; housing infrastructure involves the construction of affordable housing for IDPs and the restoration of destroyed houses; digital infrastructure involves the introduction of high-speed Internet, the expansion of electronic services for the population and business. These areas of development will help strengthen the economy, improve the quality of life of the population and contribute to the integration of Ukraine into the European environment.

In the context of war, social infrastructure becomes critically important for many reasons, including: to reduce forced migration during war; creating safe living conditions (development of housing stock, construction of shelters, arrangement of medical facilities, which reduces the need for the population to travel to other countries); access to basic services (the presence of schools, hospitals, social security institutions ensures a minimum level of living needs, which reduces pressure on migration flows); jobs (investments in social infrastructure create jobs, which helps to keep the population in place). They are decisive in choosing the place of residence of the population during war.

Migration losses of the population during the war for Ukraine are very significant. According to the National Bank of Ukraine, migration losses of Ukraine due to Russian military aggression amount to about 7 million people and this figure is growing every day [5].

According to the UN, as of the end of September 2024, more than 6 million Ukrainians had temporary protection in European countries. Another almost 600 thousand Ukrainians received protection outside Europe. Poland and Germany accepted the largest number of Ukrainian citizens - by a large margin from other countries [6].

According to a survey by the Institute for Economic Research (IER), businesses name the lack of personnel due to mobilization and departure of employees abroad in second place among the main obstacles for themselves during the war. And the weight of this factor increased sharply in the summer of 2024. In August, 65% of surveyed businesses named power outages as an obstacle, and 63% named the lack of personnel (while a month before that - 47%). And only in third place in the ranking is an obstacle directly related to the war – «it is dangerous to work», in particular, the indicator decreased from 58% in July to 46% in August [6].

Libanova E. notes that the key areas of the strategy, which will be aimed at overcoming demographic challenges, are not only attracting migrants, but also supporting Ukrainian families, increasing the birth rate, reducing premature mortality, in particular among men, and rethinking the attitude towards the aging population [7].

Awareness of the problem gives an understanding of the importance of a comprehensive approach to the formation of algorithms for its solution. This applies to both stimulating the birth rate, supporting youth, returning Ukrainians to Ukraine, and modernizing social infrastructure.

Therefore, a certain mission of the post-war restoration of social infrastructure from the position of human resources is: first, preventing new human losses and, second, returning Ukrainians from abroad, third, ensuring proper living conditions in Ukraine, supporting youth, stimulating the birth rate in Ukraine.

Summarizing the arguments in favor of modernizing social infrastructure in the border regions with the EU, we will highlight the following of them (Fig. 2.):

1. Strengthening the demographic potential of regions, in particular by stopping depopulation, stopping the outflow of youth and qualified personnel, attracting new residents, because improved living conditions can attract not only returnees, but also new residents, including foreigners.
2. Promoting the integration of displaced persons, because new social services (rehabilitation centers, employment centers) facilitate the adaptation of returnees. Social infrastructure helps minimize social inequality and promotes the integration of different segments of the population, including war veterans, IDPs and other vulnerable groups.
3. Positive impact on the economy and attracting investments, because developed social infrastructure attracts investors as

guarantors of stability and promising development of the region. Social infrastructure contributes to improving business conditions, attracting investments and creating new jobs. This is especially important for regions that were destroyed during the war.

4. Human capital development through quality education, healthcare and housing forms the basis for long-term economic growth, stimulates the return of internally displaced persons (IDPs) and stops the outflow of youth and skilled personnel.
5. European integration, as border regions are a kind of «gateway» to the EU. Infrastructure development allows for deepening economic and social ties between border regions of Ukraine and neighboring EU countries, contributing to overall stability and prosperity.

