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# МЕТОДИЧНІ ПІДХОДИ ДО ОЦІНКИ ОБ'ЄКТІВ ЗЕЛЕНОЇ ІНФРАСТРУКТУРИ МІСЬКИХ ЕКОСИСТЕМ

***Актуальність.*** *Дослідження стану розвитку міського господарства доводить наявність екологічних проблем та необхідність переходу на принципи екологоорієнтованого управління, зокрема, впровадження дієвих заходів екологічного та соціального спрямування та збільшення об'єктів зеленої інфраструктури для забезпечення оптимальності розвитку сучасних міст. Це передбачає зміну існуючих управлінських підходів на нові концепції, що забезпечуватимуть збалансований та стійкий розвиток урбанізованих територій.*

***Мета дослідження*** *Мета дослідження полягає в обґрунтуванні методологічних підходів до оцінювання об`єктів зеленої інфраструктури урбоекосистем на основі екосистемного та поліфункціонального підходів та завдань сталого розвитку.*

***Матеріали та методи.*** *Матеріали статті базуються на узагальненні та систематизації вітчизняних та закордонних наукових досліджень .В дослідженні використано такі методи: системно-структурний аналіз; порівняльний аналіз; метод синтезу знань, абстрагування та аналогії, оптимізації.*

***Результати.*** *У статті автори обґрунтовують думку, що результати оцінювання екосистемних функцій зеленої інфраструктури міської екосистеми повинні відображати економічні, екологічні та соціальні наслідки її використання та невикористання. Врахування екосистемних функцій в економічній оцінці – це можливість забезпечити прийняття екологічно орієнтованих рішень при обґрунтуванні окремих проєктів і програм розвитку: чим вище значення оцінки, тим більше шансів, що проєкти враховуватимуть екологічні пріоритети, впровадження ресурсозберігаючих технологій, забезпечення комплексного використання природних ресурсів, підвищення потенціалу зеленої інфраструктури. Соціальна цінність визначається потенціалом життєзабезпечення та засобів до існування, культурною, історичною, естетичною цінністю певної території, значенням у формуванні основних територій міста. Або, іншими словами, визначається потенційною можливістю забезпечити рекреацію, відтворення життєвих сил в екологічно сприятливих умовах. Водночас це інвестиційна привабливість певної території, формування сприятливого мікроклімату. Екологічна цінність зеленої інфраструктури визначається потенційними можливостями екосистем до відновлення та забезпечення регуляторних і підтримуючих екосистемних послуг.*

***Висновки.*** *Розвиток методології оцінювання зеленої інфраструктури має відбуватись з розумінням зростаючої ролі екологічного чинника для сталого розвитку міст. Тому необхідно розробити оціночні показники, які відображали б соціо-еколого-економічну цінність зеленої інфраструктури та соціо-еколого-економічний ефект від її створення та функціонування, ефективності освоєння природних ресурсів в різних сферах використання для вибору оптимального варіанту, оскільки вважаємо, що економічна оцінка природних ресурсів має безперечний вплив на прийняття управлінських рішень щодо їх використання, а отже, формування комфортних умов життєдіяльності населення міст, обґрунтування екологоорієнтованих програм розвитку міст загалом.*

***Ключові слова:*** *природні активи, зелена інфраструктура, урбоекосистема, екосистемні послуги, економічна вартість, управлінські рішення.*

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# METHODICAL APPROACHES TO ASSESSING GREEN INFRASTRUCTURE FACILITIES OF URBAN ECOSYSTEMS

***Topicality.*** *The study of the urban economy development state proves the existence of environmental problems and the need to transition to the principles of environmentally-oriented management, in particular, the implementation of effective environmental and social measures and the increase of green infrastructure facilities to ensure the optimal development of modern cities. This transition suggests changing existing management approaches to new concepts that will ensure balanced and sustainable development of urban areas.*

***Aim and tasks.*** *The aim of the study is to substantiate urban ecosystem`s green infrastructure facilities assessment methodological approaches based on ecosystemic and multifunctional principals and tasks of sustainable development.*

***Materials and Methods.*** *The materials of the article are based on the generalization and systematization of domestic and foreign scientific research. In the research were used the following methods: system-structural analysis; comparative analysis; method of knowledge synthesis, abstraction and analogy, optimization.*

