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SPATIAL TRANSFORMATION FOR POST-WAR UKRAINE: EUROPEAN CASES AND THE POTENTIAL OF LOCAL INNOVATIONS

Abstract

The article examines the issue of spatial transformation in post-war Ukraine by combining European experience with local innovations. It suggests using an infrastructure-service approach to rebuild the country, combining physical reconstruction with the development of a service ecosystem focused on innovation, human capital and sustainable development to foster regional and community growth. The types of local innovation are categorised, and their unique role in territorial transformation «from below» is demonstrated. The results of European case studies on spatial transformation (in Denmark, Spain and Germany) in terms of restoring energy, social and environmental infrastructure, and restructuring the economy are presented. These results could be adapted for the post-war recon-

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struction of Ukrainian territories. The article proposes a system of metrics for evaluating the effectiveness of infrastructure and service design for managing the reconstruction of Ukraine's affected regions. This system seeks to coordinate the activities of government agencies, corporations, communities, and foreign partners; ensure the transparency of management decisions; and set criteria for choosing reconstruction projects.

Key Words:

community, European experience, local innovations, reconstruction, region, spatial transformation, Ukraine.

JEL: O18, O31, R11, R58.

2 figures, 2 appendices, 23 references.

Problem Statement and Literature Review

Even before the war began in 2022, Ukraine was experiencing growing territorial disparities and needed to update its spatial development models to adapt them to the specific characteristics of different regions and territories. This was due to a number of factors, including the decline and ageing of the rural population, its migration to large cities and the exacerbation of environmental problems in urban areas. Other factors included the mono-profile nature of their economies, income inequality and, consequently, unequal access to quality education, healthcare, infrastructure and opportunities to fulfil their potential. The large-scale destruction caused by the fighting has exacerbated these challenges, confronting the country with the need for both physical reconstruction and spatial transformation – changing how territories are organised, function and are used in response to contemporary challenges.

Global experience shows that spatial transformation usually follows shocks and crises, such as military conflicts and natural or anthropogenic disasters. This

is accompanied by changes in the spatial function, economy, society, environment, infrastructure, institutions, organisation and management, and is long-term in nature. Possible directions for spatial transformation include the formation of new regional specialisations, the creation of innovation and industrial clusters as the core of a new model of structural and spatial development, the revitalisation of industrial areas through rethinking industrial heritage and introducing innovative solutions and involving all stakeholders. Other possible directions include the creation of compact, self-sufficient living environments prioritising sustainable mobility, social integration, and environmental safety; the introduction of decentralised energy solutions involving the community (based on energy autonomy and sustainable development); the reorientation of rural areas towards organic production and the development of digital services; and the optimisation of the spatial distribution of investments, taking into account the territories' potential and the goals of their structural restructuring. These areas may be subject to critical reflection for implementation in the Ukrainian context, some of which are highlighted in this article.

The Ukrainian scientific community researching spatial transformation focuses on the structural and spatial restructuring of regional economies. This includes the implementation of the smart specialisation approach, the revitalisation of old industrial and depressed areas, urban changes, sustainable urban development, the energy transformation of regions and communities, and the post-war reconstruction of territories.

Libanova and Bystriakov (2025) therefore argue for a review of the methodological approaches to ensuring Ukraine's spatial development during the post-war reconstruction period, emphasising the importance of considering global, and particularly European, experience in overcoming shocks and crises. They argue that space should be viewed not simply as a physical environment or administrative unit, but as a «space of processes» (Libanova & Bystriakov, 2025) – a set of actions, changes, relationships and interconnections that shape the development trajectories of territorial entities. This approach involves reconsidering the concept of spatial formation as a social phenomenon, prioritising issues of human potential, social institutions, and quality of life. In this context, spatial development should be based on an interdisciplinary methodology that considers the interaction of economic, social, environmental and institutional factors.

The article by Kravtsiv and Storonyanska (2025) addresses the issue of spatial shifts in Ukraine's economy in the present context. The authors emphasise the importance of adjusting the goals and mechanisms of regional policy in response to spatial shifts caused by military shocks, particularly in conditions of martial law and post-war recovery. They highlight the need to implement key improvements to regional policy, such as adopting a territorial approach to regional and community development, updating the strategic and spatial planning system for territorial development, building institutional capacity to attract European funds, and completing local government reform. A number of recent scientific

studies have focused on structural transformations of the economy based on innovation, in particular through the implementation of a smart specialisation approach as the foundation for ensuring Ukraine's high-quality post-war recovery. The smart specialisation approach aims to modernise traditional industries, create new knowledge-intensive industries and diversify the economy by harnessing their collective potential. This influences spatial planning and the organisation of economic activity. Consequently, regions that were previously considered peripheral can become centres for investment and the development of knowledge-intensive industries and related sectors. In this context, scientists' vision for applying the smart specialisation approach to specific regional conditions to drive innovative and industrial transformation is of interest. For example, Shevtsova et al. (2020) examine the potential of smart specialisation in the Luhansk region, emphasising its role in the digitalisation of the chemical industry and its integration with the agricultural sector to form a new agrochemical ecosystem, ensuring the region's sustainable development. Chornyi et al. (2025) identify opportunities for Ukraine's regions to transform into innovation-industrial growth points by modernising the industrial base, developing industrial parks, supporting enterprise relocation and creating a favourable environment for innovation.

