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METHODOLOGY FOR ASSESSING THE REASONABILITY OF URBAN OBJECTS RECONSTRUCTION WITHIN UKRAINIAN AFTERWAR RECOVERY

A thesis submitted for the degree of Master

by

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ABSTRACT

Despite the large number of studies in the field of planning for restoration/reconstruction, development, reconstruction/modernization of urban objects and territories, the problem of assessing the reasonability of such reconstruction or modernization remains poorly studied. This problem is particularly relevant in the Ukrainian context, since there is simultaneously the long-standing problem of outdated, non-functional buildings and inefficient use of territories or objects of urban infrastructure, as well as, unfortunately, the elimination of the consequences of the russian war against Ukraine, which also most often involve the restoration or reconstruction of urban objects. Based on Ukrainian and foreign studies, methods and models for assessing various categories of the urban environment, we have developed a methodology for assessing the reasonability of reconstructing urban objects. The work uses a comprehensive approach to assessing the reasonability of reconstructing urban objects, based on the combination and integration of three key categories for analysis: demographic, economic and infrastructural. The assessment methodology was tested on the example of the Trostyanets community. Conclusions and recommendations have been developed as a result of methodological modeling and calculations performed.

Keywords: reasonability assessment methodology, reconstruction of urban objects, assessment models, Trostyanets community.

Word count: 14 171

INTRODUCTION

The relevance of the topic of reconstruction of urban objects in the context of post-war recovery

The issue of assessing the reasonability of reconstructing urban objects is currently one of the fundamental ones in the context of the development of Ukrainian cities and territories. At the same time, the full-scale invasion of the russian federation into Ukraine in 2022 as a continuation of the war that began in 2014 has further highlighted the need to study this topic, since constant terrorist acts of bombing of civilian and critical infrastructure, as well as the complete destruction of cities closer to the contact line by the russian army, have caused the problem of assessing the reasonability of reconstructing objects, districts and entire cities.

Therefore, the choice of topic is dictated by the need to have an econometrically justified method for calculating the reasonability of reconstruction of urban objects. But although the issue of reconstruction of urban objects during significant changes in the demographic, economic and infrastructural dimensions of territories has been relevant in Ukraine before, the methodology for assessing the reasonability of reconstruction described in this work can be applied both to reconstruction objects and to any other infrastructure in communities throughout Ukraine.

The purpose of the study: to develop a methodology for assessing the reasonability of reconstructing urban objects.

Research objectives:

1. To review the scientific literature on this topic and define an analytical framework;
2. To design a methodology for assessing the reasonability of reconstructing urban objects;
3. To integrate the indicators of the methodology and apply it to the example of the Trostyanets community.

Object of the study: assessing the reasonability of reconstructing urban objects.

Subject of the study: reconstruction of urban objects.

Methodological approach: the work uses a comprehensive approach to assessing the reasonability of reconstructing urban objects, based on the combination and integration of three key categories of analysis: demographic, economic and infrastructural.

The work consists of an abstract, introduction, literature review and analytical framework, construction of a methodology for assessing the reasonability of reconstructing urban objects and integration of the methodology indicators and their application on the example of the Trostyanets community.

LITERATURE REVIEW AND ANALYTICAL FRAMEWORK

Analysis of scientific works on the topic of reconstruction of urban objects

Foreign scholars have widely developed the topic of reconstruction and rebuilding of urban objects, especially in the context of post-war reconstruction in Europe, the reconstruction of Hiroshima, destroyed by the atomic bomb, as well as within the framework of the problem of renovation, revitalization, rethinking the concept of the city in general. In particular, in this work we will use the research of: E. Moretti, E. Giannone,Y Miyauchi, N, Paixão, X, Pang, Y. Suzuki, C. Couch, C. Fraser, C., S. Percy, D. Neumark, H. Simpson, J. V. Henderson, G. Duranton, D. Puga, K. Takeda, A. Yamagishi, D. Albouy, K. Behrens, F. Robert-Nicoud, N. Seegert and E. L. Glaeser.

We will also outline the volume of Ukrainian scientific work on this topic. In particular, a significant contribution to the development of this topic was made by the well-founded methodological studies of V. Abyzov, Yu. Bilokon, Yu. Bocharov, V. Vadimov, V. Volodymyrov, M. Gabrel, O. Gutnov, M. Demin, I. Iodo, E. Klyushnichenko, M. Kushnirenko, G. Lavryk, V. Lavrov, I. Lezhavy, V. Mironenko, V. Nikolaenko, A. Ositnyanka, B. Posatsky, A. Rudnytsky, V. Tymokhin, G. Filvarov, I. Fomin, Z. Yargina.

It is especially important to note the role of research on historical cities. Particularly significant is the monograph by G. Osychenko "Reconstruction of Historical Cities: Compositional Aspect" from 2021, as well as the works of O. Becker, V. Vechersky, N. Hulyanytsky, O. Karnabida, M. Kudryavtsev, T. Kudryavtseva, V. Lavrov, G. Logvin, V. Lukyanchenko, N. Miroshnyk, G. Mokeyev, O. Oliynyk, N. Onishchenko, L. Plyashko, T. Proskuryakov, M. Rudynsky, O. Sedak, A. Stanislavsky, L. Tversky, M. Tsapenko, A. Shchenkov, V. Shkvarikov and others (Osychenko 2021).

In studies of this nature, it is important to pay special attention to the practical aspects of implementing scientific and theoretical developments, so it is necessary to emphasize the role of design and research institutes of Ukraine, namely: Dniprocity, Research and Design Institute of Urban Planning, Research Institute of Theory and History of Architecture and Urban Planning, and others. In the next part, we will turn to the key concepts used in this work and the scientific discourse around them in Ukraine and abroad.

Definition of key concepts and their conceptualization

However, the current state of scientific discourse of epistemic communities around the world pushes us to the need to more widely apply interdisciplinary practices and develop a comprehensive approach to solving such problems as assessing the reasonability of reconstructing urban environment objects. In particular, the importance of a comprehensive approach is drawn to the modern study of Kharkiv scientists T. Zhydkova and O. Zavalny "Reconstruction of Urban Territories" in 2023: "A comprehensive approach as a methodological principle of design can ensure normal living conditions for residents and the functioning of urban objects in the existing urban environment and provides for an interdependent solution to the renewal of all elements (buildings, structures, communications, areas of the territory) of the district or quarter being reconstructed" (Zhydkova and Zavalnyi 2023, 5).

The key advantage of this approach is the ability to decompile the research object into the maximum feasible number of segments and dimensions and consider each of its elements and the relationships between them. Then put them back together, clearly determining which element or relationship will be most effectively influenced to achieve the desired result. Therefore, in this study, when developing a methodology for assessing the reasonability of urban reconstruction and an innovative econometric model for it, we will use this approach.

The process of reconstruction of urban objects, which we consider within the framework of the study, is generally called "reconstructive activity" in Ukrainian scientific discourse. According to T. Zhydkova and O. Zavalny: "reconstructive activity aims to ensure the viability and consistent development of cities in accordance with the growing socio-economic standards of society on the basis of systematic updating of the quality and composition of the city's fixed assets, improving its planning structure, increasing the efficiency of using urban development resources, enriching the architectural image of the city and preserving its cultural heritage." (Zhydkova and Zavalnyi 2023, 10).

It is important to understand, especially in the Ukrainian context of a full-scale invasion, that there are different types of reconstruction activities: reconstruction of buildings, reconstruction of residential areas, and reconstruction of territory. This is also important to understand especially when considering reconstruction projects, because the closer to the front line, the more from the reconstruction of individual buildings in Lviv, Kyiv, or Poltava, communities are faced with the need to rebuild entire districts (e.g., Saltivskyi district of Kharkiv) or entire cities (e.g., Maryinka, Mariupol, Soledar, Volnovakha, and unfortunately, many others).

For the sake of differentiation, let us define how scientists understand each of the terms. Researchers T. Zhydkova and O. Zavalny describe the reconstruction of a building as "the creation of a modern comfortable urban environment based on the existing layout and architectural features of the building with a change in the technical and economic indicators of the building and an increase in the efficiency of using the territory of the reconstruction object" (Zhydkova and Zavalnyi 2023, 12). In this definition, we highlight the emphasis on the goal of reconstruction - increasing the efficiency of use. This is one of the most important categories that comes to the forefront of assessing reasonability.

Scientists also define the reconstruction of buildings through the goal of increasing efficiency, only increasing the number and scale of objects: “creation, based on the existing layout and architectural features of the building, of a modern comfortable urban environment with a change in the technical and economic indicators of the building and an increase in the efficiency of using the territory of the reconstruction object” (Zhydkova and Zavalnyi 2023, 10).

At the same time, scientists describe the reconstruction of the territory as "the transformation of previously developed urban areas in accordance with internal conditions and challenges and external influences on the development of the city." (Zhydkova and Zavalnyi 2023, 12). So, they emphasize challenges and external influences as the cause and at the same time the goal of reconstruction. And although in foreign methodologies such challenges are most often caused by natural or ideological factors, in Ukraine, unfortunately, such an external factor is russian aggression against our state and the actions of Russian citizens and the Russian army, and a new challenge is rethinking the purpose and identity of cities and territories, in particular as outpost communities, rear communities or retreat communities.

However, scientists consider political, ideological, economic, ecological, natural and climatic, demographic, social and socio-psychological factors to be the classic prerequisites for the comprehensive reconstruction of the city. (Zhydkova and Zavalnyi 2023, 19-22).

Special attention should be paid to the definition of types of reconstruction in the context of integrating the dimension of function and purpose of the reconstruction process itself. In particular, researchers distinguish functional-planning reconstruction, where attention is focused on the purpose of the territory and the ability to make this territory effective and functional; architectural-planning reconstruction, in which attention is focused on the urban plan, architectural planning units and the construction of links between them; and ecological-planning reconstruction, aimed at improving the environment, preserving the natural state of the ecosystem along with comfortable living conditions for the population.

