

# Integrated approach to assessment and formation of sustainable development of the territory of the city of Tyumen

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**Abstract.** The multifunctionality of the city covers in its development all its subsystems, modifying them throughout all life cycles. It is difficult to stop this process, but it is possible to reduce anthropogenic and man-made stresses. For this, according to the authors of the article, it is necessary to model the electronic resource of the urban (territorial) information and analytical space containing up-to-date data, which will allow on the basis of the key principles of environmental management, integrated landscape and urban planning, to ensure the maximum possible sustainable development of the territory of the urban planning system.

## 1 Introduction

The problem of the formation of sustainable urban areas covers all life cycles of urban landscapes, takes into account the multifunctional purpose of the urban planning system, as well as the legal, social and environmental components that regulate its development. Considering that modern urban land use is characterized by the highest degree of change in the natural and territorial complex, solving the problem of sustainable development is possible only through an integrated approach using a number of factors, Indicators, assessments, methodologies, methods and technologies. The authors of the article propose and test complex landscape-ecological-ecological and skeleton approaches that provide the most sustainable development of all subsystems of urban land use.

## 2 Materials and methods

Scientific approaches, methods and technologies in the field of assessment and formation of sustainable development of urban area (city) were reflected in the scientific works of a number of Russian scientists: Starkov A. A., Vladimirov V. V., Sevostyanov A. V., Rogatnev Y. M., Zalesskaya L. S., Zandvorna A. V., Lappo G. M., Raymers N. F., Sidorchuk V. L., Podkovyrova M. A., Shaldunova N. P., Savvateeva O. A., Belov P. etc. [1-7].

It should be noted that the existing scientific potential deserves due attention, but in today's conditions of significant growth of cities there is an increase in anthropogenic loads

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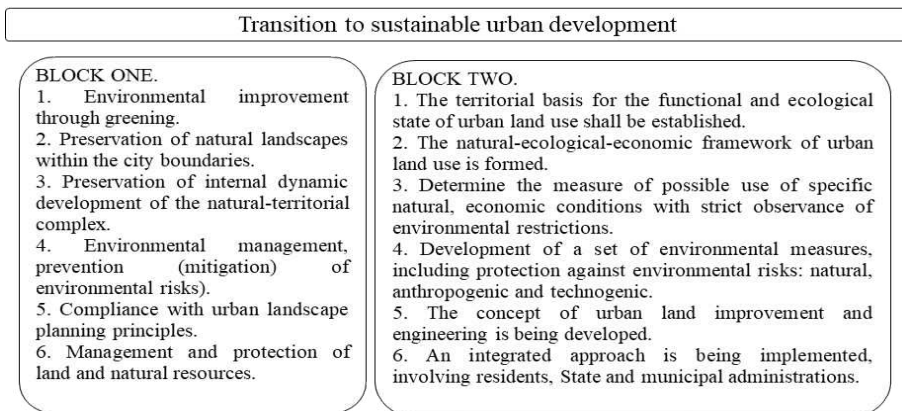
on natural and territorial complexes (through the construction of large residential and industrial estates, site engineering), requires the systematization of scientific approaches, techniques and technologies. The authors of the article propose a method of formation of a vector scientific and methodical approach to complex modeling of the city of the most sustainable its development [1-7]:

- Justification in the Concept of sustainable development of its territorial interpretation.
- Analysis of the scientific and methodological basis of the integrated assessment of the urban area, based on the natural-territorial complex.
- Comprehensive assessment of the specific features of the formation and functioning of the studied area as a socio-economic system, followed by identification of possible optimization options in the use of urban land use.
- The use of spatial, spatial and planning analysis, geographic information systems and remote sensing materials in the planning of urban development.
- Formation of information and analytical resource on the socio-economic and economic state of the city.
- Defining a vector in planning sustainable development of the city.