***Research results.*** *The author's position is that the assessing ecosystem functions results of the urban ecosystem`s green infrastructure should reflect the economic, ecological and social effects of its use and non-use. Taking into account ecosystem functions in the economic evaluation is an opportunity to ensure the adoption of environmentally-oriented decisions while justifying individual projects and development programs: the higher the value of the evaluation then greater the chances that the projects will take into account ecological priorities, implement resource-saving technologies, ensure the integrated use of natural resources, and increase the potential of green infrastructure. Social value is determined by the potential of life support and livelihood, the cultural, historical, aesthetic values of a certain territory, the importance in the formation of the city main areas. Or, in other words, it is determined by the potential opportunity to provide recreation, reproduction of life forces in ecologically favorable conditions. At the same time, it is the investment attractiveness of a certain area, the formation of a favorable microclimate. The ecological value of green infrastructure is determined by the potential opportunities of ecological systems for restoration and ensuring of regulatory and supporting ecosystem services.*

***Conclusion.*** *The development of the green infrastructure assessment methodology should take place with an understanding of the environmental factor growing role for the city's sustainable development. Therefore, it is necessary to develop evaluation indicators that would reflect the socio-ecological-economic value of green infrastructure and the socio-ecological-economic effect of its creation and operation, the reclaim efficiency of natural resources in various areas of use for choosing the optimal option, since we believe that the natural resources economic evaluation has an undeniable influence on decision-making management regarding their use, and therefore, the formation of comfortable living conditions for the cities population, the substantiation of ecologically oriented programs of urban development in general.*

***Keywords:*** *natural assets, green infrastructure, urban ecosystem, ecosystem services, economic value, management decisions.*

**Problem statement and its connection with important scientific and practical tasks.** Based on the processes study that take place in the field of urban economy, it can be concluded that the transition to environmentally-oriented management should be accompanied by effective measures of ecological and social direction to ensure the development optimality and avoid the interest's inconsistency regarding the use of natural objects that arise between city stakeholders. This can be achieved through an environmentally-oriented structural realignment of their interaction and a change in funding priorities from the city budget, which suggests investing in environmentally safe technologies, financing preclusive measures to protect the environment to prevent its further degradation, structural changes in the city's system of nature and resource use, forecasting changes in

the quality of the urban environment as a result of changes in the social, production, infrastructure load. This transition suggests to change existing management approaches to new concepts that will ensure balanced and sustainable development of urban areas (Popyk, O.V., Khumarova, N.I., 2019; Cherchyk, L.M., Khumarova, N.I., 2022; Cherchyk, L.M., Khumarova, N.I., 2023).

**Analysis of recent publications on the problem.** Economic evaluation is a traditional component of the market mechanism, which is an attribute of the relationship between its subjects. In the system of economic relations, each of the subjects through their own activities not only contributes to the development of natural resources and conditions economic assessments, but also forms and uses certain tools that either provide assessment or allow these assessments to be taken into account in business practice: the state collects taxes, resource owners determine the amount of rent, intermediaries justify the amount of transaction costs, nature users – the expediency of natural resources development and use, determining the impact of the resources value on financial results. Thus, there is an urgent practical need for economic evaluation and theoretical-methodological substantiation of the natural resources assessment peculiarities for certain types in general, and cities natural resources in particular.

The public need to assess the natural resources qualitative and quantitative characteristics of cities is to determine the optimal ways of their use in the city community`s interests.

We will consider the emphasis made by scientists on the essence of the natural resources economic evaluation to substantiate methodological approaches of the urban ecosystems green infrastructure facilities assessment:

- "this is a monetary expression of the natural resources economic value, which is determined by the effectiveness of their reproduction (protection and reproduction of ecological systems, exploitation and processing of natural substances) and is used in connection with the need to take into account the influence of the natural factor on the efficiency of production, stimulation of rational use and protection natural resources" (Danylyshyn, B.M. et al., 1999, p.103);
- determined by the specificity of the consumer natural resources value, which is interpreted, on the one hand, as utility, on the other hand, as a carrier of value and a material element of wealth. And for resources to become a consumer value, there is a public demand for them (Mamutov, V.K. et al., 1992, p.67);
- "the essential basis of the natural resources assessment is the category of value, which reflects the real relations of man with the surrounding world, the properties of its elements to satisfy certain human needs. Needs act as a subjective factor of value, real properties of the assessment object are objective" (Cherchyk, L.M., 2014);
- "the economic assessment of natural recreational resources is reflected in monetary terms of their value in certain socio-economic conditions, modes of nature management, permissible social, ecological, technical restrictions on recreational and other activities types. The assessment should reflect the consumer properties of these resources, the ecological and social effect of their use" (Cherchyk, L.M., 2014).

Economic evaluation classic approaches are rent, cost, result, and opportunity cost. At the core of the cost concept is the provision that the resources cost estimation depends on the actual costs of their development, maintenance in normal operating condition and restoration. The resulting evaluation method suggests accounting for the consumer properties of natural resources, that is, their ability to satisfy certain needs: the value of a natural good (that is, the ability of a conditional unit to satisfy one or another need), or an economic assessment of its substitutability (that is, at what price can the lack of a given resource be compensated for by using other resources or capital). The rent approach is based on the concept of the differential rent existence.