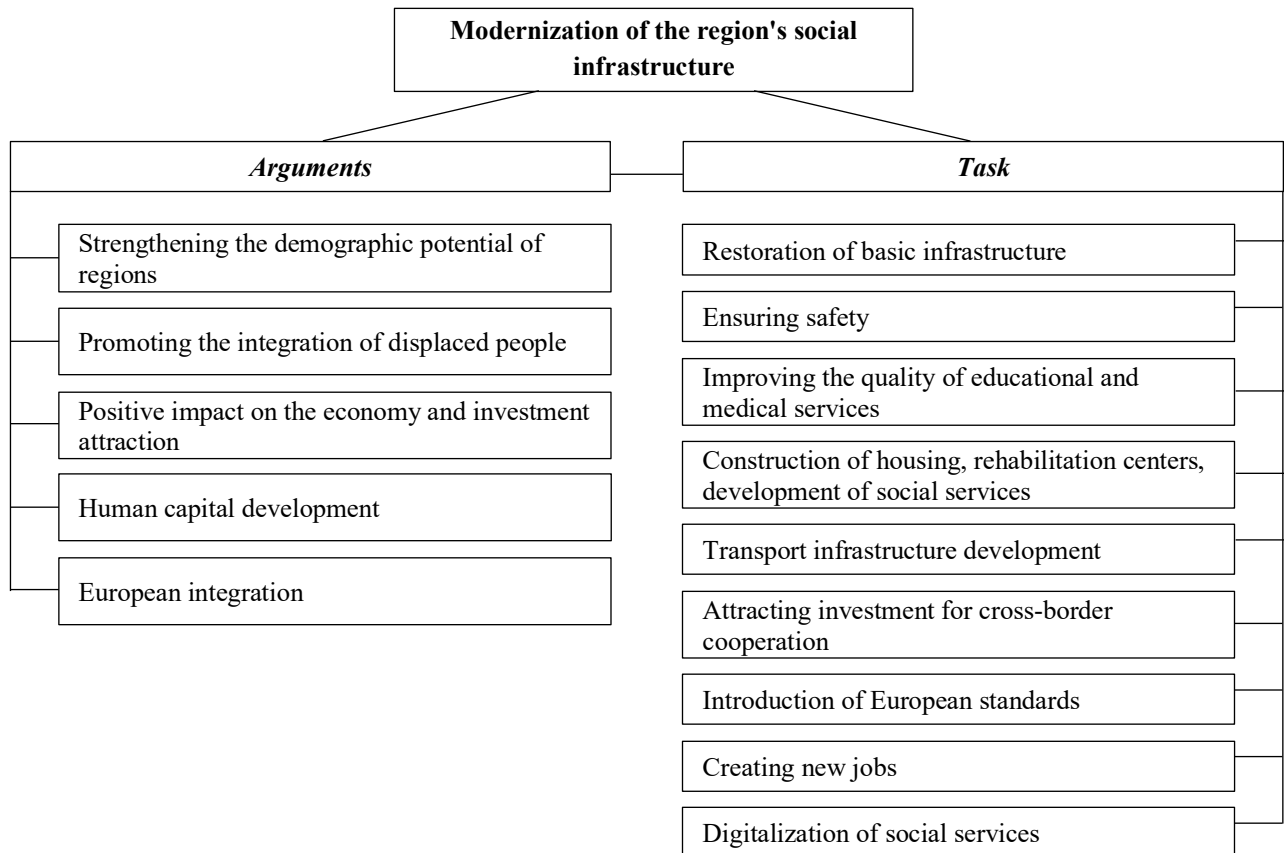


Fig. 2: Arguments and tasks for the modernization of the social infrastructure of the region

Regions on the border with the EU can become models for the implementation of European standards in the service sector. This strengthens Ukraine's integration into the European space. Modernization of social infrastructure according to European standards contributes to the faster integration of Ukraine into the EU, cross-border cooperation, the creation of joint projects and improving conditions for business and tourism. That is, the modernization of social infrastructure in the border regions with the EU in the post-war period is aimed at ensuring the quality of life of the population, restoring the economy and integrating Ukraine into the European space.

The tasks for such modernization are:

1. Restoration of basic infrastructure, which involves the reconstruction of damaged facilities (reconstruction of schools, hospitals, residential buildings, transport hubs and utility systems), ensuring access to water, electricity and heat, i.e. ensuring access to basic needs.
2. Ensuring security, including the creation of shelters (construction or modernization of safe spaces in schools, hospitals, residential buildings), training of response services (equipping and training rescuers, doctors and social workers to work in emergency situations).
3. Improving the quality of educational and medical services: modernization of educational institutions, introduction of modern technologies, training of qualified personnel, ensuring access to inclusive education, equipping hospitals with

new equipment, development of telemedicine, improving access to medical services, particularly in rural areas.