### 3 Results

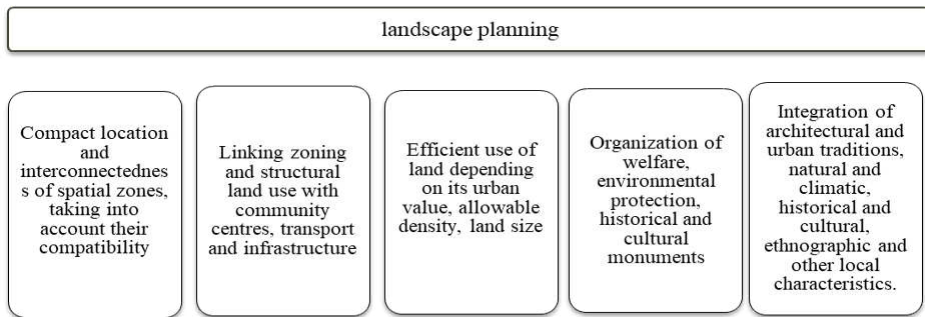
The choice of the concept of sustainable territorial development of urban land use is impossible without a correct assessment of the features of the conditions of formation and functioning of the studied territory as a system, its natural and resource potential, environmental and social Economic conditions, as well as the degree of influence of both external and internal factors, followed by the identification of possible options for the socio-economic optimization of urban land use. This involves the imposition of a number of restrictions and burdens on the use of urban land (natural resources) and the development of a set of activities to implement them.

In considered concept, the process of transition to the most sustainable development of modern urban land use is more related to the ecological component, natural resource potential (Figure 1).



**Fig. 1.** Algorithm of transition to sustainable development of urban area.

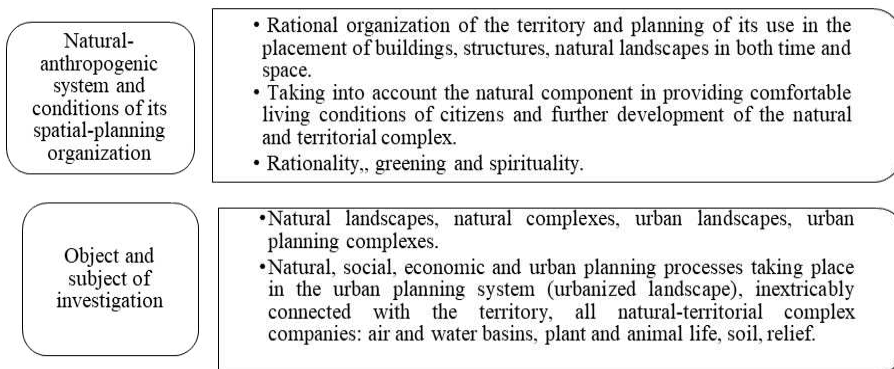
In our view, the natural and anthropogenic system and conditions of spatial planning should be closely correlated (Figure 2) [7-10].



**Fig. 2.** Natural-anthropogenic system and conditions of its spatial-planning organization.

Modern practice of the frame approach to urban planning and landscape planning allows to create universal models of the urban environment, characterizing the multifunctionality of the city and meeting the requirements of urban planning and environmental regulations, see Figure 3 [5-7, 9, 11, 12]:

- The concept of development of green public spaces of general urban purpose "Green Novosibirsk" (t. Novosibirsk).
- Concept of greening of the city area (t. Nizhnevartovsk).
- Concept of the development of the green framework of the city on the basis of a comprehensive assessment of the urban landscape, etc. (t. Omsk).
- Concept of the formation of a holistic natural and ecological framework of the city and municipal district (Omsk, Yuzhno-Sakhalinsk).
- Concept of greening and humanization of urban space (environment) of the city (Moscow).
- Concept of ecological renovation of established cities, etc.



**Fig. 3.** Tools and techniques for landscape planning.

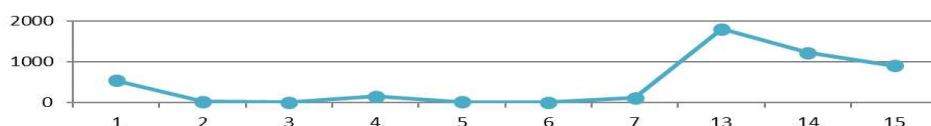
Considering the issues of sustainable development of the city subsystems, the formation of its natural and ecological framework, which should be in accordance with the key principles of construction based on environmental management and landscape approach, acquires special importance [4-8, 10].