Although there are studies devoted to the practical aspects of implementing smart specialisation, the theoretical understanding of this approach from the perspective of different schools of economic thought is underdeveloped. Oleksandr S. Vyshnevskyi rightly draws attention to this gap in the scientific literature. In a collective publication under his scientific editorship (Vyshnevskyi et al., 2023), the influence of various schools of economic theory (Schumpeterianism, institutionalism and developmentalism) on the formation of smart specialisation strategies is examined. Taking this into account, directions for improving relevant strategies and policies are determined, particularly at the regional level. This work builds on the author's previous studies, particularly Vyshnevskyi (2022), which examined the concept of smart specialisation from the perspective of nine leading schools of economic theory. This laid the theoretical foundation for smart specialisation strategy at the regional level.

Cherevatskyi et al. (2024) examine the challenges of spatial transformation in coal regions and mining communities facing the consequences of restructuring in the mining industry. The authors critically reflect on the widespread tendency to perceive brownfield sites (areas that have lost their original productive function) as flat, two-dimensional spaces. They instead argue for a three-dimensional view of these regions and communities that takes into account changes in geological structure, underground water and gas flow movements, and the potential use of gravitational and geothermal energy. This approach is set out in a monograph edited by Amosha (2020), in which spatial transformation is viewed as a multi-level process integrating the principles of the circular economy, innovative energy technologies, smart specialisation and the adaptive management of shrinking cities – urbanised areas undergoing prolonged deindustrialisation, depopulation and

declining economic activity, as well as social and environmental problems. Such areas are usually single-industry industrial centres whose spatial renewal requires a comprehensive approach.

The issue of spatial transformations of regions in its various manifestations has also attracted the attention of foreign scholars (Bajwoluk et al., 2024; Fazio et al., 2025; Miljanović et al., 2023). While acknowledging the scientific achievements of Ukrainian and foreign scholars, it should be noted that the scale and nature of the challenges facing Ukraine require a broader focus on analysing applied transformation models that can be adapted to national conditions.

The purpose of this article is therefore to analyse European cases of spatial transformation and types of local innovation in terms of their potential for adapting to the post-war reconstruction of regions and territories of Ukraine.

Methodology

This study is grounded in institutionalism and evolutionary economics, drawing upon theoretical contributions from Ukrainian and international scholars regarding spatial transformation, smart specialisation, the revitalisation of industrial areas and the sustainable development of regions and communities. Methods of analysis and synthesis, systematisation and generalisation, a historical approach, and comparative analysis were employed in the work.

Research Results

Regional differentiation of needs in the post-war reconstruction of Ukraine

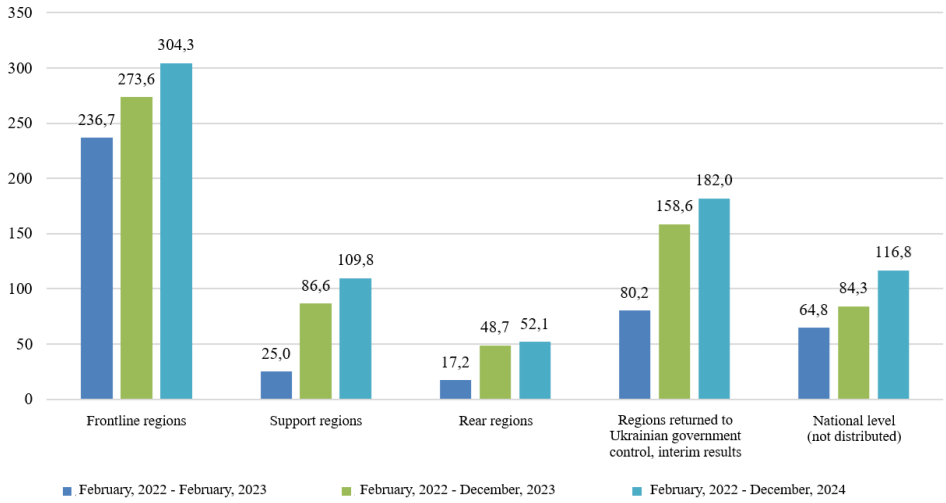
The regions of Ukraine differ in terms of economic development, socio-demographic parameters, resource availability, as well as historical and cultural characteristics. Since the military conflict in eastern Ukraine began in 2014, each region has suffered varying degrees of destruction and will therefore have different needs in the post-war reconstruction process[1].

[1] *Reconstruction* is understood as a multidimensional process involving interrelated types of multidirectional change. These changes can be physical-spatial or functional and can involve improvement (renewal) and/or radical reconstruction (transformation). The aim is to eliminate the effects of shocks and crises, or to implement social transformations.

The regions of Ukraine most affected are the frontline industrial areas of Donetsk, Luhansk, Kharkiv and Zaporizhzhia (see Figures 1 and 2). These regions account for almost a third (31.8%, or US$242.9 billion) of Ukraine's reconstruction needs. Given the structural weakness of the industrial regions' economies, which are dominated by low-tech industries, the relevance of restoring prewar development models is diminishing amid the global implementation of Industry 4.0–5.0 (Vyshnevskyi et al., 2024; Ghobakhloo, Iranmanesh, et al., 2024; Ghobakhloo, Mahdiraji, et al., 2024). At the same time, the large-scale destruction and loss of industrial assets in these territories provides an opportunity to restart their economies on an innovative basis.