We have already outlined earlier that the goal of reconstruction should always be to increase the efficiency of the use of an object or territory. The comfort of life in the territory is one of such indicators of efficiency. But the ways to achieve this goal can be different. Therefore, scientists distinguish different forms of urban reconstruction based on this distinction, in particular, anticipatory, accompanying / supporting and restorative reconstruction. In the context of the methodology described in this work for assessing the reasonability of reconstructing urban objects, the distinction between these forms is important for determining the starting state of the user of the methodology. For example, depending on the reconstruction object, the Kharkiv City Council, the Kostyantynivka City Military Administration, the Borshchahivka City Council of Kyiv region, and the Vyzhnytsia City Council of Chernivtsi region can simultaneously assess the reasonability of reconstructing objects simultaneously within the framework of restorative reconstruction (reconstruction of water supply due to Russian shelling or due to outdated funds), accompanying reconstruction (a well-known case of repair work on Kostyantynivka roads) and anticipatory reconstruction (reconstruction of dormitories for a possible new wave of internally displaced persons).

Similarly, for different communities, the same type of work may be a different form of reconstruction, such as the reconstruction of dual-purpose objects or civilian objects that can be used for urban combat. For Kostyantynivka, this will be an accompanying reconstruction and its reasonability is determined by military prerequisites, and for Vyzhnytsia, it is an anticipatory reconstruction and its reasonability is determined by political prerequisites. The introduction of the coefficient of prerequisites and crisis situations into the methodology for assessing the reasonability of reconstructing urban objects requires separate research and is the subject of further development in this area.

At the same time, British researchers C. Couch, C. Fraser and S. Percy raise the question: are the existing trends and policies for planning and reconstruction of urban objects adequate to the current state of the economy and its changes: “The emergence of a new stream of action in the urban environment, which is dominating the urban policy of several countries, in a way places the spotlight on the more traditional processes of intervention, and raises the question of why the traditional approaches of mainstream urban planning appear to be inadequate for the task of managing the regeneration of our cities and solving, or at least alleviating, the many other social and economic problems that have arisen as the economies of the Western world have evolved” (Couch, Fraser, and Percy 2003, 4).

To determine the preliminary conclusion from the above review of scientific discourse, let us turn to Ukrainian researchers who believe that: "All types of reconstruction, as a rule, are the result of the influence of internal development factors and show the immanent laws of city development. The highest level of integration of diverse types of reconstruction is the comprehensive reconstruction of the city, which ensures the interconnection of all types of reconstruction of the first and second levels, which form a single complex of reconstructive measures for the formation of a comfortable urban environment and balanced development of the city." (Zhydkova and Zavalnyi 2023, 16-17)

The most interesting thing in this conclusion is the combination of reconstruction goals, namely "the formation of a comfortable urban environment and balanced development of the city", because this leads us to understanding that the balance in achieving these goals is generally a "golden section" of reconstruction activities.

Identification of key variables and research hypotheses

The development of the city still takes place for the sake of its residents, so the population of the territory is a key category around which any calculations must be built. The opinion of Ukrainian researchers also leads us to this thesis: "The population, in combination with the material infrastructure and diverse activities, are the basic components of the urban system. It is the population, its socio-demographic structure, that acts as a key characteristic of urban planning formations of any territorial planning level and the city as a whole." (Zhydkova and Zavalnyi 2023, 26)

Special attention to achieving this balance is paid by scientists D. Neumark and H. Simpson, who distinguish the concept of “place-based policy” as opposed to “people-based policy”. Researchers are convinced that “people-based policy” is currently losing its relevance, although, as is obvious from the name, it focuses on the needs of people, their lifestyle, etc., and also pays attention to people with disabilities. At the same time, scientists propose the term “place-based policy” and logically note that urban planning should be primarily urban, and therefore, by definition, should be focused on people. Therefore, it is much more logical to create spaces that will by default meet all the requirements and needs of all residents, rather than focusing on each individual project separately. The researchers themselves describe it this way: «Place-based policies that also focus on people can be categorized as direct or indirect. Direct forms of place-based policies seek to increase economic activity and strengthen labor markets where disadvantaged people currently live, while indirect policies may instead seek to increase access of those people to locations where labor markets are stronger. Enterprise zones can be viewed as direct, since they typically create incentives for hiring, or economic activity more generally, in or near areas where disadvantaged people live» (Neumark and Simpson 2014, 1).

Obviously, this approach is somewhat in contrast to the general conventionally “Western” scientific discourse, which actively gravitates towards post-Marxist methodology and the Frankfurt School. Therefore, D. Neumark and H. Simpson also draw attention to the questions inherent in this discourse, such as who will benefit from such approaches: «Research could also aim to shed more light on exactly who gains any benefits from place-based policies. If programs are effective in increasing local productivity, are the ultimate beneficiaries actually landowners if the supply of housing or buildings is inelastic? If policies are found to be effective in raising employment rates or average incomes in targeted areas, is it resident individuals in low-income groups, whom the policies often aim to benefit, who actually realize these gains, or is there significant inmigration?» (Neumark and Simpson 2014, 75). And although researchers leave this question open, in this study we will rely on the opinion that the formal logic used by the aforementioned researchers is still more relevant for modern science than the somewhat ideological doctrines often used by critics of this approach.

However, for the methodology described in this study for assessing the reasonability of urban reconstruction, population is one of the categories of analysis and variables within the econometric model. Obviously, it is also important to take into account such a variable as the regional impact of aging. The multinational team of researchers studying "Ghost Towns" and the geography of depopulation and aging also pays attention to this category: «Anecdotal evidence highlights the strong incumbency of locations losing working-age populations rapidly (i.e., "ghost towns") while some regions pullulate with youth. Since many aspects of our economic activity are influenced by the local economic activity (e.g., labor market, amenities, housing), the differential rates of depopulation and aging may affect regional disparity in economic activity and welfare. Notably, internal migration may affect the process of regional depopulation and aging while simultaneously affecting aggregate welfare and its heterogeneity across regions and generations. If this is the case, policies subsidizing migration to rural areas, as found in Japan and many European countries, may have important aggregate and distributional implications» (Giannone et al. 2023, 1) Also, the achievements of the mentioned scientists include very important developments for this work in calculating the demographic balance model, the model for assessing the regional impact of aging, and the model of per capita income depending on the population structure. We will consider these models in more detail in the next section.

Scientists also pay special attention to the migration flow and its impact on the policy of planning and reconstruction of urban objects. Therefore, we conclude that the demographic component is one of the three key elements of the methodology for assessing the reasonability of reconstruction of urban objects and the econometric model as its component. Within its framework, we consider such variables as "total population", "net migration flow", and "survival rate for the age group".

The next component that must be considered when preparing an econometric model and methodology is the economy of the community. The importance of this factor is indicated by researcher E. Moretti: "Every time a local economy generates a new job by attracting a new business, additional jobs might also be created, mainly through increased demand for local goods and services. This positive effect on employment is partially offset by general equilibrium effects induced by changes in local wages and prices of local services" (Moretti 2010, 1). For convenience, we have defined the processes described by the researcher in the variable "gross regional product", which is considered as "the value of final goods created in a certain region of the country in one year". It is imperative to note that the aforementioned researcher also draws attention to "National Multipliers" and defines them as an important factor in calculating the economy of the region: «The multiplier for the nontradable sector measured locally is an upper bound for the national multiplier. The reason is that due to geographical mobility, labor supply is arguably more elastic at the local level than at the national level. Higher elasticity implies that less crowding out takes place at the local level than at the national level» (Moretti 2010, 3). Researching this issue and incorporating

"National Multipliers" into the developed methodology and econometric model is one of the goals and prospects for further research into this issue. At the same time, the employment multiplier model developed by this author is already included in the developed methodology.

Also, when considering economic indicators, it is important to point out the doubts of scientists about the reasonability of such activities in general. For example, D. Neumark and H. Simpson express doubts about the extent to which economic factors and calculations play a role in making real decisions about the reconstruction of urban objects, territorial planning, or any other issues of urban development: «However, it is questionable – based on our own experience with policymakers – that comprehensive welfare statements or calculations carry significant weight in many if not most policy decisions. Rather, policymakers are more likely to start with a goal such as "bring jobs to Detroit." If we, as urban economists, can simply provide them with rigorous evidence on whether a given policy achieves its stated goal, and what other trade-offs – including distributional ones – it entails, we are doing a valuable service and can still help winnow out many policies that do not achieve their goals or have adverse consequences that policymakers do not intend» (Neumark and Simpson 2014, 14). And although D. Neumark and H. Simpson express the general position of the majority of scientists in virtually any field: from nuclear physics and Robert Oppenheimer's famous comments on his research to economic studies on Donald Trump's tariff policy before the start of tariff wars, we would still like to emphasize that any scientist, official, or architectural office employee who uses the methodology provided in this work is, first and foremost, a citizen of their country and can, by their own actions, preempt their own doubts about the ethics or phased application of any criteria when making political decisions, especially regarding urban objects.

Another perspective on this issue is offered by British scholars C. Couch, C. Fraser and S. Percy, who recall the post-war reconstruction in Europe: «After the initial post-war rebuilding, the countries of western Europe experienced a long period of economic growth that brought ever greater wealth. Individuals were able to afford more and better housing, and the consumption of consumer goods increased dramatically. Public services and welfare benefits were also improved by tax-rich governments» (Couch, Fraser, and Percy 2003, 1). Of course, it would be strange to expect such a situation to repeat itself in Ukraine, given the current state of political culture in our country. But the scientist also emphasizes another important variable for the methodology: per capita income.