In addition to the classic approaches, new ones are becoming widespread, the main are: the method of comparative sales, which is based on the comparison of data on current sales of similar plots; transfer method, when the total sale price is divided into the value of the plot itself and the cost of improvements (buildings, landscaping); method of extraction, i.e. assessment and allocation of the improvements contribution value o from the agreements` results; direct capitalization of land rent or its variant is a residual method that supposes discounting the flow of net operating income that accrues to the land plot into the current cost price (Cherchyk, L.M., 2014).

In our opinion, the perceived usefulness of a certain natural good should be an important and starting point. It is perceived usefulness that is a measure of the natural resources value (price). We consider the concept of perceived usefulness from the standpoint of social, ecological, economic, and institutional changes. The essence of these institutional changes, first of all, boils down to the need of form new value priorities in people. In

particular, this is a departure from the anthropocentric model of existence and development, recognition of the priority of ecological safety, a healthy lifestyle, taking care not only of physical, but also of spiritual health, the maintenance of which is possible under the organic unity condition with the natural environment and its comfortable conditions; acceptance of the mankinds collective responsibility idea for the biosphere preservation; refusal, as from the main slogan of economic development – satisfaction of ever-increasing consumer needs.

From the complexity`s point of view the approach to the assessment of nature attempts the concept of total economic value is the most promising and take into account not only its direct resource functions, but also assimilation functions and natural services. The value of the total economic value is the sum of two indicators – the value of use (consumer price) and the value of non-use.

**Allocation of previously unsolved parts of the general problem.** From the point of view of the complexity approach to the assessment of nature, it is necessary to take into account not only its direct resource functions, but also assimilation functions and natural (ecosystem) services, which requires the application of the total economic value concept. Despite the significant potential of the natural resources economic assessment methods, methodological provisions regarding the formation of relevant methods the cities green infrastructure assessment demand development, which requires further scientific research.

**Formulation of research objectives (problem statement).** The aim of the study is to substantiate methodological approaches of urban ecosystem`s green infrastructure facilities assessment.

In order to realize the set aim, it is necessary to perform the following tasks: study and generalize the existing prerequisites and methodological approaches to the evaluation of urban ecosystems green infrastructure facilities; to substantiate methodological approaches to the urban ecosystem`s green infrastructure facilities assessment relevant to the domestic practice of urban economy and construction.

**Materials and Methods.** The following methods were used in the study of green infrastructure assessment methodological basics: system-structural analysis, which allowed to comprehensively consider the use of green infrastructure facilities; comparative analysis was used to determine approaches to the economic evaluation of ecosystem services and natural infrastructure facilities, methods of knowledge synthesis, abstraction and analogy – to substantiate the indicators and tools for assessing green infrastructure. The materials of the article are based on the generalization and systematization of domestic and foreign scientific research.

**An outline of the main results and their justification.**

*Green infrastructure of urban ecosystems as an object of assessment.* The growing importance of cities and the general pace of urbanization in the modern world is an objective consequence of globalization phenomena, socio-demographic processes and fundamental transformational changes in the structure of social development.

This has led to a severe limitation and scarcity of land resources in cities, which causes the transformation of land into the most valuable asset. This led to the intensification of semi-legitimate and illegitimate processes of land plots privatization in cities, including change in the intended use of public use objects (city forests, parks, squares, beaches, squares, etc.) on unreasonable terms and at unacceptably low prices. Natural areas and city facilities, which we consider as green infrastructure, are the first to suffer from urban development.

In this context, one of the important city management components is the determination of the such territories status, assessment of their condition, value assessment for the formation of strategically and tactically justified management decisions. This involves determining the parameters of the local territorial units state, identifying for the purposes of assessment existing methodological approaches, identifying the most relevant in each individual case.

The need for improvement and development of methodological approaches to the assessment of green infrastructure is determined by a number of factors, in particular:

- lack of a unified system for determining the status of green infrastructure facilities of municipal territorial communities;
- the high dynamism of changes in the quality of the natural components of the urbanized environment and the economic conditions of society's existence;
- insufficiently regulated spatial development of cities and intra-system zoning and zoning of cities;
- the lack of an ecosystem approach to the procedure for assessing the parameters of the state of urbanized territories (Popyk O.V., Khumarova N.I., 2019; Cherchyk L.M., Khumarova N.I.,

2023).

