
Human-Centered Reboot of Green Urban Ecosystem Management in the Context of Digitalization

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Abstract:

Purpose: The purpose of the research is to identify the key components of a human capital strategy for achieving the UN Sustainable Development Goals (ESG benchmarks).

Design/Methodology/Approach: The conceptual dominant of the research methodology is the statement about the possibility to consider human capital as a multi-parameter socio-resource component of the vector of "green" development of the urban ecosystem. The application of this methodology made it possible to realize qualitative-quantitative parameterization of the benefits and obstacles associated with the implementation at all levels of green urban management of human-oriented principles of sustainable management.

Findings: The result of the study is methodologically substantiated and empirically verified components of the strategy of reproduction of quality human resources in the management system of metropolitan ecosystem's innovation-oriented "green" development. It is proved that in the conditions of digitalization the algorithm of implementation of green HRM should be systematic, which initiates the increase of sustainability of resource using, reduction (elimination) of environmental damages, updating technologies, contributing to the effectiveness of all components of human resource management.

Practical Implications: Modern management of the "green" urban ecosystem under the influence of digitalization trends has a growing need for a balanced development of various industries/sectors: economic, socio-environmental, innovative, and governmental structures, IT industry based on the reproduction of qualitative human resources. This is due to the dominant role of human resource management (HRM) in the reproduction process of innovative type.

Originality/value: The requirements for the ESG toolkit for assessing strategic decisions at different levels of green HRM are formulated, as well as recommendations for actors to use the toolkit to analyze the causes of the slowdown in the implementation of green HRM and to develop adequate policy measures aimed at sustainable human capital development are created.

Keywords: Management, green urban ecosystem, human-centered reboot, digitalization.

JEL classification: J24, C54, O15.

Paper Type: Research study.

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1. Introduction

Modern processes of economic transition to the concept of Industry 5.0 mark a shift of emphasis from technology (characteristic for Industry 4.0) to humans and social values (Breque *et al.*, 2021). This human-centered approach to megacity management means the growing importance of adapting Industry 4.0 technologies, especially digital ones, which increase the sustainability of the urbanized system to the needs of city inhabitants.

Despite the universal recognition of the need to transform modern city dynamics, taking into account the interactions of the three subsystems (socio, ecological and economic), the processes of increasing capital mobility, characteristic for the 21st century, contribute to the preservation of technological priorities compared to anthropoecological ones in a multi-level system for managing urban ecosystems.

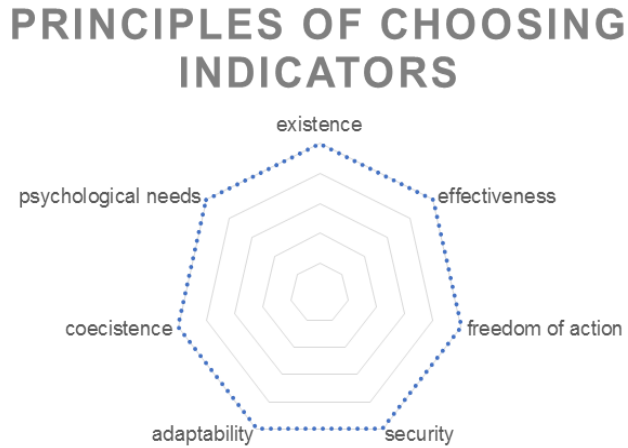
The resulting spasmodic (instability) of dynamic trajectories impedes the ripening (relevant) transformations, more and more slowing down the transition of urban territories to an intelligent economy. These processes stimulate an increasing understanding of the importance of the qualitative characteristics of human, social and environmental capital, increasing the potential of green urban ecosystems development.

The growing importance of the anthropoecological factor in the urban ecosystems has initiated social and scientific discussions about the ways of a phased transition to a sustainable type of innovative socio-ecological-economic development (Glazyrina, Zabelina, 2018; Laskowska and Danska-Borsiak, 2016). One of the key principles recognizes the need to shift the emphasis in the system of indicators from measuring production to measuring the level of achieved prosperity. Widely understood well-being includes four interrelated subsystems that characterize the quality of individual human capital as well as of social and natural environment, and the standard of living (Lazareva *et al.*, 2023).