4. Creating favorable conditions for the return of the population, including: construction or reconstruction of affordable housing for displaced persons, expanding access to rehabilitation centers, psychological assistance services, adaptation programs for veterans and displaced persons, development of educational, cultural and sports institutions for the younger generation.
5. Development of transport infrastructure, including improvement of border crossings to reduce border crossing time through the introduction of modern technologies, modernization of roads and railways, ensuring convenient communication between regions of Ukraine and EU countries.
6. Attracting investments for cross-border cooperation, developing projects to attract European grants, investment programs and cooperation with international organizations, implementing joint projects.
7. Integration of European standards, in particular through the implementation of environmental standards, development of energy-efficient buildings, use of renewable energy sources, ensuring the quality of medical, educational and social services in accordance with EU standards.
8. Creation of new jobs through the development of enterprises serving social infrastructure (construction companies, service organizations), development of human capital through the provision of training programs for employees in key areas.
9. Digitalization of social services, in particular electronic services, introduction of e-government and access to online services, implementation of «smart» solutions for managing energy consumption, transport and utilities.

Modernization of social infrastructure in these regions will contribute not only to improving living conditions, but also to strengthening the regions as strategic points of Ukraine's integration into the European Union.

To modernize social infrastructure in the EU border regions in the post-war period, it is important to implement a comprehensive approach that takes into account social, economic and institutional aspects. The main stages of such modernization are (Fig. 3):

1. Assessment of the current state and needs, including conducting an infrastructure audit to determine the extent of damage and analyzing available resources, collecting data on the needs of the population, developing regional strategies, and formulating development plans taking into account international standards and the needs of specific territories.
2. Planning and financing, which involves finding sources of financing (state budgets, international aid programs (EU, World Bank, USAID, etc.), grants from non-governmental organizations, partnerships with the private sector (Public-Private Partnership) and developing transparent financing mechanisms.
1. Considering the post-war situation, it is not difficult to predict a lack of financial resources for the modernization of social infrastructure in border regions. Therefore, the search for additional sources of financing is one of the most important stages of modernization, which requires knowledge, experience, communications, partnership, a number of organizational and coordination actions.
2. Determining the priority of the implementation of infrastructure projects, which depends on the assessment of the current state and the provision of basic needs. The choice of priority becomes especially important in the absence of an adequate level of financing for all needs.
3. Integration with European standards, in particular, harmonization of legislation, implementation of EU standards in the fields of healthcare, education, transport and social services. The post-war restoration of the Ukrainian economy in all areas requires the introduction of European standards, taking into account the choice European vector of development of the country. This also applies to social infrastructure and its modernization.
4. Involving the community in the implementation of projects, public discussions of feasibility, priority, financing, conducting campaigns to explain the importance of modernization. Post-war reconstruction and development of Ukraine requires thoughtful, balanced and coordinated mechanisms. The development of civil society, taking into account public opinion in the system of complex interpersonal post-war relations is difficult, but the only correct one.
5. Monitoring and assessing the effectiveness of project implementation and their impact on the quality of life of the population of the border regions with the EU. This includes, among other things, involving independent experts, assessing the compliance of the results with European standards. The results of such monitoring are, if necessary, adjusting strategies, improving development plans based on the results obtained. Therefore, the scheme indicates feedback.