The green infrastructure of urban ecosystems is a complex object of assessment from several positions, which are reflected in the author's classification of its elements:

- by origin – natural (natural forest areas, swamps, rivers, lakes, seacoast), artificially created (parks, squares, plantings, forest strips, ponds, reservoirs, fountains, lawns, green walls and roofs, permeable pavements and road surfaces);
- according to the specifics of use – special or direct purpose (water protection, water regulation, soil protection, dust protection, recreational etc. areas), general or indirect use and impact (natural territories (forests, wetlands) for biodiversity conservation, carbon deposition, climate regulation);
- according to the functional purpose – recreational and health (natural objects where you can rest, get healthy, develop physically and spiritually), cognitive (arboretums, botanical gardens, other natural attractions and unique natural objects where a person can improve its level of knowledge in the field of natural sciences and nature protection), utilitarian (floristic resources, garden and country plots, forest plots where you can be engaged in amateur crafts), sports;
- by component structure – water, forest, mountain, steppe, swamp, botanical, general zoological, ornithological, entomological, ichthyological, general geological, paleontological and karst speleological, etc., landscape and technogenic complexes, agrolandscapes; informational (digital);
- by administrative-spatial feature – local, regional, national, international;
- by level of uniqueness: typical, unique (innovative);
- according to terms of use – seasonal, short- and long-term use;
- according to the criterion of accessibility – well accessible, accessible, difficult to access;
- by degree of mastery: mastered, poorly mastered, unmastered;
- according to the level of degradation – not disturbed (not changed), cultivated, anthropogenically changed, disturbed (possible restoration), denaturalized, degraded;
- according to the ability to reproduce – capable of self-reproduction; not capable of self-reproduction, renewable, non-renewable;
- by status: resources of the nature reserve fund, health resort and recreation areas.

So, the main characteristics of green infrastructure facilities are:

- multifunctional purpose;
- functioning in two forms – material and value;
- territorial determination and localization;
- relative preservation of natural form and properties;
- uniqueness of each object and territory;
- formation of consumer value under the influence of natural factors and human labor;
- availability of investment value;
- provision of physiological, social, intellectual, cognitive, cultural and aesthetic needs of a person;
- low price elasticity, long-term use of the same resource, territory and the ability to serve as a basis for the formation of various services;
- different effects of consumption (use) for different purposes (Cherchyk L.M., Khumarova N.I., 2023).

So, green infrastructure facilities have a number of features: they are stationary, non-transportable, have features in their creation and functioning, require maintenance, and ensure appropriate conditions of use. That is, the formation, maintenance in proper condition and use requires funding (investment, operating), which can be multivariate with significant seasonal fluctuations in volumes.

Facilities of green infrastructure are closely related to the land, most of them are dynamic in their development, therefore they have the increasing value attribute. Factors such as the shortage of land plots in cities, antagonism of interests in their use, and inflationary processes also affect the increase in value. That is, they are attractive for investment and can be considered as an investment object that brings income.

The above allows considering green infrastructure as the urban household natural assets with all prerequisites and consequences (such as reflection in General development plans, development strategies, plans and projects, accounting in municipal accounts, distribution of responsibility for creation, operation, restoration, etc.), which will be directly revealed on the green infrastructure system management (Cherchyk L.M., Khumarova N.I., 2023).

Elements of the urban ecosystem`s green infrastructure as assessment facilities should be:

- clearly defined in the city space;
- have a specified owner/owners;
- have organizational, territorial affiliation and subordination, in particular, stand on the balance sheet of the relevant communal service;
- for each element (object of green infrastructure), accounts of operating expenses

must be kept, which will be taken into account in their cost, which will change with the change of qualities and characteristics.

In general, the composition of green infrastructure facilities includes natural objects of the green frame of the city and other urban subsystems. The main facilities of green infrastructure, which are actively used in practice today, are: city forests, squares, groves, parks; wetlands (natural and artificial); green and blue roofs; waterproof coverings of sidewalks, roads, basketball courts, parking lots; rain gardens; bioworlds; green alleys; green school yards; ecoducts (green corridors that ensure the movement of living organisms and preserve biodiversity) (Cherchyk L.M., Khumarova N.I., 2023).

The complexity of the assessment lies in the determining possibilities / impossibility of the value of most green infrastructure facilities due to their multifunctionality. If these functions are consciously perceived as a need that creates demand, as a value that is consumed, then they should be evaluated as ecosystem services (Golikova, O.S., 2021).

Ambiguity in the perception of cities natural resources determines the expediency of considering different approaches to their assessment and forms of representation in such formalized documents as property registers, balance sheets, territory passports, cadastres etc.