In the process of scientific searching different views on the methodology, criteria and instruments of human-oriented "green" urban ecosystem management restart collide. Modern topic research is carried out in three directions: 1) identification and reasoning of the key green urban development parameters / factors in the digital economy; 2) development of adaptive management principles in the territorial sustainable development projects implementation; 3) development of socio-environmental-economic urban sustainability models.

Among the indicators / factors of a stochastically determined urban ecosystem management, such as the spatial organization of the territory, its anthroposocial, environmental and economic resources, determining the potential for sustainable development should be highlighted. In Figure 1 the principles for choosing the indicators are shown.

Figure 1. Principles of choosing sustainability indicators



Source: Own study.

2. Literature Review

The growing relevance of innovation factor and digital transformation initiated the movement of innovative capital into the center of strategic regulation of the urban socio-economic development. These processes served as a driver for the development of a diverse range of parameters/indicators that reflect the changes taking place, innovative technologies for making management decisions (Antonelli and Feder, 2020; Bikse *et al.*, 2021; Fonda and Meneghetti, 2022; Lenihan *et al.*, 2019; Ratti and Claudel, 2016; Russell and Smorodinskaya, 2018).

These studies also analyze modern approaches to human capital, consisting in a comprehensive vision of it as the most important socio-economic resource and a factor of sustainable innovation-oriented development (Thalassinos *et al.*, 2023; Velinov *et al.*, 2023; Ojaghlou *et al.*, 2023). Human capital is both a factor and a goal of human, family, and social development. Together with financial, natural, and physical resources, it forms the basis of national wealth (Buevich *et al.*, 2020), which requires new approaches and criteria for measuring human capital (Ali *et al.*, 2016; Jílková, 2021; Lazareva *et al.*, 2021), as well as new ways to effectively invest in it.

Most of the methods for the formation (justification) of human-oriented "green" urban development scenarios involve the use of certain tools of economic-mathematical modeling of dynamic processes and systems – from expert-analytical decision-making models (DMMs) to classical models of system dynamics and econometrics (mathematical statistics) (Anopchenko *et al.*, 2019; Lazareva *et al.*, 2021; Meadows *et al.*, 2004; Lazareva and Dong, 2020; Xu and Li, 2020).

The methodology models should meet such basic requirements as taking into account the mutual influences (direct and reverse flows) of the urban ecosystem subsystems, non-linearity and guaranteeing uniformity of the “intergenerational” distribution of restrictions on the natural, social and economic capital using and a number of others (Anopchenko *et al.*, 2021).

The inclusion in the model of stability conditions for dynamic trajectories can be implemented in various ways - to establish inter-temporal restrictions on the level of welfare / level of the region economic development, or to limit intersectoral flows (for example, to establish maximum permissible levels of polluting emissions).

Economic-mathematical models for "green" urban development managing based on a variety of decision tools are increasingly used in practice. However, the task of finding a systematic toolkit to create an effective system of strategic urban management, based on the socio-environmental and economic assessment of sustainability, cannot yet be classified as solved.

At present, there is a growing understanding of the need to form a unified decision support toolkit, which is determined by their systemic interconnectedness. The advantage of the holistic approach to factor research are the positive effects of each of the blocks of the integrated model toolkit.

System analysis of human resources determinants by DMMs (the first block of the toolkit) provides completeness, objectivity and transparency of the results of multi-parametric choice of factors, econometric analysis of the influence of selected factors on the level of human resources development (the second block) allows to rank the statistically significant factor variables of the model by the degree of impact on this level, forming the basis for strategic human resources decisions.

The econometric models construction makes it possible to statistically reflect the characteristics dependence of a particular scenario on various socio-environmental and economic factors and to identify the most statistically significant factors, based on which to substantiate strategies for the urban sustainable development. It is possible to identify typologies and integrally evaluate the potential for sustainable development using the methods of multivariate statistical and rating analysis (Lazareva and Dong, 2020).

The methodology of integrating the benefits of expert and econometric modeling approach to the study of human-centered green urban development scenarios is presented in the next section.

3. Research Methodology

The methodological support task for the selection of representative scenarios of the human-oriented urban sustainable development is due to the need to make decisions

in the face of uncertainty. The main requirement when choosing a methodology is its sufficient simplicity in combination with acceptable efficiency and reliability.