Figure 1

Evaluation of the total damage and losses in Ukraine's regions, by type of region, in billions of US dollars

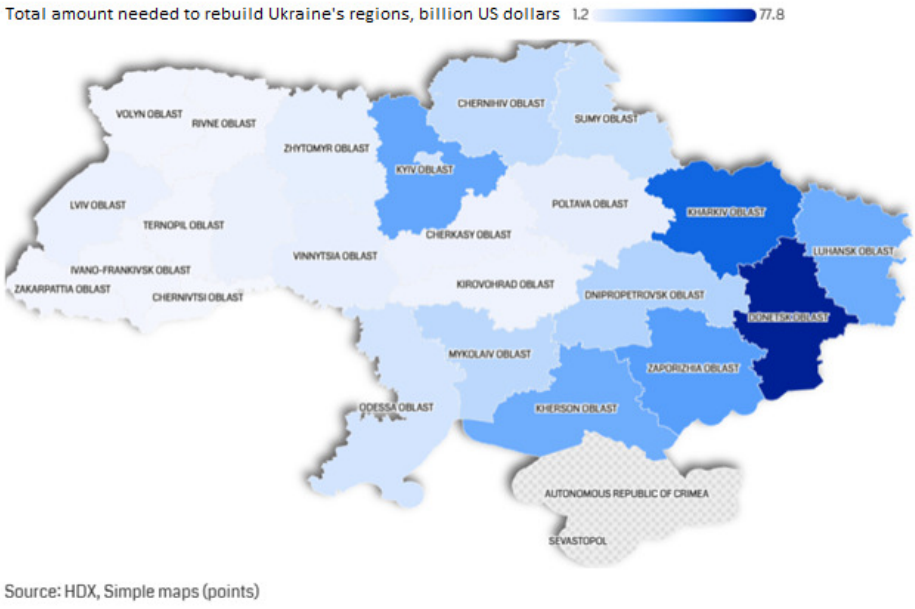


Source: created by the authors based on European Union et al. (2023, 2024, 2025).

A comprehensive approach to reconstruction involving significant financial resources is also required for other regions and territories of Ukraine that have been less affected and have different specialisations (see Figure 2).

Figure 2

Total needs for the restoration and reconstruction of Ukraine's regions (for the period from February 2022 to December 2023), billion US dollars



Source: European Union et al. (2025, pp. 43-44).

Currently, Ukraine is receiving substantial financial support from international partners. According to the Ukrainian Ministry of Finance, this amounted to US$116.6 billion for the period 2022–2024. This covered over 50% of state budget expenditure each year, including 58.6% in 2024. Clearly, in the post-war period, international financial support will decrease, forcing the country to rely mainly on its own strength and resources, as well as to repay its debts. Therefore, it is already necessary to focus on increasing the country's economic self-sufficiency by investing in infrastructure and housing, updating regional development strategies, rebuilding industry and creating powerful incentives to attract investment in the development of new technologies, as well as rapidly developing activities that will form new markets in the coming decades. These processes should be based on a spatially balanced approach that considers the rational use of resources and the strategic location of industrial production and infrastructure, taking into account changes in Ukraine's population size and structure. Different approaches to reconstruction should be applied depending on the type of region

(see Figure 1), its strengths and weaknesses, needs, resource availability and the extent of destruction and damage suffered as a result of military action. This requires an infrastructure and service design approach that focuses not only on rebuilding physical infrastructure, but also on the economic, social, environmental, historical and cultural components of spatial development. The practical implementation of this approach requires the creation of individual profiles for the reconstruction of territories based on the following (Omelianenko & Omelyanenko, 2023):

- spatial and functional zoning, including the demarcation of industrial, residential, service and environmental zones;
- the institutional and resource capacity of territorial communities;
- the logic of integrated development, combining the reconstruction of engineering, transport and digital infrastructure with the formation of a service environment (education, healthcare, culture and eco-innovation);
- revitalisation tools, which are particularly relevant for industrial and demilitarised territories.

This approach is consistent with the «build back better» principle, which is the guiding principle for Ukraine's reconstruction (National Recovery Council, 2022). In the National Recovery Plan for Ukraine, its essence is defined as follows: rebuilding using higher-quality, more advanced, and more sustainable technologies than those of the damaged or destroyed assets, and aligning the recovery and reconstruction of Ukraine with EU principles of green transition and digital transformation. According to the provisions of the United Nations Office for Disaster Risk Reduction report (2016, p. 11), implementing the «build back better» principle requires both the physical restoration of infrastructure and the adoption of innovative spatial development practices to ensure the sustainable, environmentally safe, and inclusive transformation of affected areas. With this principle in mind, the needs for Ukraine's recovery were calculated in the fourth and previous joint assessments by the European Union, United Nations, the Government of Ukraine, and the World Bank (European Union et al., 2023, 2024, 2025) (see Figure 2).