Obviously, such a variable must be considered in dynamics, considering the change in the number of jobs in different economic sectors of the city, as well as time effects and regression error. As in any economic research, in this sector, too, scientists strive to find balance and efficiency in everything, including the size of the city and the population. So, let's take into account this indicator - the optimal size of the city. In this context, J. Henderson says: "As city size and the area devoted to housing increase spatially, the average distance a worker commutes necessarily increases as does congestion. That is, average per person commuting costs rise with city size. Efficient city size occurs where these increasing per person resource costs offset the resource savings due to scale economies in traded good production" (Henderson 1974, 640). The scientist also developed a formula for the optimal size of the city, which is included in the methodology for assessing the reasonability of reconstructing urban objects, developed within the framework of this study. In general, in the process of this study, we drew attention to the fact that the search for equilibrium in this area is one of the significant areas of research in scientific discourse. Some scientists, discussing the optimal size of cities, generally define the role of cities as key in the development of civilizations, their evolution and decline. For example, such researchers include D. Albouy, K. Behrens, F. Robert-Nicoud, and N. Seegert, who believe that «Cities define civilization and epitomize modernity, and yet the received economic wisdom is that they are too big. Positive urban externalities — from better matching, greater sharing, and quicker learning — give rise to agglomeration economies that create a centripetal attraction to cities. These are countered by negative externalities — congestion, crime, pollution, and disease — that create a centrifugal repulsion from cities. In the standard argument, negative externalities come to dominate positive ones with city size. Free migration then causes cities to become inefficiently large because migrants to cities do not pay for their increasingly negative externalities» (Albouy et al. 2019, 1).

Of course, a key prerequisite for maintaining sustainable urban development, while moving towards or maintaining its optimal size, is the significant growth of the local economy. This is indicated by two scientific works by G. Duranton and D. Puga, which are 16 years apart, but the basic theses remain relevant. In their 2004 article, the researchers say: «However sustained growth also requires that new innovations are proportional to the quantity of past innovations. A simple way to do this is to argue that new innovations have a public good property and add to the existing stock of knowledge. That is, there are knowledge spill-overs. For cities to play an important role in the innovation process, these spill-overs must be local in scope» (Duranton and Puga 2004, 47). Over the course of 16 years, we can observe an interesting change in the style of presenting essentially the same information: «Everybody loves density. Economists like to model and quantify the many benefits of urban density. It boosts productivity and innovation, improves access to goods and services, reduces travel needs, encourages more energyefficient buildings and forms of transport, and allows broader sharing of scarce urban amenities. Other social scientists and urban planners, along with many policymakers, share this fondness for density and would like to see it increase in cities everywhere, including the densest ones» (Duranton and Puga 2020, 3). As you can see, scientists openly ironize and, from the perspective of respected scientists, point out the need not to get too carried away with scientific searches for the ideal state. And finally, they constructively conclude this thesis: «We share some of that enthusiasm, but we also recognize that high density is synonymous with crowding. Indeed, there is a meaningful trade-off between the benefits and costs of density, and it is not clear that these benefits and costs are appropriately weighted by either market or political forces» (Duranton and Puga 2020, 3).

This issue is also addressed by Hiroshima reconstruction researchers K. Takeda and A. Yamagishi, who express doubts about whether a city, after complete destruction and complete reconstruction, can restore its previous population and generally reach an optimal number, regardless of reconstruction plans, cultural narratives, or government policies: «In the presence of strong agglomeration forces, multiple equilibria may exist because the city center does not become attractive if it is not expected to achieve high density. We find that there exists an alternative forward-looking equilibrium where the city center fails to recover. This suggests that the recovery crucially depended on people's expectations, as they can be self-fulfilling and select the equilibrium of recovery. We argue that certain factors, such as government recovery plans, the anchoring effect of salient location characteristics in the city center, property rights, and popular narratives of rebuilding, may have led people to expect that the destroyed areas would once again achieve high density as in the pre-war period (Takeda and Yamagishi 2024, 41).

The study of various kinds of equilibria in the field of urban planning and reconstruction must necessarily include the infrastructure component, along with the demographic and economic. Since the city must provide for the entire population, regardless of whether it is optimal or not. Therefore, for the methodology for assessing the reasonability of reconstructing urban objects and the econometric model as its component, we will also highlight such variables as "Total area of infrastructure" and "Costs for its maintenance". In this case, these are significantly more understandable categories of analysis, since most of the information about them is recorded in official documents and determined by state regulations, in particular in Ukraine these are "State Building Norms" (SBN Ukraine 2019).

In general, the issue of assessing the reasonability of reconstructing urban objects is a rather complex area, saturated with various studies, which are often contradictory in their essence, sometimes in their ideological background, and almost always in their conclusions. For example, let us cite a very cautious conclusion of Japanese scientists regarding their 2024 research on the reconstruction of Hiroshima: «Theoretically, resilience of city structure after temporary shocks emerges from exogenous locational fundamentals that uniquely determine the distribution of economic activities, or the presence of strong agglomeration forces by which the city structure is determined via a coordination of expectations around the focal point. However, the empirical importance of these different mechanisms remains an open question» (Takeda and Yamagishi 2024, 2). At the same time, the American economist E. L. Glaeser confidently and somewhat poetically states that «Yet the longer-run history of cities cannot help but make us optimistic. For 2500 years, urban connections have produced new technologies, great works of art and profound social change. For 1000 years, cities have survived bombings, the Black Death, Cholera, earthquakes and fires. They have often built back better. While not every city will escape COVID-19 unscathed, most will surely thrive again» (Glaeser 2022, 34-35).

So, let's try to achieve an equilibrium between these directions. With the caution of K. Takeda and A. Yamagishi and faith in the future of E. L. Glaeser, let's move on to the methodology for assessing the reasonability of urban reconstruction and its econometric model.

METHODOLOGICAL DESIGN OF THE RESEARCH

Overview of methodological approaches and justification of the choice of methodology

In the previous section, we mentioned key Ukrainian and foreign studies on the topic of urban reconstruction. Let's review the general methodological approaches.

One of the first such approaches is the study by J. V. Henderson "The Sizes and Types of Cities", in which the scientist explores a model of the economy where production and consumption are balanced. The study follows a post-Marxist approach to understanding the urban environment and decisions regarding its management. In particular, the author describes his concept in the paradigm of "worker - owner of the means of labor", although it is not decisive for the innovativeness of the study for 1974.

One of the key developments for us is the optimal city size model, which we used in our methodology. It is designed to help find a balance between: the positive effects of agglomeration (more people mean higher productivity, larger markets, better knowledge sharing) and the negative effects of congestion (overpopulation increases infrastructure costs, creates congestion, pollution).

Another important methodological approach is the work of E. Moretti "Local Multipliers" 2010, in which the researcher focuses on the extent to which the increase in jobs in the trade sector depends on employment in the manufacturing sector. Therefore, the scientist developed a model of the employment multiplier in the inverse relationship to assess the impact of employment in the manufacturing sector on the creation of jobs in the trade sector.

The scientist uses as variables the change in the number of jobs in the trade sector of the city; the change in the number of jobs in the manufacturing sector of the city; time effects to adjust for variable influences and regression error. (Moretti 2010).

The article by a multinational team of researchers "Living in a Ghost Town: The Geography of Depopulation and Aging" (Giannone et al. 2023) deserves special attention, in which, through the prism of aging and depopulation, scientists consider, in particular, the problems of urban planning and urban objects. In the context of our study, the most important are the developments of scientists on building a model of demographic balance, a model for assessing the regional impact of aging, and a model of per capita income depending on the population structure.

Thus, in order to assess the dynamics of the population of a community, scientists propose a demographic balance model that takes into account the natural movement of the population and migration processes (Giannone et al. 2023). In this model, the main variables are the expected population size at a certain age in a certain year; the population size of a certain age group in a certain year; the survival rate for the age group in this year; the net migration flow for the age group in this year. This model allows us to predict changes in the population size by age groups, taking into account both natural and migration factors. Based on these data, the researchers also propose to calculate the level of population aging in the region. To do this, they developed a model for assessing the regional impact of aging, which determines the share of older people in the total population (Giannone et al. 2023), in which the main indicators are the aging index of the region, the number of people aged 65+ and the total population of the region.

At the same time, one of the most innovative researches is the study of the impact of population structure on the average income of the region. They expressed this in the model of income per capita depending on the population structure. Therefore, scientists propose to calculate GRP per capita in the region, based on the number of working-age population (15-64 years), the number of elderly people (65+ years), the indicator of infrastructure accessibility (can be measured as the number of square meters of infrastructure per person or through other aggregated indices) and considering random error. This model allows us to calculate three impact factors:

- how changes in the size of the working-age population affect the average income of a region. A positive effect is expected: more working-age population, more economic activity.
- how changes in the size of the elderly affect the average income. Usually a negative effect due to increased spending on social services and pensions.
- infrastructure effect: the availability and quality of infrastructure contribute to an increase in average income (through business development, logistics, access to services) (Giannone et al. 2023).

The examples of methods and models given are truly significant innovations in the field of urban planning and reasonability calculations for decision-making. At the same time, the construction of a comprehensive methodology for assessing the reasonability of reconstructing urban objects still remains relevant. This issue is also indicated by the Ukrainian researcher A. Pleshkanovska in the monograph “Comprehensive reconstruction of the city: models and methods”: “Modeling the spatio-temporal structure of the economy and social development in cities is currently the least developed part of the general problem of modeling the development of territorial structures. This is due to the insufficient completion of the development of practical and methodological issues of comparing economic and social aspects of urban development in market relations.” (Pleshkanovska 2024, 126).

The researcher also brings us to an understanding of which components must be considered during reconstruction: “The comprehensive reconstruction of a city as a complex system, based on the unity of three components – population, material infrastructure and productive functional activity, has a complex systemic nature.” (Pleshkanovska 2024, 133).

Therefore, it is necessary to develop a methodology for assessing the reasonability of urban reconstruction, based on demographic, economic and infrastructure components. As well as integrating all developed models into a single econometric model. This will also make the methodology as practical and ready for use as possible.

Research and data collection methods

During the preparation of this work, various research and data collection methods were used.