The advantages of DMM tools in supporting the process of multi-criteria selection of scenarios for the urban sustainable development include hierarchical reflection of the relationship of decisions with factors and evaluation criteria, ensuring accuracy, information base consistency, as well as identifying the most significant factors and likely situations of decision changing (Lazareva *et al.*, 2021).

The study was conducted with the cities of South Russian macro-region database using. For selection of the scenario of the urban sustainable development, a methodology for solving the decision-making problem based on a system concept was proposed. This task involves choosing the best scenario in terms of social, economic, environmental and managerial criteria for the long-term urban development. This methodology in general is as follows:

- constructing an urban sustainable development model, using the qualitative characteristics of human, social and environmental;
- studying problems of sustainable development by applying expert-econometric methods to construction of the city model as a managing problem;
- the meaningful (in the language of the concept of sustainable development) interpretation of the results obtained as findings of modeling in the perspective of their practical use.

According to the authors, the model of sustainable development of the urban system should meet the following requirements (Lazareva *et al.*, 2023):

- orientation of the model for a long time interval and its nonlinearity;
- inclusion of the social, ecological and economic subsystems feedback flows;
- restrictions on natural, social and economic capital using as a condition of concern for future generations.

Human-centered green development of urban ecosystems as a multi-vector controlled dynamic process, involving the fulfillment of certain principles and conditions, is the basis for formalizing the problem of identifying alternative scenarios in the form of a multi-criteria model, which can be represented as follows:

1. Statement (type) of the problem, characterizing the goals of decision-making. Solving problems in terms of goals is based on the axiom of “super-goal generation”. For example, highlighting the best alternative is choosing the best scenario for the urban sustainable development.

2. Formation of the set of criteria $\{K\}$, (requirements recognized by the decision maker as characteristics of the degree of achievement of the sub-goals based on two basic principles – the principles of completeness and simplicity.

According to the global model of sustainable development the four aspects criteria must be used in the procedure of scenarios evaluation – economic, ecological, social and managerial (institutional) (Huang *et al.*, 2015). In modeling economic efficiency, economic, social and environmental safety, social and environmental fairness of management decisions should be simultaneously provided (Figure 2).

3. Development of a plurality of rating scales $\{X\}$, the assessment of which can be carried out either through physical measurements, or by expert means. The set $X = \{x_i\}$, $i = 1, 2, \dots, n$, may contain scales of various types. Each alternative is rated on $\{x_i\}$ scales, that is, each alternative s from the set S is associated with an n -dimensional vector estimate $X = (x_1, \dots, x_i, \dots, x_n)$, where x_i is the vector value of the i -th criterion on the x_i scale.

4. The formation of many alternatives $\langle S \rangle$ - a set of scenarios for the urban sustainable development, satisfying certain constraints in each task and considering as possible ways of achieving the mission. The basic principles for the formation of alternatives are the rules of “Quotas” (establishing a fixed number of alternatives to a given problem) and the rule of several decisions, which has something in common with the principle of diversity in system analysis.

The software product was used to obtain alternative scenarios for the urban sustainable development, it helped to implement a modified Solow model. Scenarios were obtained as a result of simulation experiments with constraints (Anopchenko *et al.*, 2019).

5. The methods determination for evaluating the results of solving the problem. To do this, select the decisive rule $\langle R \rangle$ is the principle of comparing vector estimates and making judgments about the preference of some over others.

The iterative procedure of ranking the directions for the implementation of a particular scenario of the urban system green development is implemented by using the methodology of econometric (multiple correlation- regression) analysis. It allows us to express the impact of several independent variables on the controlled indicator simultaneously (Lazareva and Dong, 2021).

The result of expert-econometric research is a list of ranked socio-economic factors determining the level of well-being as a multifaceted target indicator of sustainability of urban system development.

Figure 2. *Criteria for competitive selection of the urban sustainable development scenario*