Local innovations as drivers of spatial transformation in Ukraine

In Ukraine's post-war reconstruction process, local innovations are playing a particularly important role in activating the internal potential of devastated territories and transforming them «from below» with the participation of the local population. These are community-level practices developed in conditions of limited resources in response to local challenges. On the one hand, they address gaps in national and regional strategic documents, which often fail to consider local specifics and lack flexibility in addressing local issues. On the other hand, they influence the organisation of the territory, the development of local activities, and the functioning of local institutions.

In global practice, the role of local innovation is at least as follows:

- *Transformation of space functions:* Thanks to residents' initiatives, the intended use of territories is changing. For example, industrial zones are being transformed into creative or technological centres, and transport corridors into safe public spaces.
- *Increased adaptability of transformations:* Local innovations take into account the specifics of the territory – its challenges, needs, limitations, and opportunities. The aim is to find non-standard, cost-effective, and efficient solutions in complex conditions.
- *Activation of human capital:* Local residents are moving from being passive observers of the officials' and politicians' actions to becoming initiators, developers, implementers, and controllers of innovative solutions. Given the scale of human losses, injuries, internal displacement and external migration in Ukraine, it is advisable to prioritise three target guidelines when considering such intensification: *firstly*, the preservation and development of the existing human potential within territorial communities; *secondly*, the return of Ukrainians from abroad and their subsequent employment in Ukraine; *thirdly*, the reintegration of veterans and combatants into civilian life and productive employment. These guidelines should be implemented by (a) providing citizens with affordable housing and basic services; (b) simplifying administrative procedures and providing adequate digital support to service recipients; (c) launching state programmes to bring Ukrainians back from abroad, prioritising family reunification in Ukraine and securing their return by creating well-paid, highly skilled jobs; (d) organising vocational training and retraining programmes, providing subsequent employment opportunities and supporting self-employment and entrepreneurship, especially for veterans and combatants (who should be considered a sepa-

rate target group), and providing them with medical, psychological and rehabilitation assistance; (e) deploying cluster initiatives as a tool for job creation and the economic reintegration of Ukrainian migrants and veterans into productive employment (Pidorycheva et al., 2025). Coordinating the efforts of authorities at all levels to achieve these goals will enable the development of a people-centred reconstruction policy to restore Ukraine's socio-economic dynamics.

A summary of global practices in local development has made it possible to identify various types of local innovation arising from resource constraints and economic, social and institutional factors. These innovations are also stimulated by the active involvement of the local population, entrepreneurs and local authorities in developing non-standard approaches to solving local problems and forming new spatial development models. The main types of local innovation are as follows:

- ***«Frugal innovations»*** are inexpensive, accessible products or technological solutions designed for people with low incomes. They are created or adapted within a specific area, taking into account its needs and limitations. The key idea is to minimise costs while maintaining basic functionality, achieved through engineering savings, simple designs and adaptation to local conditions. Such innovations are usually easily scalable and can be replicated in other regions with similar socioeconomic, environmental, and other characteristics. Examples include modular or temporary housing and compact drinking water filtration units that are manufactured locally from available materials.
- ***«Constraint-based innovations»*** (also known as ***«Jugaad innovations»***) are improvised, non-standard solutions created from readily available materials in resource-scarce conditions. They are characterised by simplicity and minimalism, and focus on solving specific local problems quickly. For instance, refrigerators can be made out of clay, plastic bottles can be used to light dark rooms, old car tyres can be recycled into furniture, garden swings and garden beds, and school desks can be created out of cardboard boxes.
- ***«Rural innovations»*** refer to solutions that address specific problems in rural areas where access to basic services, finance, markets and technology is limited. These solutions are based on a combination of local knowledge, social capital, and available natural resources. They increase the self-sufficiency of rural communities and help to reduce territorial inequality. For example, villages can use biogas from organic waste for energy supply, small farms can use locally adapted irrigation systems, and remote and hard-to-reach rural communities can benefit from mobile veterinary clinics.

- ***«Pro-poor innovations»*** include products or services that aim to improve the well-being of households without adequate access to essential resources and services, such as electricity, drinking water, housing, healthcare and education. Taking into account the social and financial constraints of the target group, these innovations are highly accessible in terms of production and consumption. They are usually implemented through social enterprises, non-governmental initiatives or international technical assistance programmes. Examples include mobile medical clinics in remote areas, open online educational platforms for those affected by natural disasters and military conflicts, and solar chargers and lanterns for households not connected to the electricity grid.
- ***«Endogenous innovations»*** are innovative solutions that arise within the community based on its own resources, knowledge and initiatives. Unlike «frugal innovations», they are not necessarily cheap but rather act as a catalyst for the development of the territory by addressing more than just the need to overcome resource constraints. Endogenous innovations are community-oriented, covering social, economic, and other areas of development while strengthening local self-sufficiency and social cohesion. Examples include the community and local entrepreneurs introducing local energy conservation or waste recycling programmes, developing local educational or digital platforms to improve residents' skills and support local employment, and creating a local product brand (e.g. cheese factories, eco-farms and mini bakeries) that creates added value in the community and stimulates the local economy's development.

The distinctive features that determine the uniqueness and role of the main types of local innovations, as defined above, are as follows:

Informality of the environment of origin: Most local innovations are created outside of formal institutions (such as enterprises, research organisations and universities), based on local practices and initiatives.