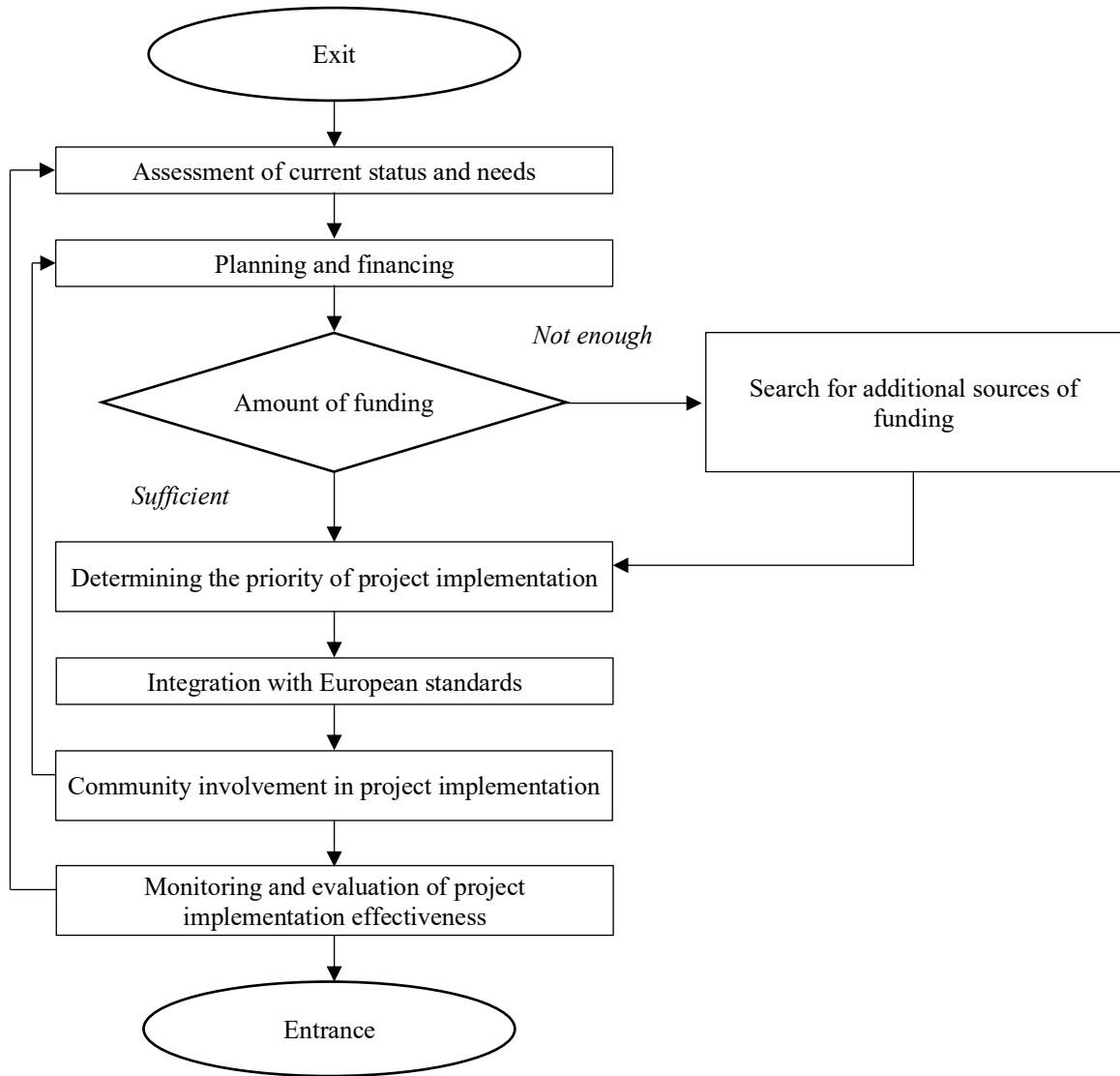


Fig. 3: Main stages of the process of modernization of the region's social infrastructure

Thus, the modernization of social infrastructure in border regions is an important factor for economic recovery after the war, as it contributes to the return of labor resources and economic development, including by using cross-border potential. This is one of the key factors that can change migration trends, stimulate the return of Ukrainians and ensure sustainable development of border regions, strengthen Ukraine's position on the path to recovery, but also create new prospects for integration into the European community.

Table 1: Comparison of Social Infrastructure Indicators

Indicator	Border Region A	Border Region B	Border Region C	National Average
Number of Hospitals	2	3	1	5
Schools per 1,000 Residents	1.5	2.0	1.0	3.0
Public Transport Availability	Limited	Moderate	Good	Good
Percentage of Population with Access to Internet	40%	55%	30%	75%

Table 1 compares key social infrastructure indicators among three Ukrainian border regions and the national average. The metrics analyzed include the number of hospitals, schools per 1,000 residents, and percentage of population with access to internet.