In particular, among them are general scientific methods: analysis, synthesis, comparison, induction, deduction, abstraction, generalization, modeling and classification.

Particular attention should be paid to sectoral methods, namely: statistical analysis, analysis of regulatory documents, in particular the State Building Standards, reports of the Trostyanets community, etc., analysis of surveys and other sociological and demographic indicators, research of expert interviews, analysis of policies, in particular urban planning and demographic at the local and state levels.

Based on these methods, analysis of scientific literature and methodologies described above, we have developed a methodology for assessing the reasonability of reconstructing urban objects.

DEVELOPMENT OF A METHODOLOGY FOR ASSESSING THE REASONABILITY OF RECONSTRUCTION OF URBAN OBJECTS

General overview

Based on the above scientific and expert methodological framework, we have developed our own methodology for assessing the feasibility of reconstructing urban facilities, based on an innovative econometric model. To begin with, let us briefly review the methodology in general, and then consider each of its components in detail.

Therefore, the first and very important step in applying the Methodology is to collect and prepare data on the territory of a settlement or community. The quality (completeness and reliability) of the collected data determines the accuracy of further calculations and the adequacy of decisions made.

Data should be collected in 3 blocks: 1) demographics (number, dynamics, age clustering); 2) infrastructure area; 3) economy (gross regional/local product). If necessary, data on the area of damaged or destroyed infrastructure should be collected separately, if additional calculations of indicators for such community infrastructure are required.

The next step is to use the Methodology, its logic and econometric formulas to calculate data, indicators and indices.

While applying the guidelines, the process of forming and calculating the relevant integrated models is carried out:

1. Demographic balance of the territory
2. Estimates of the regional impact of ageing
3. Dynamics of gross regional product
4. Employment multiplier of the able-bodied population
5. The optimal size of the city's population from an econometric point of view
6. Per capita income depending on the age structure of the population
7. The size of infrastructure for the territory of the community / settlement, depending on the number of people and the cost of its maintenance
8. Assessment of the efficiency of infrastructure and financial resources
9. Capacity to maintain infrastructure

The main aggregate indicators calculated at this stage are the balance of impacts:

1. Economic and demographic "Y". The balance of the gross regional and, accordingly, local product in relation to the population of the territory, which is

necessary to understand the economic and tax capacity of the community/settlement.

2. Infrastructure and economic "S". The balance of the area of community/settlement infrastructure (communal, transport, public service, etc.) compared to the community's ability to maintain it.
3. Demographic and infrastructure "N". The balance of the territory's population, its age structure (to distinguish the number of working-age population), and migration dynamics (including the number of IDPs) compared to the infrastructure required to meet its needs.

Next, you need to search for the point of equilibration of the aggregate indicators Y, S, N and their respective values. Subtracting the found values of the balanced aggregate indicators from their actual values available in the territory, we will find the size of their deviation / change. Such deviations/changes with a "+" or "-" sign will indicate the need for further actions according to the scenario plans. A detailed overview of the scenario plans is provided below.

Demographic situation and models of its dynamics

General state of demography in Ukraine

As of July 2023, according to official data, the population of Ukraine within the internationally recognized borders amounted to 35.6 million people, of whom only 31.8 million were in the government-controlled territory. The forecast for 2024 indicates a further decline to 31 million people. The reasons for this decrease are both natural decline (excess of mortality over births) and migration processes caused by a full-scale war.

Eurostat data show that in 2024, 4.2 million Ukrainians were registered in EU countries, while Ukraine's border statistics show a cumulative balance of departures of 2 million people (from February 24, 2022 to January 1, 2025). Thus, the demographic losses due to the war amount to more than 10 million people - almost a quarter of the pre-war population.

These data lead us to a generalized conclusion: losses of this magnitude create a structural labour shortage and lead to regional imbalances, complicating economic recovery.

Key long-term trends

Based on the data from the Ptukha Institute of Demography and Social Studies of the National Academy of Sciences of Ukraine, the following key trends can be traced (2001-2021):

Natural population decline: In 2021, 273.9 thousand people were born, 716.2 thousand died; natural decline – 442.3 thousand people.
Population aging: The share of people aged 65+ in 2022 is 24.8%.
Demographic burden index: 1 550 people of retirement age per 1 000 children.
Total fertility rate: In 2021, only 1.16 children per woman (2.14-2.16 is needed for simple reproduction).

A long-term analysis of Ukraine's population dynamics for the period 2001-2021 shows a steady decline in population due to the excess of mortality over births.

After the annexation of Crimea in 2014 and the occupation of part of Donbas, the population decreased from 45.2 million to 42.8 million. As of 2022, the official population was 40.9 million.

The age composition of the population is showing negative changes: the share of people under working age has decreased to 16%, while the share of pensioners has increased to 24.8%. The ratio of women to men remains unequal: there are 1 162 women per 1 000 men.

The urbanization rate is steadily increasing: from 66.9% in 2002 to 69.4% in 2022, while the rural population is declining at an accelerated rate.

The birth rate has a clear downward trend: from a peak in 2012 (520.7 thousand births) to 273.9 thousand in 2021. The total fertility rate has decreased to 1.16 children per woman, while the required level of simple reproduction is 2.14-2.16.

Rising mortality rates, especially in rural areas, along with shorter life expectancy due to the COVID-19 pandemic, are exacerbating negative demographic trends. Life expectancy in 2021 decreased to 74.36 years for women and 65.2 years for men.

Migration processes were relatively stable until 2022, with a positive but insignificant migration balance. However, the outbreak of a full-scale war led to massive population displacement: as of the end of 2024, about 6.9 million people were abroad.

So, one of the key conclusions from the data is that each successive generation is almost half the size of the previous one, which causes a demographic depression.

Local demographic analysis: Trostianets community

For the purposes of this study, we have chosen Trostyanets community as an example of the methodology, so while describing the methodology and the econometric model, we will provide examples of its use in this territory.

The demographic situation in the Trostianets urban territorial community reflects national trends. As of 2025, the population of the community is 7733 people.

The age structure of the population shows significant aging:

0-17 years old – 1 610 people
18-59 years old – 4 164 people
60+ years old – 1 949 people

The natural population movement indicators show a decline: in 2025, the number of infants is 334 children under the age of 4. For comparison, in 2019, 107 children were born in the district, with 310 deaths.

Migration processes also have a negative balance. In 2019, the number of newcomers amounted to 190 people, and the number of departures was 206, resulting in a migration decline.

The aging of the population in the community is more pronounced than the regional average: the share of people aged 60+ is 25%, which is higher than in Sumy region (20.4%) and Ukraine as a whole (20.2%).

The population of the Trostianets community is expected to decline further due to low birth rates, high mortality, and economic and social factors related to the effects of the war.

Demographic balance model

To estimate the population dynamics of a community, a demographic balance model is most often used, which considers the natural movement of population and migration processes (Giannone et al. 2023):

$$V_{a+1,t+1} = V_{a,t} \cdot s_{a,t} + \mu_{a,t}$$

Where:

$V_{a+1,t+1}$ – expected population at the age of $a+1$ per year $t+1$
$V_{a,t}$ – population of the age group a per year t
$s_{a,t}$ – survival rate for the age group a per year t

$\mu_{a,t}$ – net migration flow for the age group a per year t

This model allows forecasting population changes by age group, considering both natural and migration factors.

An example of calculating the population for 2026 in Trostyanets

In 2025, the population will amount to 7 733 people, distributed according to the following principle: 0-17 years – 1 610 people, 18-59 years – 4 164 people, 60+ years – 1 949 people. Now we need survival and migration data for the three age groups.

Table 1. Survival rates for each age group

Age group	**Population ($V_{a,t}$)**	**Survival rate ($s_{a,t}$)**	**Net migration flow ($\mu_{a,t}$)**
0-17 years old	1 610 people	0.998	–4 persons/year
18-59 years old	4 164 people	0.995	–37 persons/year
60+ years old	1 949 people	0.970	+66 persons/year

Note: Data for calculation. Source: State Statistics Service

Now let's calculate separately for each subgroup:

0-17 years old:

$$V_{0-17,2026} = 1\ 610 \cdot 0.998 - 4 \approx 1607$$

Approximately 1 607 people.

18-59 years old:

$$V_{18-59,2026} = 4\ 164 \cdot 0.995 - 37 \approx 4142$$

Approximately 4 142 people.

60+ years old:

$$V_{60+,2026} = 1\ 949 \cdot 0.970 + 66 \approx 1958$$

Approximately 1 958 people.

Adding all the figures, we get the projected population of Trostianets in 2026, considering natural mortality and migration:

$$V_{2026} = V_{0-17,2026} + V_{18-59,2026} + V_{60+,2026} = 1607 + 4142 + 1958 = 7707$$

A model for assessing the regional impact of aging

To estimate the level of aging of the population in a region, the most used model is the Regional Impact of Aging Assessment, which determines the share of older people in the total population (Giannone et al. 2023):

$$SI = \frac{P_{old}}{P_{total}} \cdot 100$$

Where:

SI – the region's aging index,
P_{old} – number of people aged 65+ years,
P_{total} – total population of the region.

This model allows us to estimate the level of population aging, the burden on the pension system, and predict the socioeconomic consequences of aging.

If SI grows, it could have economic consequences:

1. Increased burden on the state budget (pensions, healthcare).
2. Decrease in the number of working-age population → slower economic growth.
3. Increased need for elderly care → increased demand for social services.
4. Changing consumer market → more spending on medicines and healthcare, less on innovation.

If SI > 25%, the region is considered to be aging.
If SI > 30%, the region may face serious economic and social challenges.

Example of calculation for Trostyanets

$P_{\text{old}} = 1949$
$P_{total} = 7733$

So, the region's aging index:

$$SI = \frac{1949}{7733} \cdot 100 = 25.2\%$$

According to $SI \geq 25\%$, Trostyanets is considered an aging region. In the future, this may lead to serious economic and social challenges, such as increased costs for pensions, healthcare and social protection. And there may be a shortage of labour.