Spatial connection and active community participation: Generated in settlements (villages, towns and cities) through the involvement or initiative of local residents, who seek practical solutions to their everyday problems. This not only makes them active consumers, but also active developers of innovations, strengthening social cohesion and fostering a sense of belonging to the community.

Facilitation and partnership: Local innovations are usually created by the community but are scaled and disseminated thanks to facilitation by local authorities and partnership initiatives. This facilitation takes the form of organisational or financial support from local government bodies, international organisations and volunteers. This interaction does not replace local initiative but creates the right conditions for its implementation.

Social sensitivity: A significant aspect of these innovations focuses on the needs of vulnerable groups, such as low-income families, rural residents and displaced persons. This helps to reduce social inequality and poverty.

Multidimensional nature: Local innovations can be social, economic, environmental, organisational or a combination of these, offering solutions that go beyond technology alone;

Potential for sustainable development: Even if the initiators do not set this goal directly, local innovations often have a positive socio-economic and/or environmental effect, contributing to the achievement of the Sustainable Development Goals.

Thus, local innovations can drive local development and provide improvised responses to local challenges. In any case, they are an important part of territorial transformation processes «from below». There are numerous examples from around the world of small, local initiatives influencing the resolution of local problems. In the Ukrainian context, their importance is growing considering the need to rebuild territories affected by hostilities and to regenerate depressed communities. With institutional and partnership support, local innovations can evolve into sustainable models of local development, transforming communities from objects of reconstruction into subjects of strategic change. For instance, local craft producers registered as businesses can grow to become a separate sector of the local economy, producing goods such as cheese from farm milk, sourdough bread, jam, natural juices, wine, liqueurs, candles, handmade soap and wooden toys. Another example is the standard practice of conducting an online survey of the local population on the development of public spaces. The European cases presented below illustrate the potential of local innovations as catalysts for new models of spatial development. A critical analysis of these cases will allow us to identify elements that are relevant to the reconstruction of Ukrainian regions and communities.

Cases of spatial transformation: European countries' experience and lessons for the reconstruction of Ukraine's territories

The examples of spatial transformation presented here demonstrate various types of local innovation, from endogenous initiatives to socially oriented solutions aimed at the structural renewal of territories. Each case is not only an example of spatial redesign, but also a model for the incorporation of innovative practices «from below» into strategic transformation processes.

The case study of the energy transformation on Samsø Island in Denmark demonstrates how a rural community can achieve energy autonomy

by combining local resources and innovations. The project is based on residents' initiatives, available technologies, and local resources.

With a population of around 4,000, Samsø Island belongs to the European classification of local administrative units with populations of fewer than 150,000. In Ukrainian terms, this corresponds to the level of a territorial community. In 1997, the island's energy system was entirely dependent on imported fossil fuels – oil and coal. In response to the need to ensure the energy independence of islands such as Samsø, the Danish government announced a competition for projects introducing renewable energy sources for local self-sufficiency. The winning project was submitted by three Samsø residents and envisaged not only meeting the island's energy needs fully through renewable energy sources, but also transforming Samsø into an energy exporter. The initiative received support at local, regional and national levels. By 2007, just 10 years later, the island had achieved complete energy autonomy based on green technologies.

The project model included constructing three combined heat and power plants, installing 11 onshore and 10 offshore wind turbines, and making energy-efficient upgrades to more than 200 private households. A key factor in the project's success was the active participation of the local population, who invested €2 million in setting up the local energy company, Samsø Energy Supply Company. This company managed the processes of generating and distributing energy. Consequently, five of the offshore turbines became the property of the municipality, two were owned by local residents and three by private investors.

Despite initial mistrust and resistance from residents, especially regarding the placement of turbines along the coast, implementing the project had several long-term positive effects: it formed the basis of the island's energy independence, reduced unemployment, curbed depopulation, increased local incomes and attracted investment and new businesses. Samsø is currently implementing solar energy development projects and plans to abandon the use of fossil fuels completely by 2030 (Pidorycheva, 2023).

Ukraine is interested in this example due to the destruction of cities' energy infrastructure and the resulting electricity shortages, as well as the need to decentralise the energy system, strengthen community energy security, and mobilise local potential for the energy transformation of settlements based on the «build back better» principle.

The case study of sustainable urban mobility and public space reconfiguration in Spain demonstrates the contribution of urban transformations to sustainable spatial development in densely populated areas. This case study is based on the introduction of the concept of superblocks – an endogenous innovation – which involves restricting through traffic, prioritising pedestrians and cyclists, bringing basic services closer to residential areas, introducing green spaces, and promoting energy-efficient construction.

The reconstruction of housing stock destroyed as a result of hostilities, as well as the reconfiguration of public spaces, is currently one of the main ways of ensuring the sustainable, inclusive and environmentally safe development of Ukrainian territories. When seeking effective solutions, it is important to consider European practices that have proven effective in complex urban conditions. In particular, the experience of the Spanish cities of Barcelona and Vitoria-Gasteiz is worth noting, as they have implemented a programme to transform the urban environment based on the concept of superblocks. Superblocks are an innovative form of urban space organisation involving the creation of areas with maximum restrictions on transit traffic and prioritising pedestrian and bicycle mobility, environmental safety, and social integration (see Appendix A).