*Authors suggestions regarding the assessment of green infrastructure facilities of urban ecosystems.* As pointed out by Costanza R. et al. (1997), all ecosystem services are free because people do not pay for their use or consumption. Part of such services can be monetized, that is, evaluated in monetary terms. For example, the total value of forest products and services consumed by people during the year, according to a group of American researchers, is 4.7 trillion dollars.

This assumption has now acquired a powerful development. A review of literary sources shows that in practice the economic evaluation of natural resources is used for those types of them where there are appropriate markets, and a market price is formed. In particular, Daily G. et al. (2009) focuses on the such advantages of local markets for ecosystem services as relatively better definition, distribution transparency of the benefits and payments, which leads to more optimal "cost-benefit" schemes for organizing ecosystem services payments, which makes it possible to evaluate services as close as possible to their marginal value.

Green infrastructure facilities of urban ecosystems mainly perform ecosystem functions, in particular regulatory, supporting and recreational, which are evaluated depending on how valuable they are considered. There is no, and probably cannot be, a single method that would allow to estimate the economic value of ecosystem services. However, an economic evaluation of the city's ecosystem functions is necessary to ensure their tireless use and prevent degradation and loss of recreational services (attractions) (Vernihorova, N.V., 2023).

The study of methodological approaches to the assessment of natural resources allows us to conclude that they can be used locally to a large extent to assess the cities green infrastructure facilities, taking into account their specification, features of the location, purpose, priority functions they perform.

In fact, this vision is implemented in the methods developed in a number of programs and projects for the development of green infrastructure in different countries of the world. At the same time, different variations of assessment of ecosystem functions of green infrastructure were used. Note that quite often the ability to provide ecosystem services is a criterion for classifying certain natural objects as green infrastructure (Baral, H. et al., 2014; Bhatta, L.D. et al., 2015; Chaudhary, S. et al., 2015).

When forming the concept of green infrastructure and in the practice of assessment the elements of green infrastructure, *a problem-target approach* was used, since the development projects of the city`s green infrastructure were designed to solve specific problems through the use of non-traditional technologies, which involved the creation of natural and anthropogenic facilities instead of artificial technical solutions.

First of all, we are talking about utilitarian projects of stormwater management, filtering wastewater from the roofs of buildings and streets. It was designed to solve this problem of floods and water pollution that rain gardens and alleys, bioworlds were created as an alternative to waterproof surfaces and water channels made of concrete or asphalt, construction of wastewater collection and treatment systems.

In this case, for the assessment of green infrastructure facilities, it is advisable to apply the specified approach and evaluate their ability to solve the problems of stormwater management and wastewater treatment.

The cost of green infrastructure facilities can be defined as the sum of investment and operating costs (cost approach using direct calculation

methods of the project estimated cost and current costs of use throughout the entire life cycle).

Another example is the use of existing natural facilities of green infrastructure – wetlands for the same purpose – stormwater management and wastewater treatment. Here you can focus on a limited list of regulatory ecosystem services, neglecting, cultural and aesthetic ones.

It is the problem-target approach and cost-effective methods that have practical application for determining the book value of green infrastructure facilities. However, most of the cities green infrastructure facilities are characterized by multifunctionality. For example, parks, urban forests, everything that is included in the green zone of cities, covering all natural areas and water bodies, are not just fed by stormwater, but also provide natural cleaning of stormwater (natural filtering), form water reserves for urban water supply, purify air, absorb excess moisture, heat, that is, form a more favorable microclimate. At the same time, these are recreational zones and territories for the biodiversity preservation. Therefore, we consider it incorrect to use the previous approach for their assessment. The creation of a multifunctional urban eco-environment provides an appropriate *multifunctional approach* using the method of assessing the total economic value. The assessment of all the main functions is necessary to determine the optimal areas of green areas and their types, where their purpose would be reflected. This is of practical importance for the projects` substantiation of cities territorial development and reflection in the its General Plan.

With such an assessment, it is necessary to take into account the population to determine the load on green areas, so as not to deteriorate their condition over time and ensure accessibility for residents and guests of cities. At the same time, a significant part of them should be preserved in a relatively "wild" state in order to preserve biodiversity, perform regulatory and supporting ecosystem services.

In this case, it is possible to apply assessment methods used in landscape planning and assessment methods for individual ecosystem services. There are examples of the use of methods for assessing the total economic value of the community's benefits from the conservation of nature-protected areas and the assessment of ecological services of nature-protected areas.

The application of methods for assessing the total economic value is also relevant for the assessment of the recreational function of spacious green areas. This is mainly an assessment of the cost of living using indirect assessment tools based on a survey of the population about their willingness to pay for attractions.