Fig. 4: Comparison of Social Infrastructure Indicators across Border Regions and National Average

The figure shows considerable disparity between the border regions and the national average across all indicators. Border Region B leads among the border areas in terms of schools and internet access, which suggests relatively more developed infrastructure. However, all border regions have far fewer hospitals and schools per capita than the national average, and a much lower rate of internet connectivity. This infrastructure gap can affect public health, education, and digital inclusion, highlighting the urgent need for targeted development.

The visualization makes these differences clear: while the national average substantially exceeds the border regions on all measures, Border Region B demonstrates localized progress. Addressing such gaps, especially in medical services and digital access, is critical for economic recovery, social welfare, and the effective integration of these regions within broader national and European frameworks.

An important factor in the successful modernization of social infrastructure is the active participation of non-governmental organizations. Due to their flexibility and proximity to the needs of communities, they are able to initiate new formats of social services, develop and implement projects for the construction or restoration of medical, educational and cultural institutions, organize the work of rehabilitation centers, veteran hubs, youth and sports spaces. NGOs play the role of an intermediary between citizens, business and state structures, ensuring the effective attraction of resources and the formation of innovative management models.

In the scientific literature, when studying the concept and features of the activities of «non-governmental organizations», the concepts of «non-profit organization», «public organization», and others are also used, which generally characterize civil society organizations. What they have in common is that they operate outside the state and business [8].

Non-governmental organizations are able to complement state efforts, attract additional resources, expert knowledge and provide a flexible response to the social needs of the population. The participation of NGOs in border regions is especially relevant, where it is necessary to integrate displaced persons, support vulnerable groups and promote cross-border cooperation. Non-governmental organizations participate in various mechanisms for modernizing social infrastructure. Among them are the assessment of population needs and the audit of social facilities, the implementation of projects in the fields of education, medicine, culture, sports and digital services. They also attract funding through grants, international programs, partnerships with the private sector and charitable contributions, coordinating their actions with state and local programs.

The participation of NGOs will contribute to increasing the efficiency of the implementation of key stages of modernization. They can accelerate the restoration of basic infrastructure, promote European quality standards through training and expert programs, and also participate in monitoring and evaluating the results of project implementation. Such interaction provides additional flexibility, reduces the risks of inefficient use of resources and promotes social integration of the population.

The integration of NGOs into the process of modernization of social infrastructure is of strategic importance for the sustainable development of border regions, the preservation and restoration of human capital, as well as for strengthening cross-border cooperation and the integration of Ukraine into the European socio-economic space.

Social entrepreneurship also deserves special attention as an innovative tool for modernizing social infrastructure. It can act as a factor in maintaining employment, stimulating the local economy, and at the same time solving socially significant problems. Social enterprises combine business logic with a social mission, directing part of their profits to community development, supporting vulnerable groups, and creating social services [9].

The development of social entrepreneurship can enhance the effectiveness of infrastructure modernization, as it not only provides services, but also creates new jobs, promotes the return of veterans and internally displaced persons to active economic life, and develops a culture of partnership between the state, business, and the public sector. In this sense, social entrepreneurship becomes an important factor in economic growth in conditions of instability and a tool for long-term sustainability of territories.

In the strategic perspective, the modernization of the social infrastructure of the border regions of Ukraine should be considered not only as an intrastate priority, but also as a tool for deepening cross-border cooperation.

Cross-border cooperation ensures sustainable development and competitiveness of Ukrainian border territories [10]. The integration of European standards in the field of health care, education, social protection and rehabilitation creates conditions for the synchronization of social policies with neighboring EU countries. This contributes to increasing population mobility, the formation of joint development programs, attracting additional investments and strengthening trust in the regions as a safe and promising space.

Thus, the modernization of social infrastructure in border regions acquires the status of a strategic landmark, which determines their role in the processes of European integration and sustainable development. It is this perspective that opens up opportunities for generalizing the results of the study and drawing conclusions regarding further directions for the restoration and development of regions in the post-war period.

4 Statistical Analysis

To summarize the central tendency and dispersion of key infrastructure indicators (hospitals, schools, and internet access), Table 2 provides the mean, variance, and standard deviation across the border regions. This, according to the descriptive Statistics.

Table 2: Descriptive statistics of key social infrastructure indicators across Ukrainian border regions.