In Barcelona, this concept was implemented as part of the Superblock Programme and became a model for street transformation in dozens of cities worldwide. One of the first superblocks was in the Poblenou district. By 2018, the area accessible to pedestrians had increased by 80%, the space for cars had decreased by 48%, and green areas had almost doubled (Pidorycheva, 2023).

The city of Vitoria-Gasteiz identified 77 potential superblocks, two of which were fully implemented and 17 of which introduced measures to restrict traffic and create «quiet» neighbourhoods. Empirical evidence shows that noise pollution in superblocks has decreased by 5.5 dB, air quality has improved, and carbon dioxide and nitrogen oxide emissions have decreased by 42% (ICLEI, 2019).

In Ukraine, it would be advisable to pilot the superblock concept in cities of various sizes to compare results, by integrating it into projects to rebuild destroyed or damaged city centres and/or create new residential neighbourhoods. Densely populated micro districts should be prioritised for implementation, as restrictions on transit traffic, the expansion of pedestrian and bicycle zones, the greening of territories, energy-efficient construction and proximity to basic services can ensure sustainable development, inclusiveness and social cohesion. Successful implementation of the superblock concept requires consideration of several local factors, including community budgetary capabilities, existing infrastructure constraints, cultural characteristics and traditions of public space use, employment levels (as superblocks can contribute to the development of local businesses such as bicycle repair shops, coffee shops, and bakeries when employment is low), and public participation levels.

The transformation of the Ruhr region in Germany is an example of the comprehensive regeneration of a depressed industrial area. This was achieved through the introduction of «frugal», endogenous innovations, as well as innovations aimed at alleviating poverty. A few initiatives were implemented to restore employment and social integration for residents who had lost their jobs due to the closure of mines and factories. These initiatives included professional retraining, job creation in new industries and involvement in cultural and tourism projects.

In the second half of the 20th century, the Ruhr region's economy experienced a crisis caused by the depletion of natural resources and the decline of the extractive industry. In response to this socio-economic decline, the IBA Emscher Park programme was implemented between 1989 and 1999. This strategic initiative aimed to comprehensively transform the industrial region, involving all 17 municipalities, leading experts and civil society.

The programme aimed to urbanise the region and shape its new identity by combining industrial heritage with creative and ecological solutions. The following projects played a particularly significant role in this:

- *The conversion of the former Zeche Zollverein colliery, the largest coal mining enterprise in the region, into a multifunctional cultural complex.* An industrial design, recreation and tourism centre has been created on the site of about twenty former industrial buildings. The buildings were renovated to preserve their authentic appearance as much as possible, while being given new functions, such as museums, creative exhibitions, cafés, restaurants and multifunctional recreational areas. This has ensured that industrial heritage has been adapted to meet the demands of the modern economy, transforming the region into a contemporary, multifunctional cultural and social space;
- *The establishment of the Rhein Elbe Science Park has been initiated on the grounds of a decommissioned metallurgical facility in Gelsenkirchen.* The project was designed to counteract the effects of deindustrialisation in the region by establishing a new area of specialisation for the city: research and development in renewable energy;
- *Foundation of Ruhr University Bochum (Ruhr-Universität Bochum)* marked a new stage in the region's development, as it had no universities in 1962. Today, the university is one of the country's leading research and educational centres, combining fundamental research with applied developments focused on the needs of the economy and society. In 2024, Ruhr University Bochum received the HR Excellence in Research Award from the European Commission, which recognises scientific institutions that offer researchers the best working conditions and environment.

These examples symbolise the transformation of the Ruhr region from a centre of heavy industry to a creative, high-tech hub. The region's transformation programme was largely implemented according to the logic of infrastructure and service design. The following main principles of its implementation are of interest to Ukraine:

1. Rethinking industrial heritage. Rather than being seen as a burden to be discarded, the region's industrial past was embraced as a resource for shaping a

new identity. Historically and symbolically important industrial sites were not destroyed but repurposed instead.

2. Coordination of actions based on political consensus. From the outset, the authorities decided that the process of revitalising the region should be based on broad political consensus and the active involvement of all stakeholders. The alignment of vision and priorities was identified as the primary criterion for selecting projects for implementation.

3. Systemic thinking in project portfolio formation. The programme encompassed the execution of multiple autonomous initiatives, which were regarded not as discrete projects, but as components of a holistic vision for the future of the region. Each project was evaluated in terms of its contribution to the implementation of the regional development strategy, which aimed to transform a depressed industrial area into an environmentally safe, economically diversified and culturally attractive environment by combining industrial heritage with innovative and creative development.

4. Quality focus. All infrastructure and urban planning decisions – from residential development to the revitalisation of industrial areas – were implemented exclusively on the basis of open competitions. The selection process was based on a set of criteria, including the quality of the proposals, the professional qualifications of the participants, and the potential for job creation. The competitions frequently attracted leading architects, engineers and artists of international renown.

5. Flexible and inclusive management model. The programme was overseen by a dedicated public-private agency, *IBA Ltd*, which was owned by the state of North Rhine-Westphalia. The composition of the delegation included representatives of state institutions, scientific and expert circles, and civil society organisations. This format enabled the overcoming of the long-standing institutional inertia and passivity of the management system, which had been hindering the region's transformation for a considerable time.