Currently, the methods of assessing the total economic value have been transformed into methodical approaches to the assessment of ecosystem services of various natural territories and facilities.

We consider the city as a complex environment with intensive flows of matter, energy and information that determine the nature of human interaction with the surrounding environment. In the conditions of existing urban ecosystems, there is a significant weakening of regulatory and supporting ecosystem services due to the artificial origin of the urban ecosystems and, as a result, a significant weakening of self-regulatory mechanisms for restoring the quality conditions of the city`s natural component. At the same time, cultural ecosystem services are characterized by a sufficient potential and grade of realization due to the fact that the source of their origin is a person, as an active agent of the creating process for urbanized environment. The task of green infrastructure development is to create an environment that would ensure the realization of all ecosystem services groups (Popyk O.V., Khumarova N.I., 2019).

In our opinion, to evaluate the ecosystem services of the city’s green infrastructure, by analogy with the evaluation of the total economic value, it is advisable to use methods of cost evaluation. Only on their basis can reasonable management decisions be made regarding the selection of optimal options for their use, distribution of city budget funds, feasibility of investment, establishment of lease payments, concession, charging of fines and compensations for deterioration of green infrastructure conditions.

In particular, for many elements of green infrastructure, their ecosystem services can be estimated as the value of the predicted loss from not receiving them, i.e. using various cost methods: replacement costs, restoration costs.

The method of benefits transfer or the method of analogies can be used if there is an artificial or natural counterpart with a defined value for ecosystem services and their effects.

For most ecosystem services of green infrastructure, the method of subjective benefits remains relevant, which allows taking into account the cost of non-use or passive use. The population of cities is quite well acquainted with environmental problems and the functions of ecosystems, so they are able to assess them adequately.

For the official transfer of green zones and other natural or natural-anthropogenic territories (objects) to the city's green infrastructure, a *normative approach* should be used, as well as for the average assessment of their value as a reference for establishing the book value, for project evaluation, for investors, for insurance. This is also important in the context of ensuring investment activity in green infrastructure. Normative monetary evaluation and assessment of the investment attractiveness of green infrastructure is necessary for the selection of promising directions and investments expediency.

The potential opportunity to increase the value of land in general, urban land in particular, is related to their limitation, growth in demand, deterioration of the environment quality and the state of people health, growth in the need for recreation, health, development, mobility of the land use system, inflationary processes. Therefore, green infrastructure can be considered as an attractive object for investment. The latter determines the need to take into account various combinations of legal rights and interests, in particular, from the standpoint of use forms (purchase, lease), restrictions and encumbrances, distribution of rights to airspace, subsoil, and land plots. These nuances determine the peculiarities of taxation and to a large extent affect the possibilities of receiving income, and therefore, investment activity.

Also, one of the popular assessment tools in the system of environmental quality management and risk management is natural resource insurance, which is advisable to use for the assessment of green infrastructure facilities. This is a specific system of redistributive relations in the process of ensuring continuous economic activity and human well-being through insurance protection against losses associated with the irrational use of natural resources, as well as against the loss of their consumer values, etc. (Kharichkov, S.K. ed., 2012).

In the context of a theoretical and methodological basis formation for the assessment of green infrastructure, it is advisable to distinguish two options:

1) comprehensive assessment of green infrastructure, taking into account all ecosystem services that are provided and may be provided in the future;

2) local assessment of individual green infrastructure facilities in the context of obtaining certain (specific) ecosystem services.

Both options are important, but the second has more applied value.

The first option ensures the definition (establishment) of the "green stock of the city" based on the accounting and assessment of all ecosystem services of the city's green infrastructure.

Most often, the reason for using the second option can be the city`s environmental problems and the possibility of solving them by creating green infrastructure facilities. Accounting and balance sheets of the owners is carried out according to the book value of the green infrastructure facilities. This is a dynamic type of assessment, as the value indicators will change over time due to the need to take into account additional investments for the new projects implementation to create the green infrastructure facilities or improve the existing ones.

In order to evaluate explicit ecosystem services, costly methods are used, and to substantiate the feasibility of green infrastructure use for implicit ecosystem services, the method of analogies or conditional methods can be used, for which it is necessary to collect data on the advantages of alternative options, their inclusiveness, perception by the city community and their willingness to pay for these services.

When developing a specific methodology for green infrastructure facilities assessment, we recommend taking one of the following approaches:

- *targeted,* when the assessment of those ecosystem services that match the main goals of creating green infrastructure facilities (project goals) is carried out;
- *functional,* when the ecosystem services of green infrastructure facilities are evaluated, which provide certain defined functions, but without worsening other effects;
- *synergistic*, in which all ecosystem services of the city's green infrastructure are assessed according to the principle of cumulative effects;
- *behavioral,* when the evaluation of green infrastructure`s ecosystem services are carried out from the position of a certain group of city stakeholders or according to the preferences of the main services consumers groups of green infrastructure facilities (controversiality of both green infrastructure and ecosystem services is taken into account).