Indicator	Mean	Variance	Standard Deviation
Number of Hospitals	2	1	1
Schools per 1,000 Residents	1.5	0.25	0.5
Internet Access (%)	41.7	104.22	10.2

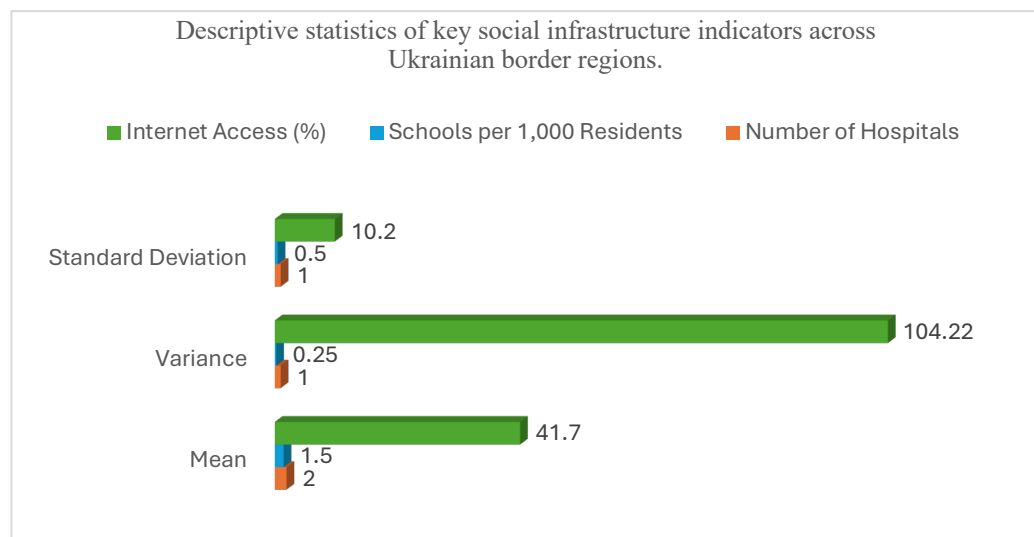


Fig. 5: Descriptive statistics of key social infrastructure indicators across Ukrainian border regions.

The standard deviation for internet access is relatively high (10.2%), showing notable inequality in digital infrastructure across border regions. Hospital and school access shows less variance, but even the region with the maximum value still lags seriously behind the national average (5 hospitals, 3 schools per 1,000, 75% internet). This persistent gap indicates a need for targeted investment. Moreover, region B is visibly higher in both schools and on the Internet.

5 Discussion

Discussions on the modernization of social infrastructure in the border regions of Ukraine focus on the sequence and priorities of the stages of restoration: assessment of the state of infrastructure, planning of financing, integration of European standards, and monitoring of effectiveness. Some authors emphasize the importance of strategic prioritization at the initial stage, while others emphasize community involvement and adaptation to local needs. At the same time, the balance between the rapid restoration of basic infrastructure and the long-term implementation of European standards is debatable, which emphasizes the need for a flexible and adaptive approach for the sustainable development and integration of Ukraine into the European space.

6 Conclusion and Recommendations

Modernization of social infrastructure in the border regions of Ukraine with the EU is an important factor in the post-war economic recovery, preservation and development of human capital, and integration of the country into the European space. Analysis of the types of social infrastructure, arguments and tasks of modernization, as well as the main stages of its implementation demonstrates the complex nature of this process, which includes assessing the needs of the population, planning financing, setting priorities, integrating European standards, community involvement and monitoring effectiveness.

Effective modernization of social infrastructure helps to stop the outflow of youth and qualified personnel, attract internally displaced persons, develop the economy of regions and increase their strategic significance. Integration of European standards in all areas of social infrastructure allows to improve the quality of life of the population, strengthen cross-border cooperation and create prerequisites for sustainable development of border regions. A comprehensive and systematic approach to modernization ensures not only prompt recovery, but also long-term stability and prospects for Ukraine's integration into the European socio-economic space.

In addition, some recommendations must be taken into account for the upcoming study:

- For future statistical robustness, more granular (micro-level or year-over-year) data must be collected.
- Benchmark with similar border regions in EU.
- Regular composite index monitoring (principal component analysis) is recommended to rate regions and guide resource allocation.

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