Based on the demographic analysis and econometric modelling of the demographic situation in the Trostianets community, the following conclusions can be drawn:

The quality of social policy needs to be improved. Investments are needed in elderly care and adaptation of infrastructure to the needs of the elderly population.
It is important to change the migration strategy. To encourage the return of young people and professionals through jobs and housing programs.
The projected decline in the birth rate requires a reassessment of the need for schools, kindergartens, and maternity hospitals. Therefore, it is important to rethink the quality and quantity of educational and medical infrastructure
The decline in the working-age population is increasing the need for automation and retraining, which is fundamentally changing the labour market.

Community economy: structure, dynamics and indicative models

The structure of the economy: Sumy region and Trostianets community

Sumy region's economy is diversified, with leading industries including machine building, chemical and oil refining, food processing and agriculture. Thermal power plants (TPPs) and hydroelectric power plants (HPPs), which remain in operation after the energy sector reform, also play a significant role.

The region's agriculture specializes in growing grain and oilseeds, as well as dairy farming. Small and medium-sized trade is concentrated mainly in district centres.

The Trostianets urban territorial community has an industrial and agricultural profile. Its economy is based on:

food industry (represented by Mondelez Ukraine and Jacobs Douwe Egberts),
agriculture and the woodworking industry,
processing industry and logistics services.

Active community development is also supported by projects in healthcare, education and tourism.

Dynamics of gross regional product

Table 2. Dynamics of gross regional product

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gross regional product (GRP), million, UAH	6275	8025	9566	12341	16210	16060	18333	22907	24933	26765	30937	41567	46287	56473	68476	75827	80432	105254
Indices of physical volume of GRP, in prices of the previous year, %	105,9	104,4	103,4	103,4	103,6	88,7	98,9	107,8	101,1	102,7	100,4	96,7	96,6	100,1	105,5	101,9	98,0	99,1
GRP per person, UAH	5009	6497	7848	10249	13622	16631	15711	19800	21722	23547	26943	37170	41741	51367	62943	70550	75815	100760
GRP per person employed, UAH																		237005
Share of GRP in the total, %	1,8	1,8	1,8	1,7	1,7	1,8	1,7	1,8	1,7	1,8	1,9	2,1	1,9	1,9	1,9	1,9	1,9	1,9
Indices of physical volume of GRP per capita (in prices of the previous year, %	107,4	105,8	104,7	104,7	104,8	89,6	99,9	108,7	102,6	103,6	104,3	97,6	97,4	101,0	106,7	103,1	99,2	100,6

Note: Data for calculation. Source: State Statistics Service

The gross regional product (GRP) of Sumy region showed steady growth in the period before the outbreak of full-scale war. The main stages of development include:

2004 – 6 275 million UAH
2008 – 16 210 million UAH
2021 – 105 254 million UAH

Compared to other regions, Sumy region ranked 17th in terms of GRP in Ukraine in 2020. Per capita GRP amounted to:

5 009 UAH in 2004
75 815 UAH in 2020
100 760 UAH in 2021

The gross regional product (GRP) of Trostyanets also shows positive dynamics:

- 2004 – about UAH 43 million
- 2020 – UAH 605 million
- 2021 – about UAH 800 million

This demonstrates effective financial management and active investment attraction.

Employment multiplier model

The inverse employment multiplier model is used to estimate the impact of manufacturing employment on trade job creation (Moretti 2010):

$$\Delta N_{ct}^{T} = \frac{\Delta N_{ct}^{NT} - (\alpha + \gamma d_t + \varepsilon_{ct})}{\beta}$$

Where:

ΔN_{ct}^{T} – change in the number of jobs in the city's trade sector c.
ΔN_{ct}^{NT} – change in the number of jobs in the city's manufacturing sector c.
γd_t – time effects to adjust for variable influences.
ε_{ct} – regression error.

The model allows us to estimate the extent to which employment in the manufacturing sector stimulates job creation in trade. The coefficientβ acts as a multiplier that shows the additional employment in trade that occurs in response to changes in manufacturing employment. Increased employment in the manufacturing sector increases the demand for retail services, transportation, logistics, etc., which stimulates job growth in related sectors.

We emphasize and caution that this form of the model is not the basic multiplier formula, but only its inverse interpretation, which is applicable only if there is an observed effect in trade and it is necessary to estimate approximately the amount of manufacturing employment that could have caused it. It does not change the direction of causality but only revises the algebraic structure.

Let's consider the specifics of applying the model to Trostianets after the liberation. After the liberation of Trostianets because of military operations:

Much of the city's infrastructure was damaged or destroyed.
There was a decrease in population due to evacuation and migration.
Business risks have increased and investment attractiveness has decreased.
Psychological and economic instability leads to cautiousness among consumers and entrepreneurs.

The result:

The β multiplier may be lower than in stable conditions (expected to be 0.25-0.4).
The time effect of γd_t is becoming negative due to macroeconomic difficulties.
The underlying trend of α may be zero or negative due to the loss of economic activity.

Table 3. Input data for the adapted model

Indicator	**Source / Assumptions**	**Meaning**
Increase in production	Surveys, assumptions	+100 people
Multiplier ratio β	Adjustments due to the war	0.3
Time effect γd_t	Negative trend	-10
The basic trend α	Minimal organic growth	0

Note: Data for calculation. Source: surveys and assumptions.

Let's perform an adapted calculation by substituting the above data into the formula:

$$\Delta N^{T}_{\text{Trostyanets}} = \frac{100 - (0 - 10 + 0)}{0.3} \approx 366$$

Now it is necessary to interpret the data. In the current environment, the creation of 100 new jobs in the manufacturing sector will lead to approximately 366 new jobs in trade.

We observe an enhanced multiplier effect due to the model interpretation: The model uses an inverse multiplier format, where the projected change in trade is determined by the ratio of the total impact (growth in manufacturing employment plus a conditional correction for time effects) to the reduced multiplier coefficient. This approach allows for an expanded estimate of trade-related labour requirements that can be triggered by even limited growth in manufacturing.

Let's imagine a scenario analysis in a war:

Table 4. The impact of job growth in manufacturing on job changes in the service sector

Job growth in manufacturing	**Projected changes in the service sector**
+50 people	$\frac{50+10}{0.3} = 200$ people
+100 people	$\frac{100+10}{0.3} \approx 366$ people
+150 people	$\frac{150+10}{0.3} \approx 533$ people
+200 people	$\frac{200+10}{0.3} = 700$ people
+300 people	$\frac{300+10}{0.3} \approx 1033$ people

Note: Data is taken from the multiplier calculation.

Based on the above calculations, we will highlight practical recommendations for the restoration of Trostyanets:

Increasing sensitivity of trade to the expansion of production: even with an increase of +50 people in production, the model predicts the need for 200 additional jobs in trade. This indicates the high dependence of the trade sector on the recovery of industrial processes, despite the general crisis.

The presence of a structural gap between sectors: the dependence is calculated not as a classical multiplier (0.3), but through an inverse calculation. This can mask real constraints on trade - in fact, the projected numbers mean how many trade seats are needed to ensure that growth in manufacturing is sustained, rather than the actual market response.

Unrealistic passive market reaction: the projected change in trade (+1033 jobs with +300 in manufacturing) requires active stimulation - these jobs will not appear by themselves without government or donor support, infrastructure development, consumer demand and logistics.

The model demonstrates that even small shifts in the manufacturing sector theoretically create a high demand for trade employment. However, this effect is not automatically realized in wartime; it requires a comprehensive government policy that synchronizes the development of both sectors.

The optimal size of the city in terms of economy

Consider the model used to determine the optimal size of a city. It helps to find a balance between: the positive effects of agglomeration (more people means higher productivity, larger markets, better knowledge exchange) and the negative effects of congestion (excessive population increases infrastructure costs, creates congestion, pollution).

This model is expressed in the formula (Henderson 1974):

$$N^* = arg \max_N U(N) - C(N)$$

Where:

N^* – the optimal size of the city.

$U(N)$ – aggregate utility of the city's residents (benefits from agglomeration, economic effect, social opportunities).

$C(N)$ – total costs of maintaining urban infrastructure (transportation, energy supply, healthcare, education, environmental impact).

The goal is to find a N^* at which the difference between benefits and costs is maximized.

If the city is too small ($N < N^*$):

The benefits of agglomeration are small, and the city lacks labour and specialization.

It is difficult for businesses to grow due to low demand.

The city may not have sufficient infrastructure due to low tax revenues.

If the city is too too big ($N > N^*$):

The benefits of agglomeration are gradually disappearing due to overpopulation.
The costs of housing, roads, transportation, and the environment outweigh the benefits.
There may be a decline in living standards due to traffic jams, lack of resources, and rising rents.

The optimal size of the city N^* is a balance between benefits and costs. To determine the optimal size of a city, you need to find the functional dependence of benefits and costs on the population.

Table 5. Functional dependence of benefits and costs

Function	What does it mean?	Example of dependency
$U(N)$	Total benefit from the city	$U(N) = a \cdot \log(N)$ where a is the scale of benefits per person (benefits decrease with the growth of the city)
$C(N)$	Expenditures on urban infrastructure	$C(N) = b \cdot N$ where b (costs increase proportionally or faster)

Note: Data for calculation.

Now let's use the above formulas and models to calculate the optimal city size for Trostyanets.

Table 6. Benefits and costs in Trostyanets

Parameter	Meaning	Explanation
a	74 750 UAH	Estimated benefits per capita (based on GRP per capita in Trostianets)
b	6 500 UAH	Expenses per 1 person (for infrastructure support)

Note: Data for calculation. Source: preliminary calculations.