Drawing upon the experience of *IBA Emscher Park*, a system of metrics for employing the infrastructure-service design approach at the regional level is proposed in four areas of measurement: spatial, social, environmental and institutional (see Appendix B). A metric is defined as an indicator that shows the state of a system, in particular its quality and effectiveness, and is used to assess the level of achievement of goals or their desired values. The measurement system presented for Ukraine can be refined and supplemented with other areas and metrics depending on the type of region, the degree of destruction and the needs for recovery.

The proposed system of metrics can be used to manage the reconstruction of affected areas in Ukraine by combining various measurements. The system aims to ensure transparency in management decisions, establish project selection

criteria and coordinate the actions of the relevant authorities, businesses, communities and international partners. However, Ukraine currently lacks the necessary data to measure some of the proposed metrics, particularly the social and environmental ones. This requires improvements to regional statistics and the creation of modern monitoring systems and open registries of spatial and environmental data. These improvements will be a prerequisite for the practical application of the infrastructure-service approach to the reconstruction of regions and communities.

Conclusions and Recommendations

Since hostilities broke out in eastern Ukraine in 2014, all regions of the country have suffered varying degrees of destruction and damage. Due to their differing scales, areas of expertise, strengths, weaknesses and available resources, a variety of intervention models must be applied to each region, ranging from damage repair to radical structural transformation. This is particularly pertinent for industrial regions, whose economies were already structurally imbalanced and innovation-weak prior to the war. As a result of the war, these regions have suffered significant damage and losses, as well as deindustrialisation and deurbanisation. In the new geopolitical, technological and environmental reality, continuing the pre-war low-tech development trajectories is not a viable option. Instead, structural changes to the economy emphasising the advanced development of technology-intensive manufacturing and/or knowledge-intensive service industries based on sustainable development principles and the «build back better» approach should be the main guideline for shaping a new model of economic recovery and development.

The principle of «building back better», enshrined in Ukraine's National Recovery Plan, should serve as a practical guide for making progressive and sustainable decisions in all areas of the country's development, from the economy to spatial planning. This is particularly important for the rational planning of settlements, construction and functional zoning of territories, and their integration into the European infrastructure space (transport, energy and digital). It is also vital to take into account the principles of environmental safety (minimising damage to the environment), climate resilience (the ability of territories to adapt to climate change and recover quickly) and social accessibility (ensuring equal access for all population groups to critical and basic social infrastructure). Furthermore, conditions must be created to coordinate spatial decisions between communities, in order to avoid fragmentation and duplication.

For regions and communities in Ukraine, it is advisable to implement an infrastructure and service design approach that is not solely focused on the reconstruction of physical objects, but also on the establishment of an effective service

ecosystem. This approach should create conditions for the reproduction of human capital, support innovative and entrepreneurial activities, and provide access to modern technologies and knowledge. The utilisation of a system of metrics (spatial, social, economic, environmental, institutional) will facilitate the evaluation of the quality and effectiveness of solutions implemented within the infrastructure and service approach.

The local population plays a pivotal role in the reconstruction of territories, engaging in discussions, planning, and choosing ways to implement reconstruction. They also initiate various local innovations aimed at solving the local problems they face. It is therefore vital for Ukrainian communities and their populations to evolve from being predominantly passive observers and consumers to active participants in the process of revitalising the settlements in which they live. Considering the capacity demonstrated in recent years by Ukrainian society to effectively self-organise and collaborate at the local level, the potential and opportunities for this exist. However, this calls for comprehensive changes, namely: introduction of openness in public administration, the establishment of partnerships between local authorities and the local population, encouragement of entrepreneurship, social and environmental local initiatives, the dissemination of successful innovative practices and sustainable lifestyles, and development of public awareness, activism and digital skills.

Despite the existence of digital tools for implementing and managing the recovery of Ukraine's regions and communities (namely the Diia.Digital Community and DREAM platforms, and the Community 4.0 programme), the participation of the local population in spatial and infrastructure planning and the implementation of these processes remains limited. To address this gap, it is recommended that the following elements be incorporated into the DREAM platform:

- public initiatives interface that would enable the population to identify local problems, submit proposals for their resolution, comment on and vote for recovery and reconstruction projects;
- feedback mechanism that would allow the population to receive responses to submitted initiatives, see the status of their consideration, explanations for rejection or postponement, and track the progress of approved project;
- algorithmic prioritisation of restoration and reconstruction projects based on a set of criteria, including the number of community votes, social and economic importance, cost, quality and time of implementation, and risks of non-implementation;
- at the level of integration with other platforms and programmes (Diia.Digital Community, Community 4.0, Diia.Education), the educational component of the country's recovery and reconstruction ecosystem should be expanded by introducing online courses, training and

recommendations on energy management, urban planning, climate adaptation and spatial planning. The purpose of this is to raise awareness among the local population, regional authorities and local self-government bodies, and civil society activists.