However, for urban planning systems, along with the environmental dimension, social and economic components contribute significantly to their sustainable development [1-4, 7, 9, 10-15]:

- Complex socio-ecological and economic assessment of the city territory, allowing to establish: system of indicators and indicators of assessment; evaluation criteria; level of comfort of the urban environment; state of the natural and territorial complex (for all key components, including the level of greening, the presence of specially protected natural areas, water bodies, etc.); the comfort of living of the urban population and the degree of environmental sustainability of the urban area as a whole. In integrated assessment, it is proposed to use data on: on emissions of pollutants into the atmosphere (from motor vehicles, electric heat, industrial sites); on pollution, flooding, waterlogging and flooding of soils; on water pollution; on the manifestation of degradation processes and environmental risks; on the density of development and its state.
- Functional and ecological zoning of the territory: a tool for determining environmental restrictions and the legal regime for the use of urban land.
- Ranking of the urban area according to the degree of social and environmental and economic benefits for individual components and in general.
- Formation of perspective use of urban land resources (based on the results of the evaluation) ensuring sustainable development of the urban area.

The system of indicators is based on the recommendations of Sidorchuk V. L. [4].

The proposed provision "...on the vital expansion of the urban green space to the level of 40%-60%. With this ratio, the natural environment will provide an increase in the indicator of ecological sustainability of the city..." was substantiated to scientists which remains relevant for the surveyed city of Tyumen. As one of the indicators of the ecological condition of the city area is taken "level of landscaping". Ten planning areas were included in the analysis (Figure 4).



**Fig. 4.** Level of greening of the city area by planning areas of the city, m<sup>2</sup> per 1 person.

According to the data received, of 10 planning districts of the city: Berezhnyakovskiy (1), Tarmanskiy (2), Parfenovskiy (3), Zatyumen (4), Zarechny (5), Central (6), Gilevskiy (7), Verkhneboreskiy (13), Myosovskiy (14) and Novoroshchinsk (15) the smallest area of greenery per person. is present in the second, fifth and sixth districts (up to 4.8 m<sup>2</sup>), higher level of landscaping in 13, 14, and 15 districts. The results of the analysis confirm the expediency of formation of the supporting natural-ecological framework of the city and primarily due to the violation of its linear-nodal structure, which reduces the degree of realization of its mediostabilizing function [5, 7-9].

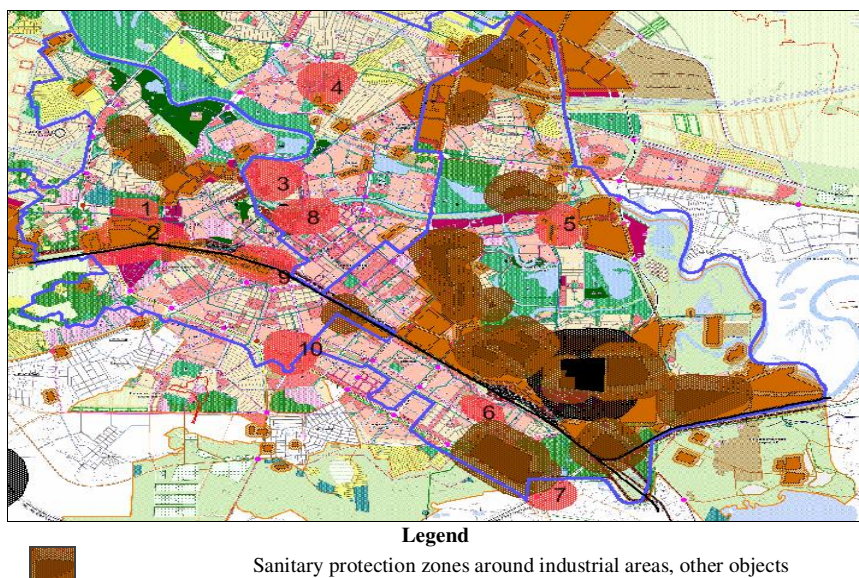
Analyzing the system of indicators, it should be emphasized that for a modern city it becomes vital to expand the green space. Sidorchuk V. L. proposes to increase the level of urban greening to 60%, noting that with this ratio, the natural environment will provide an increase in the indicator of environmental sustainability of the city area.