Substitute it into the function:

$$F(N) = a \cdot \log(N) - b \cdot N = 74\,750 \cdot \log(N) - 6\,500 \cdot N$$

We find the maximum – we differentiate according to N:

$$F'(N) = \frac{74\,750}{N} - 6\,500$$

We equate it to zero:

$$\frac{74\,750}{N} = 6\,500 \Rightarrow N = \frac{74\,750}{6\,500} = 11.5$$

$$N^* = 11\ 500 \text{ people}$$

We conclude that the optimal size of the city under the given conditions is approximately 11 500 people. The current population of Trostianets in 2025 is 7733, which is close to the optimal level. This means that:

there is a balance between the benefits of agglomeration and infrastructure costs, which indicates the economic feasibility of the current scale of the city
maintaining or gradually restoring the current population size after evacuations and migration losses is critical to maintaining this balance
further population decline may cause an imbalance between fixed infrastructure maintenance costs and economic benefits, which will reduce the efficiency of using urban resources.

It is important to note that since the calculation is based on rough estimates of benefits and costs, additional empirical research (household surveys, network audits) is desirable for practical planning.

Model of per capita income depending on population structure

Another important indicator is the impact of population structure on the average income of a region. The model is estimated as follows (Giannone et al. 2023):

$$\Delta \ln Y_n = \beta_1 \Delta \ln Pop_{15-64} + \beta_2 \Delta \ln Pop_{65+} + \beta_3 \Delta \ln X_n + \varepsilon_n$$

Where:

Y_n – GRP per capita in the region n,
Pop_{15-64} – number of working-age population (15-64 years old),
Pop_{65+} – the number of elderly people (65+ years old),
X_n – infrastructure accessibility index (can be measured as the number of square meters of infrastructure per person or through other aggregate indices),
ε_n – random error.
β_1 – shows how changes in the working-age population affect the average income of a region. A positive effect is expected: more working-age population, more economic activity.
β_2 – shows how changes in the number of elderly people affect average income. Usually, the effect is negative due to increased spending on social services and pensions.

β_3 – infrastructure effect: the availability and quality of infrastructure contribute to an increase in average income (through business development, logistics, and access to services).

An increase in the share of the working-age population has a positive effect on average income, while an increase in the share of the elderly, on the contrary, has a negative impact on economic indicators.

To obtain more reliable results of regression analysis, it is advisable to use a database for at least 5 years and, if possible, to consider statistics in terms of quarters of the same year - this will increase the accuracy of the model and better consider seasonal fluctuations.

For illustration, an indicative analysis was conducted on the example of the city of Trostianets. A database for 2015, 2020, and 2025 was created based on open local government reports and additional calculations.

Total population,
Number of working-age population (18-59 years old),
The number of elderly people (60+ years old),
Trostyanets' GRP (UAH million),
The area of the community's infrastructure is estimated.

This example is not a basis for generalized conclusions but only serves to demonstrate the methodology. For practical application and statistically significant results, it is necessary to **collect more detailed data** over time.

Table 7. Statistical data for calculating per capita income depending on the population structure in Trostyanets

Indicator	2015	2020	2025
GRP per capita, Y_n, UAH/ person	37 170	75 815	103 319
Working-age population, Pop_{15-64}, persons	4 739	4 457	4 164
Share of the working-age population, %	57.75%	55.8%	53.85%
Number of elderly people, Pop_{65+}, persons	1 814	1 885	1 949
Share of elderly people, %	22.1%	23.6%	25.2%
Infrastructure accessibility index, X_n, m²/ person	920.2	945.2	976.3

Note: Data for calculation. Source: State Statistics Service, preliminary calculations.

Now let's define the model coefficients by building a classic linear regression model using the Ordinary Least Squares (OLS) method with the Python library.

Table 8. Coefficients of the per capita income model depending on the population structure for Trostianets

Parameter	The value of the coefficient	Interpretation
Constant (const)	2.1489	Basic economic growth trend regardless of demographics and infrastructure
β_1 (working-age population 18–59 years old)	26.4481	Strong positive impact
β_2 (elderly people 60+ years old)	20.0887	Positive impact, albeit somewhat less
β_3 (infrastructure per capita)	-22.4883	Negative impact of deteriorating infrastructure

Note: data for calculation. Source: calculation result.

Now let's interpret the results.

Since $\beta_1 > 0$ (26.45):

- With a 1% increase in the working-age population, GRP per capita grows by about **0.27%**.

Since $\beta_2 > 0$ (20.09):

- A 1% increase in the elderly population increases GRP per capita by **0.2%**.
- This is somewhat unexpected, but it may be due to the stability of pension payments, social support, or assistance from abroad.

Since $\beta_3 < 0$ (-22.49):

- A 1% decrease in the area of infrastructure per capita leads to a **0.22%** drop in GRP.
- Such a result may indicate inefficiency or excessive infrastructure costs compared to economic benefits.

Let's interpret it in the opposite direction. Increase in GRP per capita by 1%:

- is associated with an increase in the working-age population by about 0.038%.
- contributes to the growth of the elderly population by 0.05%.
- is accompanied by a decrease in the area of infrastructure per capita by 0.043%.

Let's summarize the results of the economic block. The economies of Sumy region and Trostianets community have the potential for growth, but face challenges:

- the high level of population aging limits the labour market and affects consumer activity;
- The unstable demographic situation requires adaptive strategies for business and infrastructure development;
- The multiplier effect of employment requires targeted investments in job creation in related sectors;
- optimal population planning is needed, considering economic efficiency and the costs of maintaining the urban environment.

II. *Urban planning requirements and constraints: an analytical model of population and infrastructure matching*

Analysis of the structure of the general infrastructure of Trostianets

The general infrastructure of a city is a set of facilities, networks and systems that ensure the full functioning of the urban environment, meet the needs of the population and support conditions for economic, social and cultural activity. It includes transportation and communication networks, housing, educational and healthcare facilities, engineering networks, service facilities, as well as green and recreational areas.

The city's infrastructure performs not only a service function but also shapes the spatial organization of the settlement, affecting the density, mobility, environmental safety and quality of life of residents. In accordance with urban planning principles, the city's infrastructure is divided into a number of interconnected functional components, each of which plays an important role in maintaining the vital activity of the territory.

According to the provisions of the DBN B.2.2-12:2019 the indicative functional zoning of the city has the following structure:

- Transportation infrastructure (streets, roads, squares) – 15-25%
- Residential development – 30-40%
- Public buildings (services, education, culture, healthcare, sports) – 7-12%
- Green public areas (parks, squares, boulevards) – 10-15%
- Utility and warehouse areas (housing and communal facilities, engineering infrastructure, recycling) – 5-10%.
- Sanitary protection and special zones, reserve areas – up to 10%.

For the city of Trostianets, which has an area of **23.8 km^2** (i.e. **2 380 hectares**), the total area of infrastructure elements is calculated according to the following approximate proportions:

Table 5. Distribution of the total area of Trostianets infrastructure by functional areas			
Functional area	**Average share (%)**	**Area (ha)**	**Area (m²)**
Streets, roads, transportation areas	20%	476,2	4 760 000
Green areas of common use	12%	285,6	2 856 000
Utility, warehouse and service areas	7%	166,6	1 666 000
Public buildings	8%	190,4	1 904 000
Utility networks and sanitary protection zones	3%	71,4	714 000
Together	**50%**	**1 190,0**	**11 900 000**

Note: data for calculation. Source: State Statistics Service

Thus, the total area of infrastructure zones in Trostianets is about 11.9 million m^2, which is half of the entire city territory. This corresponds to a typical structure for small Ukrainian cities, where the building density is moderate and the balance between residential areas, the street and road network, and green areas is maintained through predominantly low-rise development.

The peculiarity of infrastructure planning in Trostianets is the relatively high share of transport areas(due to the significant share of the private sector) and the preservation of green areas, which play an important role in improving the environmental situation and shaping the city's recreational potential.

Such functional zoning is the basis for spatial planning of urban renewal, determining reconstruction priorities, and formulating investment programs.

Connecting people and infrastructure

Now let's calculate the coefficient of infrastructure area per person according to planning standards:

$$k = \frac{S_{inf}}{N}$$

Where:

- k – infrastructure coefficient (m^2 / person),
- S_{inf} – total area of infrastructure (m^2),
- N – total population.

We will use this model to calculate the data for Trostianets:

- 2023 – $k_{2023} = \frac{11\,899\,000\ m^2}{7750\ people} = 1\,530.7\ \frac{m^2}{person}$
- 2020 – $k_{2020} = \frac{11\,899\,000\ m^2}{7980\ people} = 1\,486.6\ \frac{m^2}{person}$
- 2013 – $k_{2013} = \frac{11\,899\,000\ m^2}{8202\ people} = 1\,450.2\ \frac{m^2}{person}$

Thus, the infrastructure ratio is equal to:

$$k = \frac{k_{2023} + k_{2020} + k_{2013}}{3} = \frac{1\,530.7 + 1\,486.6 + 1\,450.2}{3} = 1\,491.8\ \frac{m^2}{person}$$

Next, we need to look at the actual ratio of population to infrastructure, which is calculated using the following formula:

$$B = \frac{N}{S_{inf}}$$

Where: B – the number of people per 1 m^2 of infrastructure.

In the case of Trostianets, the number of people per 1 m^2 of infrastructure:

$$B = \frac{7733}{11\,899\,000} = 0.0006\ \frac{person}{m^2}$$

The next step is to estimate the necessary infrastructure for the actual population. To do this, we will use the following formula:

$$S_{required} = k \times N_{actual}$$

Where:

- $S_{required}$ – the required area of infrastructure for the actual population (m^2),
- N_{actual} – actual population.

In the case of Trostyanets, the required area of infrastructure is for the actual population:

$$S_{required} = 1\,491.8 \times 7733 = 11\,536\,090\ m^2$$

The last step of this block is to estimate the required population for the actual infrastructure, which is calculated using the following formula:

$$N_{required} = \frac{S_{actual}}{k}$$

Where:

- $R_{required}$ – the required population for the size of the actual infrastructure,
- S_{actual} – the actual area of the infrastructure (m^2).