Criteria	Interpretation
Economic criteria	
Welfare	Capitalized income
Economic efficiency	Share of budget revenues from locally produced technologies and resources used
Innovation activity	The totality of all processes that lead to an increase in production results without the additional resources using
Economic security	The degree of approximation to the thresholds of the economic system functioning
Conservation of human and natural capital	Damage to the quality of the accumulated resource base. Human Development Index
Social criteria	
Quality of life	Social efficiency of the scenario. Human Development Index
Employment	Increase in the number of people employed. The cost of jobs created. Change in working conditions of employees
Social security	The degree of segmentation of social capital
Availability of social infrastructure	Degree of approaching the standards for the availability of social infrastructure.
Ecological criteria	
Environmental safety	Degree of compliance with applicable standards for maximum permissible concentrations, maximum permissible emissions and discharges, environmental impact assessment, etc.
Environmental Justice	Equitable participation in the distribution of, and equal access to, environmental goods and resources
Biodiversity Conservation	Percentage of preserved species and landscapes that are important locally, nationally, and to humanity as a whole
Public health	Average life expectancy at birth. Access to primary health care
Water quality	Provision of the population with a safe water supply
Minimization of natural environment pollution	Reduction of air, water, soil, etc. pollution.

Source: Own study.

4. Results

The study of the model was carried out in a simulation mode by setting the control variables trajectories – the share of industrial investments in Gross City Product (GCP) per year and their structure, as well as the investments in nature (atmospheric and water) protection measures and the coefficient of cross-border interaction between the cities of different regions. Taking into account the cross-border interaction of the cities in solving the decentralized optimal control problem leads to a differential-game formulation in normal form, the standard solution of which is the Nash equilibrium.

The results of simulation experiments with constraints that set the conditions for sustainable urban development allowed to identify the following scenarios:

- Scenario 1: increasing the 37 cities' economic level (GCP) by 2 % compared to the status quo scenario; environmental pollution reducing by 7 %;
- Scenario 2: increasing the 4 cities' economic level (GCP) by 3 % compared to the status quo scenario; environmental pollution reducing by 7.5 %;
- Scenario 3: increasing the 4 cities' economic level (GCP) by 4 % compared to the status quo scenario; environmental pollution reducing by 8 %.

The results of solving the scenario choice problem allow us to carry out a multi-criteria assessment of sustainable development scenarios for the city based on mathematical-statistical processing of expert points.

This problem can be solved using the apparatus of the hierarchy analysis method. This device allows evaluate scenarios using a set of criteria and three principles. The first principle (of identity and decomposition) allows to structure the problem in the form of a hierarchy, defining criteria and forming alternatives, the second (of discrimination) – to study the structure of preferences of decision-makers using pairwise comparisons, and the third (of synthesis) – to determine the final priorities in accordance with the decision rule and the consistency of the hierarchy.

Expert evaluation of the hierarchy of factors, criteria and alternatives served as the basis for multi-criteria analysis and the choice of the scenario of sustainable urban development (Figure 3).