In the landscape planning of the territory of the city of Tyumen and the formation of its natural and ecological foundations, we proposed the following principles for their functional spatial and territorial organization [5-8, 10]:

- Typological principle.
- Principle of functional integrity.

- The principle of flexibility of the planning structure, ensuring the smooth development of the city, as well as reducing the burden on urban transport. As a consequence, the natural-territorial complex and the urban environment.
- The principle of spatial and temporal organization of the city territory.
- Principle of optimality (compliance).
- The principle of integrated development of all structural elements of the planning organization of the city.
- The principle of unity and subordination.
- The principle of the transformation of nature, the basic rules that must be observed in the development of the natural and territorial complex;
- The principle of Le Chatelier-Brown, reflecting ... «when the external influence causes the system to lose its stable equilibrium, the equilibrium is shifted in a direction in which the influence of external influence weakens».
- Principle of balance: this principle ensures the implementation of normative values regarding the level of greening of the city, etc.
- The principle of compliance with the linear node structure of the natural-ecological structure, which permeates all the above-mentioned principles, since it can be included in the category of the core or core principle that defines the framework approach itself.

The effectiveness of the process is presented in the article by the method of building a reference natural-ecological structure. First of all, it included a comprehensive ecological assessment of the city area, which allows to establish the degree of ecological sustainability of the studied area, as well as the level of comfort of the urban population [7, 16]. The assessment used functional and ecological zoning (Figure 5 shows parameters of sanitary zones around production facilities, warehouses of the city), as well as a rating scale. Functional-ecological zoning has defined environmental restrictions and legal regime of use of the land of the city of Tyumen. With regard to the indicator system, it was developed taking into account the recommendations of V. L. Sidorchuk, M. A. Podgorova, Z. F. Kocherkina, A D Murzin [4, 7, 9, 13].



**Fig. 5.** Sanitary protection zones in the functional organization of the city territory.

The article presents the results of the analysis of the state of soils [7, 12] and the air basin [7]. The results of the samples obtained allow us to conclude that the zinc content (Zn) in the soil samples of the districts 1, 2, 5, 7 exceeds the MPC value from 1.3 to 2.0 times; copper content manganese (Mp) and chromium (Cr) in all soil samples does not exceed the MPC value (Table 1).

**Table 1.** Results of assessment of the level of variability of soils contaminated with heavy metals (hm).

HM \ No. samples	1	3	4	6	8	9	10
Pb	3	2	2	1	2	1	1
Ni	3	3	4	4	4	4	4
Zn	3	3	3	3	3	2	3
Cu	2	2	2	2	2	2	2
Mn	2	2	2	2	2	2	2
Cr	2	2	2	2	2	2	3
Co	3	3	4	3	3	3	3
Hg	2	2	2	2	2	2	2
The level of soil variability	3	3	4	4	4	4	4

The level of soil variability of the studied planning areas is characterized by the third category (medium-modified). The value of the damage in value terms varies from 641,126.2 to 1,632,518.9 thousand rubles.

The main sources of pollution of the surface layers of the atmosphere of the city include automobile transport. The concentration of traffic flows in the central part of the city is the most polluting area of the Central Planning Area, and the increase in the level of atmospheric soot pollution is observed in the Central and Zarya regions.

The following degradation processes characterize the city of Tyumen: waterlogging, flooding, flooding and ravine formation. The main reason for their manifestation is economic and urban planning activities. While for the Central District the importance in nature conservation activities remains the fixing of the boundaries of the gully-bular network (6% of the district area), in the Zarechny District wetlands make 8%; 1% flood zone - 51%; flooding zone - the flooding area - 49%; Wetland conservation area 53%.