To evaluate the ecosystem services of green infrastructure facilities, their classification proposed in the UN program "Millennium Ecosystem Assessment": 1) provisioning, 2) regulating, 3) cultural, 4) supporting services (Millennium Ecosystem Assessment 2005).

A summary of the green infrastructure facilities ecosystem services and their assessment methods is shown in work (Cherchyk, L.M., 2022). In particular, it presents the main regulatory functions of the city's green infrastructure and ecosystem maintenance functions. Cultural, aesthetic, recreational, landscape ecosystem services of green infrastructure facilities can be evaluated by applying the above-mentioned methods, as well as methods of travel costs, hedonic pricing, conditional evaluation.

In our opinion, such an approach allows for a reasoned approach to the assessment of green infrastructure facilities, which will allow making informed management decisions for the implementation of real steps on the way to develop green city zones, a modern concept that is very relevant for the reconstruction of Ukrainian cities in the post-war period.

***Discussion.*** To develop the fundamental principles of the value criterion base formation and approaches to the assessment of the urban ecosystems green infrastructure, the well-known concepts of social development were adopted:

- *The concept of sustainable development*, which is based on the awareness of the inseparability principle and unity of the society environment and socio-economic development (WCED, 1987).
- *The concept of econology*, which provides for ensuring the balanced development of economic and ecological systems in conditions of accelerating the rate of natural resource potential development (Burkynskyi B.V. eds., 1995).
- *The concept of eco-innovative development*, which is based on several key provisions: in any type of nature-transforming activity, the problem of the living nature equilibrium comes to the fore, therefore eco-innovative development foresees such a level of man-made influence that preserves ecosystems` the adaptive, self-regenerating and self-organizing functions (Nikolayev, Y.O., 2005).
- *The concept of a green economy*, proposed in the context of the "Agenda for the 21st century" implementation and is based on three main principles: assessment and promotion of the preservation potential of ecosystem services at both the national and international levels; ensuring the employment of the population through the creation of "green" jobs and the development of appropriate policies; the use of market mechanisms to increase economic competitiveness, attract innovations and investments (Tilman, A., Assmann, C., 2017; UNEP, 2018).

Global development strategies and their implementation in normative acts and government resolutions of Ukraine became the impetus for research:

- Strategic agenda for water protection and building more livable communities through green infrastructure and selection of green infrastructure partner communities (EPA, 2011);
- Biodiversity Conservation Strategy until 2020 (adopted in 2011 by the EU member states), the main positions of which were the support and improvement of ecosystem services, restoration of degraded ecosystems due to the inclusion of green infrastructure in territorial planning. The main goal is to preserve biodiversity in the EU (Europian Commision, 2011);
- The "Green Print Maryland" program was developed with the aim of creating a single ecological network of territories, preserving an extensive interconnected network of lands vital for the long-term protection of the state's natural resources, in coordination with other initiatives (Weber, T. et al., 2006).

The European Commission's report "Supporting the implementation of green infrastructure" defines the following tasks:

- ensuring more effective promotion of green infrastructure at all levels;
- capacity building, training, education for green infrastructure;
- improvement of information exchange mechanisms;
- assessment of technical standards and innovative possibilities;
- assessment of costs and benefits.

In many countries, criteria and guidelines have been developed to support a more effective integration of green areas into urban planning and development. In particular, the European Commission has clearly established what refers to public green areas of the city, and proposed the following criteria:

- area of green areas in the city: not less than 9 $m^2$ per capita (up to 50 $m^2$ per capita is recommended);
- accessibility: within 300 m of a green zone with an area of at least 0.5 ha;
- quality: high level of biodiversity (Europian Commision, Directorate-General for Environment, 2016).

Note that there is international experience in green infrastructure assessment:

- a methodology for municipal General plans assessment is aimed at identifying and developing regional green infrastructure in the context of four components: natural value, environmental value, landscape value and

recreational value. Tested on materials from the city of Cagliari, Italy (Lai, S. et al., 2019);

- development of the Maryland Department of Natural Resources assessment of Maryland's green infrastructure to identify and rank areas of greatest ecological importance to the entire state and at greatest risk of loss to development (Weber, T., et al., 2006);
- green infrastructure system planning method using landscape-functional units (LaFU method) and its implementation in the Wrocław functional zone, Poland (Niedźwiecka-Filipiak, I., et al., 2019);
- a set of green infrastructure valuation tools was created, which is available under the Creative Commons license (Green Infrastructure Valuation Toolkit). It allows you to carry out an economic evaluation of interventions in green infrastructure, to substantiate management decisions. Tested in a number of areas and strategies, including the Liverpool Green Infrastructure Strategy (TMF, 2010);
- optimization of municipal General plans taking into account regional green infrastructure according to the criteria of assessment methodology (Lai, S. et al., 2019).