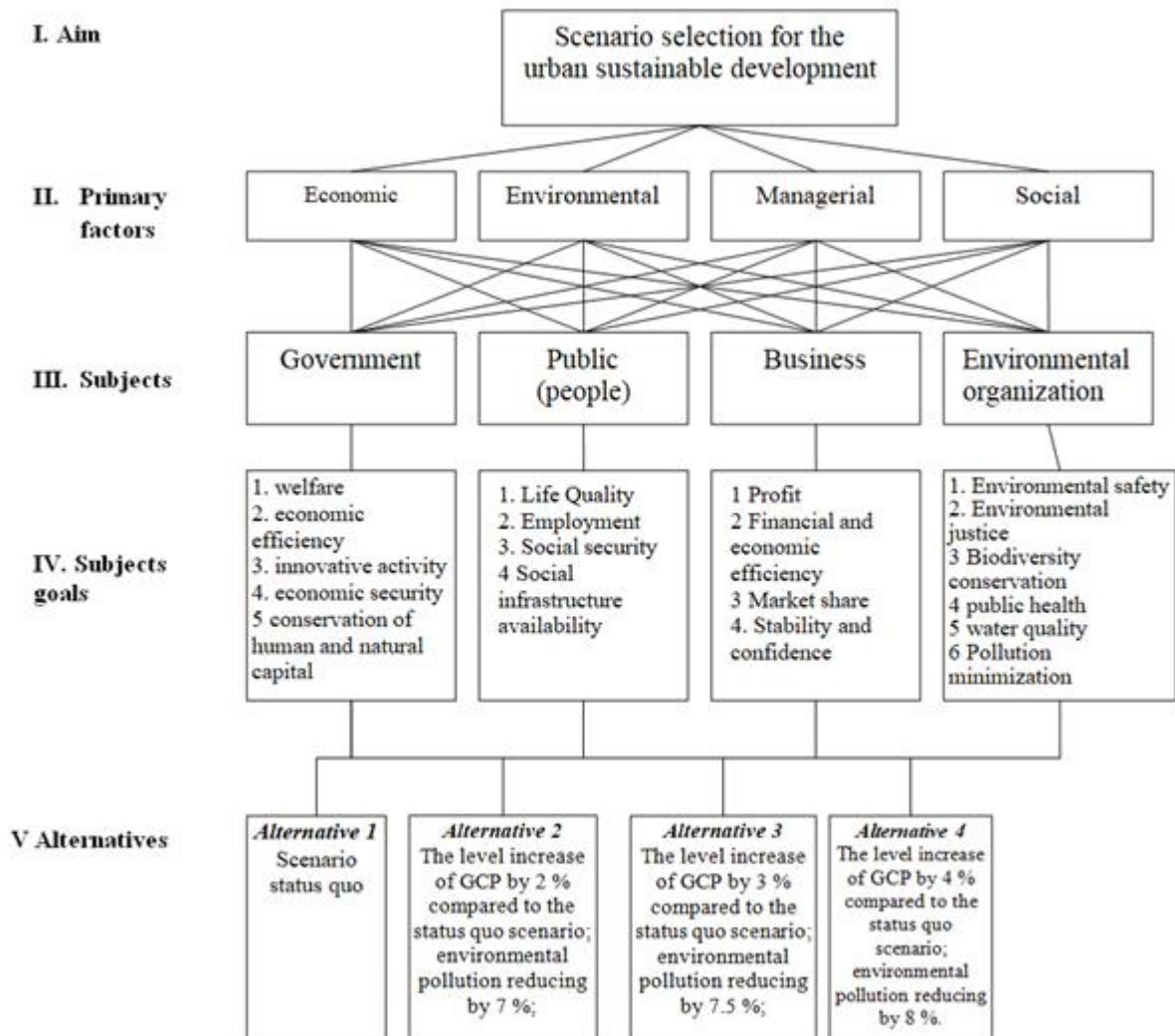
The study of the preferences of decision-makers structure using pairwise comparisons revealed the priority of the environmental criterion in assessing the urban sustainable development scenarios (0.41). When assessing scenarios for the city's sustainable development in the identified "coordinates" scenario 3 was the highest-priority alternative (0.54).

The choice of directions for the implementation of a particular scenario of the urban system green development is based on the application of econometric (correlation-regression) toolkit.

In particular, when analyzing the factors affecting the unemployment rate (one of the key social parametric characteristics of the scenarios), the econometric evaluation of the system of simultaneous regression equations using the two-step least squares method showed that the GNI per capita, the number of employers and inflation rate affect the unemployment rate to the greatest extent, while the number of self-employed in the total employed population and the share of tax revenues in GDP affect to a lesser extent.

These results served as the basis for recommendations on the formation of state policy to develop human capital and increase employment in various forms, using federal, regional and municipal measures (Lazareva *et al.*, 2023).

Figure 3. Hierarchy for choosing an urban sustainable development scenario.



Source: Own study.

The result of the development and testing on the example of "green" / "forest" cities in the People's Republic of China of an innovative method of economic evaluation of urban green spaces (a method that integrates the model tools of hedonic pricing and spatial econometrics) was a clear proof of the environmental-economic effectiveness of the proposed tool implementation in the practice of urban management. Thus, the transformation of urban green spaces spatial development policy increases the sustainability of urban systems management (Lazareva and Dong, 2021).

In general, the results of the expert-econometric study determine the priorities of formation and implementation of policy in the sphere of human-oriented green development of the city.

5. Conclusion

The findings define a new perspective on the methodology and toolkit for achieving the goals of human-centered rebooting of green urban ecosystems management in the context of digitalization. They permit to recommend to urban management to rely on the methodological basis of the theory of human and environmental resources management, as well as on a reasonable choice of criteria for assessing scenarios of sustainable ("green") urban system development in the formation of strategic policies.

The algorithm of the system expert econometric analysis of scenarios of human-oriented green transformation of urban management used in this study increases the degree of completeness and evidence of the results of multi-criteria assessment of the sustainable urban development directions and instruments.

Integration of a human-oriented mechanism of sustainable management into the urban strategy will provide a synergistic effect, expressed in an increase in both tangible and intangible assets of the city, in the growing recognition of its brand.

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