In the case of Trostianets the population is needed for the size of the actual infrastructure:

$$R_{required} = \frac{11\ 899\ 800}{1\ 491.8} = 7\ 976\ people$$

Infrastructure maintenance costs

Having examined the relationship between the demographic and infrastructure components, let's move on to the economic and infrastructure dimension - infrastructure maintenance costs. First, let's measure the standard costs of maintaining 1 m^2 of infrastructure:

$$C = \frac{C_{total}}{S_{ref}}$$

Where:

- C – costs per 1 m^2 of infrastructure (UAH/m^2),
- C_{total} – total costs of maintaining the entire infrastructure (UAH).

Now let's outline the actual costs of maintaining 1 m^2 of infrastructure:

$$C_{actual} = \frac{C_{total}}{S_{actual}}$$

Where:

- C_{actual} – costs per 1 m^2 of actual infrastructure (UAH/m^2),
- C_{total} – total costs of maintaining the entire infrastructure (UAH).

Next, let's determine the cost per person, taking into account the area per person:

$$C_{per\ person} = C_{actual} \times k$$

Where: $C_{per\ person}$ – infrastructure costs per person (UAH).

The next logical step to determine the total budget required for the actual population.

$$C_{required} = C_{per\ person} \times N_{fact}$$

Where:

- $C_{required}$ – the required budget for infrastructure maintenance for the new population (UAH).

Analysis of cost and population efficiency

Once you have the necessary budget for infrastructure maintenance and the actual infrastructure costs, you can assess whether current expenditures are in line with the needs using the classic formula:

$$\Delta C = C_{actual} - C_{required}$$

Where:

- ΔC – is the difference between actual expenses and required expenses (UAH),
- C_{actual} – actual infrastructure costs,
- $C_{required}$ – calculated the necessary costs.

If $\Delta C > 0$ → expenditures exceed what is needed (*overfunding*).

If $\Delta C < 0$ → spending is insufficient (budget deficit/infrastructure maintenance costs).

By the same token, it is necessary to estimate the optimal population size:

$$\Delta N = N_{actual} - N_{optimal}$$

Where:

- ΔN – the difference between the actual and optimal population size,
- N_{actual} – the actual population,
- $N_{optimal}$ – the optimal population size is calculated (according to local resources and economic efficiency).

If $\Delta N > 0$ → population is higher than optimal (possible *overpopulation* (including IDPs), lack of infrastructure).

If $\Delta N < 0$ → population is less than optimal (inefficient use of resources for infrastructure maintenance, outflow of able-bodied persons).

For Trostyanets, *given the available data*, the calculation will look like this:

$$\Delta N = 7733 - 7976 = -243$$

As $\Delta N < 0$, this means inefficient use of resources and an outflow of able-bodied people.

Assessment of the efficiency of infrastructure and financial resources

First, *it is important* to determine the infrastructure load index:

$$I_{load} = \frac{N_{actual}}{N_{optimal}} \times 100\%$$

Where:

- I_{load} – infrastructure load index,
- N_{actual} – the actual population,
- $N_{optimal}$ – optimal population for the existing infrastructure.

If $I_{load} > 100\%$, it means that the infrastructure is overloaded. If $I_{load} < 100\%$, the infrastructure is being used inefficiently.

In the case of Trostyanets, the calculation is as follows:

$$I_{load} = \frac{7733}{7976} \times 100\% = 97\%$$

The infrastructure utilization index is close to perfect, but the infrastructure is not currently being used as efficiently as it could be.

The next step is to determine the efficiency of actual infrastructure costs (costs per 1 m²):

$$E_{actual} = \frac{C_{actual}}{S_{inf}}$$

Where:

- E_{actual} – efficiency of actual infrastructure costs (UAH costs per 1 m^2),
- S_{inf} – total infrastructure area (m^2),
- C_{actual} – actual costs of infrastructure maintenance (UAH).

The higher the value, the more efficiently financial resources are used.

As well as the efficiency of the overall infrastructure maintenance costs:

$$E_{inf} = \frac{C_{total}}{S_{inf}}$$

Where:

- E_{inf} – efficiency of infrastructure costs (UAH costs per 1 m^2),
- S_{inf} – total infrastructure area (m^2),
- C_{total} – total infrastructure maintenance costs (UAH).

These calculations make it possible to calculate the capacity to maintain infrastructure:

$$Q_{inf} = \frac{E_{pop}}{C_{total}}$$

Where:

- Q_{inf} – index of the ability of the population to maintain infrastructure,
- E_{pop} – total economic contribution of the population (gross regional/local product, payment of taxes to the local budget) (UAH),
- C_{total} – total infrastructure maintenance costs (UAH).

If $Q_{inf} \geq 1$, then the population is able to maintain the infrastructure on its own, if $Q_{inf} < 1$, then the costs exceed the population's ability to maintain the infrastructure.

INTEGRATION AND PRACTICAL APPLICATION OF THE METHODOLOGY

Based on the analysis and empirical calculations for the Trostianets community, a universal model of urban development planning was created that reflects the systemic interdependence between three key parameters: population (N), economic capacity of the community (Y), and infrastructure provision (S). The model integrates demographic, economic, and spatial parameters to form the basis for decision-making on infrastructure development or reduction, adaptation of the city budget, and adjustment of the size of the community

Building a universal model

The model includes three interrelated blocks that form a closed cycle: the demographic and economic block, the economic and infrastructure block, and the infrastructure and demographic block.

Demographic and economic block

The first level of the model establishes the impact of population structure on the economic efficiency of a city. Gross income per capita (Y) is calculated as a function of the share of working-age population (P), the share of elderly people (A), and the area of infrastructure per capita (I):

$$Y = \beta_0 + \beta_1 P + \beta_2 A + \beta_3 I + \varepsilon$$

Where:

Y – GRP per capita,
P – the share of the working-age population (18-59 years old),
A – the share of elderly people (60+ years old),
I – infrastructure per capita (m^2/person).

β_0 – is a constant, or a basic level of GRP per capita that does not depend on demographic structure or infrastructure. This is a conditional initial level of income.

β_1 – the coefficient of influence of the working-age population (P) on income. It is expected to be positive: the more able-bodied people there are, the higher the productivity of the economy.

β_2 – the elderly impact coefficient (A).
It can be negative or slightly positive: an increase in the share of elderly people reduces the dynamism of the economy but sometimes increases due to pension transfers or assistance from abroad.
β_3 – the coefficient of impact of infrastructure area per capita (I).
Usually negative: if there is too much infrastructure (with a small population), its maintenance reduces economic efficiency.

The key conclusion is that an increase in the share of the working-age population increases GRP, while infrastructure growth without efficient use reduces it.

Economic and infrastructure block

At the second level, the model determines how much infrastructure a community can maintain given a certain population and income level:

$$S = \gamma_1 \cdot N + \gamma_2 \cdot Y + \gamma_3$$

Where:

S – the required area of infrastructure,
N – population,
Y – GRP per capita.

- γ_1 *– how much infrastructure is needed per person.*
  A typical standard is 900-1000 m²/person for small cities. This can be adjusted depending on the type of development.
- γ_2 *– the impact of income on infrastructure.*
  If income is high, the city can afford more space (more roads, parks, hospitals, etc.).
- γ_3 *– the basic amount of infrastructure that is needed even without reference to the number of people (e.g., a central square, city council, train station, etc.).*

Table 10. Values of GRP coefficients

Coefficient	Meaning	Units	Explanation
γ_1	1 100	m²/person	Standard for small cities
γ_2	0.00026	m²/UAH of income per capita	Impact of income (in UAH)
γ_3	150 000	m²	Basic infrastructure regardless of size

Note: data for calculation. Source: calculation result.

The key conclusion is that the larger the population and the higher the income, the more infrastructure a community can afford. But if incomes are low, excessive infrastructure leads to inefficient use of resources.

Infrastructure and demographic block

The third level of the model is the reverse. It shows how much population needs to be maintained to ensure efficient use of the existing infrastructure:

$$N = \frac{S}{I_{norm}}$$

Where I_{norm} is the standard area of infrastructure per person (for small cities ≈1 100 m²/person).

The key conclusion is that if the actual population is less than the amount needed to maintain the infrastructure, a budget deficit or inefficiency is created.

Interdependence of parameters and balance mechanism

All three blocks form **a closed logical cycle**:

$$(P, A, I) \Rightarrow Y \Rightarrow S \Rightarrow N \Rightarrow I \Rightarrow (P, A)$$

The demographic structure determines income.
Income shapes the limits of infrastructure capabilities.
Infrastructure requires a certain population.

Changes in population change the demographic structure.

Example 1 - Positive scenario:

The share of able-bodied people has increased (P) → Y has grown → the community has money for schools, hospitals, transportation (S is growing) → young families do not leave → the share of P remains high.

Example 2 - Negative scenario:

Population decreased → I increased (excessive infrastructure) → costs increased → budget cannot afford to maintain → infrastructure is destroyed → quality of life decreases → population decreases even more → vicious circle.

The table below shows an example of how the model works in a city administration

Table 11. Impact of model parameters on urban governance		
Parameter	**Affects**	**How?**
P – able-bodied population	Y – GRP	The more work, the more income
A – elderly people	Y – GRP	May reduce income, but stabilizes consumption
Y – income	S, B	Allows you to expand or reduce your infrastructure
S – infrastructure area	I, N	Determines how many people are needed to effectively maintain it
$I = \frac{S}{N}$	Y	Excessive infrastructure reduces efficiency
N – population	P, A	Forms the basis for the entire model

Note: data for use in city administration. Source: calculation result.

Integral efficiency coefficient and balance point of the urban system

For a comparative assessment of the feasibility of restoring different cities and regions after destruction, we propose a universal integral efficiency coefficient$K$, which combines three key indicators of urban development:

N – population (persons),
S – infrastructure area (m²),
Y – economic activity, such as gross regional product (UAH).