An example of the total economic value use by the impact method (obtaining additional or absolute effects) was used to determine the effect of the Nakivubo swamp existence in Uganda: the cost of replacing the ecological services provided by the ecosystem to ensure the population with quality water was estimated. Such ecological services of the Nakivubo swamps for the residents of Kampala as water exchange, sewage treatment, provision of its water resources were evaluated. The cost of the works necessary for the construction of an artificial sewage treatment system in the city in case of the swamp ecological service loss was calculated and there were received a total amount of more than $2 million in annual costs (Kasyan, I., 2014).

Scientists from the Lviv Forestry University, Ukraine, conducted an assessment of the cost of living for the National natural park “Skolivski Beskydy”. According to the conditional evaluation method, a questionnaire was conducted among 99 respondents regarding their willingness to pay for the preservation of the studied natural objects. To confirm the reliability of the survey results, an integrated environmental assessment was conducted, which takes into account the recreational, aesthetic, scientific, cultural-historical and ecological values of the "Skolivski Beskydy" NNP (Kasyan, I., 2014).

Experts of the public organization "Ecosphere" are developing a method of direct monetary assessment of the typical ecosystems services value for Ukraine. At the same time, specialists of the Ukrainian nature protection group focused on the study of those ecosystem services that cannot be calculated by a direct monetary valuation. It is about the cultural and social benefits that a person receives in interaction with nature, as well as ecosystem maintenance services (influence and formation of global processes on Earth) (Vergeles, Y. et al, 2015). Within the framework of the project "Ecosystem services beyond monetary valuation: how to calculate the lack of natural benefits by Ukrainians after the war", the experts of the project decided to develop methods of calculating ecosystem services not in money, but in terms of consumers, because the number of people who benefit from ecosystems is a specific number that must be accounted for.

In our opinion, these approaches are worthy of attention in the context of solving individual specific tasks, which differ significantly in each case. Methodological approaches to the assessment of green infrastructure ecosystem services proposed by the authors of the article are less situational and can be used to solve a wider range of tasks.

**Conclusions and perspectives of further research.** The conducted studies show that separate approaches and methods have been developed for the assessment of green infrastructure specific facilities, the use of which is practically impossible for others due to the specificity of these facilities, which is largely determined by the peculiarities of territorial location.

In addition, it is worth noting that at the first stages of the theory and practice formation and development of managing the cities green infrastructure, attention was mainly paid to the methods of direct costs accounting (cost approach), then later the emphasis shifted to the assessment of individual ecosystem services or groups of ecosystem services.

The development of the green infrastructure assessment methodology should take place with an understanding of the environmental factor growing role for the cities sustainable development. For this, it is necessary to develop evaluation indicators that would reflect the socio-ecological-economic value of green infrastructure and the socio-ecological-economic effect of its creation and operation, the efficiency of the natural resources development in various areas of use for choosing the optimal option, since were believed that the economic evaluation of natural resources has an

undeniable influence on the adoption of management policies decisions regarding their use, and therefore, the formation of comfortable, safe living conditions for the urban population, substantiation of ecologically oriented projects and urban development programs in general.

In our opinion, the assessment should reflect the economic, environmental and social effects of the use and non-use of green infrastructure, that is, take into account all the main functions that shape the value of green infrastructure elements.

Social value is determined by the potential of life support and livelihood, the cultural-historical, aesthetic value of a certain territory, the importance in the formation of the cities main areas, that is, the potential opportunity to provide recreation, reproduction of life forces in ecologically favorable conditions. At the same time, it is the investment attractiveness of a certain area, the favorable microclimate formation.

The ecological value of green infrastructure is determined by the potential opportunities of ecological systems to restore, provide regulatory and supporting ecosystem services. The environment quality largely depends on the balance of economic activity and the ability of the city's ecosystem to self-renew, which, again, significantly affects the living, working and leisure conditions of people.

Taking ecosystem functions into account in the economic evaluation is an opportunity to ensure the adoption of environmentally-oriented decisions when justifying individual projects and development programs: the higher value of the evaluation than greater chances that in the projects will be taken into account ecological priorities, resource-saving technologies will be implemented, comprehensive use of resources will be ensured, and the potential of green infrastructure will be increased.

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