The European cases examined in this paper, namely Samsø Island in Denmark and the superblocks in Spain, demonstrate the potential of local initiatives in the restoration of energy, social and environmental infrastructure. The importance of active community participation in planning, investing and managing transformation processes is confirmed, and such participation can serve as a valuable guideline for the reconstruction of Ukrainian territories. The transformation of Germany's Ruhr region exemplifies the potential for the repurposing of industrial heritage as a catalyst for regional transformation. Through a meticulous preservation of authenticity, a re-evaluation of industrial facility functions, and their subsequent integration into the contemporary urban landscape, this region has been able to transition from a legacy of industrial dominance to a new identity defined by a vibrant modernity. The successful transformation of regions and communities requires concerted action and coordination of efforts at the inter-territorial level, the involvement of various stakeholders, a flexible and inclusive management model, and a focus on economic recovery and development of territories.

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Appendix A

The concept of superblocks and possibilities for its adaptation in Ukraine

Components of the superblock concept	Description	Advantages and opportunities for adaptation in Ukraine
Restrictions on transit traffic	Prohibition or significant restriction of private vehicle traffic within the superblock	Reduction of accidents, noise and pollution; possible implementation in renovated city centres and new residential areas; promotion of public transport
Priority for pedestrians and cyclists	Expansion of pedestrian areas, safe bike lanes, raising intersections	Promotion of inclusive spaces and creation of convenient walking and cycling infrastructure, especially in small settlements
Expansion of green areas	Greening neighbourhoods: creation of squares, mini-parks, forest park areas, green roofs	Creation of a comfortable microclimate (reduction of heat, air purification and increased humidity) to improve quality of life, especially in environmentally polluted and significantly damaged settlements
Energy efficiency of buildings	Usage of energy-efficient materials, autonomous heating and energy supply systems	Energy consumption reduction, meeting EU Green Deal targets within the context of European integration and strengthening community energy security
Proximity of basic services to residential areas	Availability of medical and educational institutions, gyms, cultural centres, supermarkets, social and psychological support centres within walking distance	Creation of self-sufficient micro-districts during settlement reconstruction, reducing transport infrastructure load and providing on-site basic services and psychological support centres
Reduction of noise and air pollution	Measurable effects of implementation in the city of Vitoria-Gasteiz: 5.5 dB reduction in noise levels, 42% reduction in CO_2 and NO_x emissions	Improvement of quality of life, reducing healthcare costs and creating green entrepreneurial opportunities at community level, stimulating demand for green products and services (e.g. bike repair shops, roof and façade greening, water and material reuse, solar panel installation)
Strengthening of social cohesion	Spaces for communication, shared recreation, events	Social capital restoration, creating supportive environments and preventing isolation while strengthening community identity
Intelligent space management	Implementation of Smart City solutions: lighting, traffic and security management	Improvement of urban management efficiency, services digitalisation and rapid infrastructure change and failure response

Source: compiled by the authors.

Appendix B

Metrics for evaluating the effectiveness of the design of infrastructure and services for the reconstruction of Ukrainian territories

Measurement direction	Metric	Metric description (unit of measurement)	Data source
Spatial	Share of reconstructed buildings	Share of renovated or newly built industrial, engineering and transport infrastructure facilities and housing stock in the total number of existing facilities (%)	State statistics, reports from local authorities, cadastral data
	Density of service infrastructure	Number of social, educational, medical, cultural and administrative facilities per 1 km² of territory (community, district, region) (units/km²)	Regional statistics, registries of administrative service centres, GIS data (geospatial data, satellite images, topographic plans, digital terrain models)
	Integration of new functional areas	Share of territories where new functions have been introduced, e.g. science parks, cultural and recreational areas have been created (%)	Urban planning documentation, development plans, official registers
Social	Level of resident involvement in local initiatives	Share of the population that participated in public discussions, public consultations, hackathons, project implementation (%)	Sociological studies, reports from local government bodies
	Share of new jobs	Proportion of jobs created in the service, industrial and creative sectors in the overall employment structure (%)	State Employment Service, regional statistics
	Social inclusion index	Complex index that includes the level of participation, trust, sense of community belonging and access to basic services (0-1)	Independent sociological surveys
Environmental	Share of revitalised areas	Percentage of areas that have been restored, adapted to new needs or changed their functional purpose (%)	Regional statistics, local government reports, GIS data

Measurement direction	Metric	Metric description (unit of measurement)	Data source
	Share and accessibility of recreational areas	Percentage of the population living within reach of recreational areas (up to 500 m) (%); percentage of recreational areas in the structure of development (%)	GIS data, cadastral data, local government reports
	Level of air pollution	Average annual concentration of major pollutants in the air (μg/m³) within the community	Automated monitoring stations, open environmental data
	Level of noise pollution	Average daily noise level in densely populated areas (dB)	Monitoring services, environmental studies
	Index of greening of the territory	Proportion of green areas within the settlement (% of total area)	GIS data, urban planning documentation
Institutional	Level of business participation in government initiatives	Share of projects (contracts) implemented under public-private partnerships out of the total number of projects (%)	Data from the Ministry of Economy, local authorities
	Share of projects with long-term financial sustainability	Share of projects with guaranteed financial support from internal sources after the completion (reduction) of support from international partners (%)	Estimated data from open sources, financial reports and project documentation
	Level of intermunicipal coordination	Number or share of projects implemented on the basis of cooperation between communities	Data from the Ministry of Regional Development, the Decentralisation in Ukraine portal, EGAP, U-LEAD with Europe

Source: compiled by the authors.

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