The formula for the integral coefficient is as follows:

$$K = \frac{Y}{S} \cdot \log(N)$$

Interpretation of the formula:

The $\frac{Y}{S}$ share reflects the productivity of the infrastructure: how much economic value is generated for each square meter.
The $\log(N)$ multiplier models the economies of scale: cities with larger populations have more consumers, employees, and taxpayers, but the logarithmic function smooths out the dominance of megacities.

This coefficient can be used to rank cities by their potential for effective recovery: the higher the K, the more benefits the city can bring after reconstruction, provided that the economic balance is maintained or restored.

For the actual values of Trostyanets

Population (N): 7 733 people
Infrastructure area (S): 11 899 000 m²
City area: 23,8 km²
GRP (Y): 796 500 000 UAH

Integral efficiency ratio: $K = 0.07750$

Graph of the balance of three factors and the "point of harmony"

In addition to cross-city comparisons, the proposed approach allows us to identify the internal equilibrium of parameters for one particular city. Such an analysis makes it possible to determine whether the population-infrastructure-economy system is in harmony or which of its components needs to be adjusted.

Input data:

N – actual population size,
S – existing or planned infrastructure area,
Y – total economic activity (e.g., GRP).

Algorithm for finding the "golden section":

1. Initial data collection: real values of population, infrastructure area, and GRP are collected for each community.
2. Normalization: to avoid the influence of the scale of the measurement units, each indicator is reduced to a relative value within that particular city. This can be achieved by bringing to the same scale (e.g., as a percentage) or by using a selected conversion factor.

$$N' = \frac{N}{\max(N)}, \qquad S' = \frac{S}{\max(S)}, \qquad Y' = \frac{Y}{\max(Y)}$$

3. Calculating the average value for each city:

$$\tilde{x} = \frac{N' + S' + Y'}{3}$$

This value is an imaginary "balance point" between the three parameters.

4. Estimating the deviation of each parameter from the average:

$$Deviation = \mid N' - \tilde{x} \mid + \mid S' - \tilde{x} \mid + \mid Y' - \tilde{x} \mid$$

5. Optimization: in the process of modelling, the value of one of the parameters (for example, the population size) is varied within a reasonable range to find the option at which the Deviation is minimal. This allows you to identify the optimal population size that provides a balance with the available resources of the community.

Calculation and visualization of balance and harmony point - balancing of aggregate indicators

Based on the normalized indicators, a 3D graph of the balance between population, infrastructure, and economy was created. The point of harmony (equilibrium of aggregate indicators) is defined as a configuration in which these three factors are in balance, and the city does not experience overload/underutilization of infrastructure space or deficit/surplus of economic activity.

As part of the study, a software simulation was carried out for the Trostianets community in the Python environment, which allowed us to numerically verify the compliance of key parameters. As a result of the simulation, it was found that the optimal point of harmony is achieved at the following normalized values of aggregate indicators:

$$N' = 0.00001, \qquad S' = 0.0145, \qquad Y' = 1.0$$

Average value:

$$\tilde{x} \approx 0.33554$$

Total deviation:

$$Deviation \approx 1.32893$$

These values do not ensure complete symmetry between the three factors, but this configuration has the lowest level of deviation, which indicates the most balanced model among all tested options, with such values of aggregate indicators:

Population: 11 500 people
Infrastructure area: 14 500 000 m²
(infrastructure per person 1 250 m²/person)
Gross regional product (GRP): ~1 billion UAH
(income per capita 85 000 UAH/person)

Thus, the optimal scenario for Trostyanets is to restore the population to about 11 500 people with an estimated GRP of 1 billion UAH and a total infrastructure area of 14 500 000 m², which ensures the effective functioning of the community system and stable economic dynamics.

Practical application

It is recommended to use the proposed coefficient K and the harmonization method as part of the decision-making system for the allocation of recovery resources. This allows:

identify cities with high productivity potential;
determine which parameters should be adjusted (for example, to attract new population or optimize infrastructure);
set targets for cities that are being rebuilt from scratch.

It is important to emphasize that the most important component of the methodology for assessing the feasibility of reconstruction of urban facilities is its actual application in decision-making. For this purpose, we propose a scenario planning model with different indicators Y, S, N. One of the last steps of the methodology is to find the point of equilibrium of the aggregate indicators Y, S, N and their respective values. By subtracting the found values of the balanced aggregate indicators from their actual values available in the territory, we will find the size of their deviation/change. Such deviations/changes with a "+" or "-" sign will indicate the need for further action according to the scenario plans:

1. Reduction in the amount of infrastructure due to a decrease in population or insufficient resources for its maintenance;
2. An increase in the amount of infrastructure due to an increase in the population or the amount of resources for its maintenance.
3. Increase in the number of population (primarily working-age population) through migration (including IDPs), reduction/prevention of mortality (primarily working-age population), maximization of the birth rate through investments in job creation and increase in economic turnover (GRP growth). This is partly possible by reducing the cost of maintaining redundant infrastructure and attracting financial resources from diversified sources.
4. Decrease in population because of inaction on the development of economic activity and lack of optimization of costs and the amount of infrastructure space in general.
5. An increase in economic activity, GRP, tax payments, investments in job creation, and non-productive sector expenditures in the community will ensure the ability to maintain and develop/modernize the infrastructure of the territory and the growth of the population (primarily the working population).
6. A decline in economic activity (due to inactivity or incorrect/inefficient use of financial resources) will require immediate optimization of the scope and purpose of infrastructure to reduce the cost of its maintenance and will lead to a decrease in population (migration, non-births, and increased mortality among the working (!) population).

Thus, the proposed model not only aggregates key development indicators and enables informed reconstruction of facilities for communities across Ukraine but also provides a meaningful and econometric logic for managing post-war reconstruction.

Adaptation for different city scales

The proposed model is recommended to be integrated into digital urban management systems (dashboard solutions), for:

Ranking of settlements by their potential for effective recovery;
Determining which indicators should be adjusted (e.g., community engagement or infrastructure optimization);
Setting targets for new or regenerating cities;
Developing long-term budget and spatial strategies.

The model allows for scaling-up – it is adapted for:

small towns (up to 10 thousand inhabitants) - with an emphasis on the area of infrastructure;
medium-sized cities (10-100 thousand) - using industry standards;
large agglomerations - through aggregate indices of infrastructure quality.

CONCLUSIONS AND RECOMMENDATIONS

The issue of reconstruction of urban objects has been studied by Ukrainian and foreign scientists. Researchers, mostly architectural or planning, began to pay special attention to this problem in the context of post-war reconstruction, so the rapid development of various scientific schools fell on the 1950s-1970s. Later, research also focused on the problem of preserving historical monuments as part of the urban environment, and later, with the advent of new construction technologies and a general rethinking of the concept of the city and well-being, a new stage in research on the reconstruction of urban objects began. Foreign studies mainly paid attention to the problems of the regional impact of aging, the economic features of the development of cities and territories, especially in the context of agglomerations and population growth, as well as the search for a model for calculating the optimal size of the city and the optimal number of people. In Ukraine, scientific developments were focused more on the preservation of historical monuments, the restoration or rethinking of residential buildings, and the problems of architectural and planning documents and their implementation. At the same time, an analysis of the scientific literature has shown that despite the large number of models for assessing various components of the urban environment and urban objects, **a description of a generalized methodology for assessing the reasonability of reconstructing urban objects could not be found in the scientific literature**.

This prompted us to design our own methodology for assessing the reasonability of reconstructing urban objects. The methodology is based on the combination and integration of indicators from three key areas of the city's life: demographic, economic and infrastructure. The first and very important step of the Methodology is the collection and preparation of data on the territory of a settlement or community in three sectors: 1) demography (number, dynamics, age clustering); 2) infrastructure area; 3) economy (gross regional/local product). The next second step is to use the Methodology, its logic and econometric formulas to calculate data, indicators and indices. In the process of applying methodological recommendations, the process of forming and calculating the relevant integrated models is carried out: 1) Demographic balance of the territory; 2) Assessment of the regional impact of aging; 3) Dynamics of gross regional product; 4) Multiplier of employment of the working population; 5) The optimal size of the city's population from an econometric perspective; 6) Per capita income depending on the age structure of the population; 7) The size of the infrastructure for the territory of the community/settlement depending on the number of population and the costs of its maintenance; 8) Assessment of the efficiency of the use of infrastructure and financial resources; 9) Its maintenance capacity.

After that, it is necessary to calculate the aggregated indicators. The main aggregated indicators calculated at this stage are the balance of impacts:

1) Economic-demographic "Y". The balance of the volume of gross regional and, accordingly, local product in relation to the population of the territory, which is necessary to understand the economic and tax capacity of the community/settlement;

2) Infrastructural-economic "S". The balance of the area of the infrastructure of the community/settlement (municipal, transport, public service, etc.) in comparison with the capacity of the community to maintain it;

3) Demographic-infrastructural "N". The balance of the population of the territory, its age structure (to distinguish the number of working-age population), as well as the dynamics of migration (considering the number of IDPs) in comparison with the infrastructure necessary to meet its needs.

The next step is to find the equilibrium point of the aggregated indicators Y, S, N and their corresponding values. By subtracting the found values of the equilibrium aggregated indicators from their actual values available at the given territory, we will find the size of their deviation/change. Such deviations/changes with the sign "+" or "-" will indicate to us the need for further actions according to different scenario plans.

The developed methodology for assessing the reasonability of reconstructing urban objects can become the basis of an innovative urban planning model that forms a holistic logic of community and regional management in the post-war period. It will allow identifying the strengths and weaknesses of territorial systems and serves as a tool for data-based decision-making. With its help, it is possible to design not only reconstruction in Ukraine, but also territorial modernization for the long-term sustainability of Ukrainian cities in the context of the socio-economic challenges of the 21st century.

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