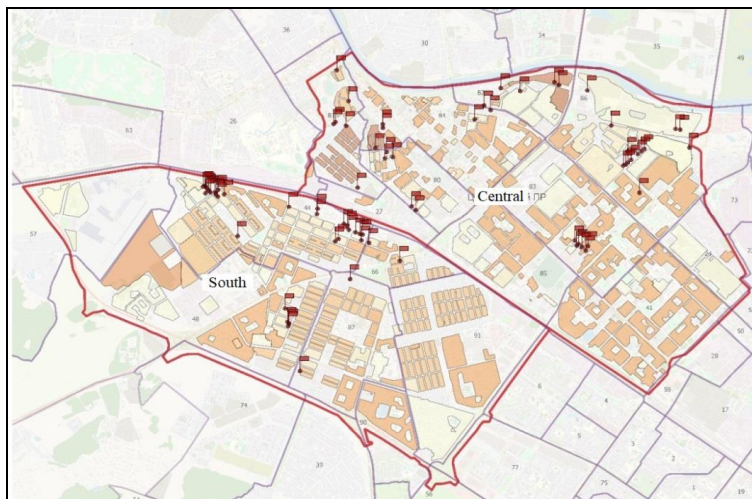
A large integrated assessment cluster covers the area of social, environmental and economic orientation and social, cultural and domestic services. This sphere reflects the level of prestige of the urban area as a result of urban planning and improvement of the city territory, as well as the degree of alteration of the natural and territorial complex caused by the presence of old and emergency housing, as one of the sources of flooding and contamination of soils, water bodies, floodplain landscapes (change of coastal floodplain complexes) occurring within the limits of the city of Tyumen.

To date, 23.18 hectares of floodplain areas in the Gilev planning area fall into residential development, and 292.59 hectares are represented by an unsuitable territory [7].

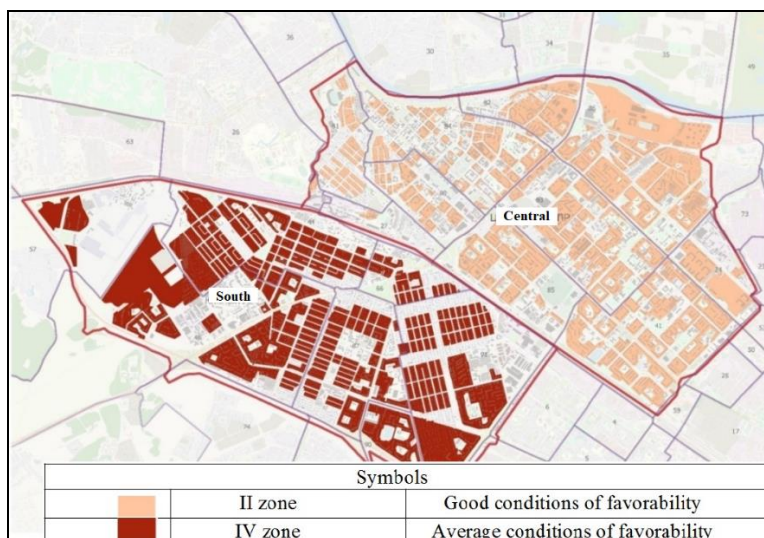
The largest number of dilapidated and emergency housing is located in the central (86 houses) and southern (44 houses) planning areas of the city, which necessitates the redevelopment and improvement of these areas (Figure 6).

With regard to the provision of social and cultural services to the population, the evaluation included an analysis of the overlap of health-care structures, schools and pre-schools, and trade in accordance with urban planning regulations. The evaluation required the development of an integral assessment scale.

The results of this type of assessment (Figure 7) are presented on the example of the created cartographic material.



**Fig. 6.** Map of old and emergency housing in the city.



**Fig. 7.** Assessment map of social and cultural amenities in residential areas on the example of two administrative districts of the city of Tyumen (on Lipovka N. A.).

The degree of favorability of social, cultural and household services for the population reflects compliance with the requirements of urban and landscape planning, the degree and nature of changes in the natural and territorial complex. With increased building density in the Southern planning area the degree of component-based functioning of the natural-territorial complex decreases.

## 4 Discussion

In order to improve the reliability of the results of the integrated assessment of the territory of the city of Tyumen and the prospects for its planning, space images were used. The

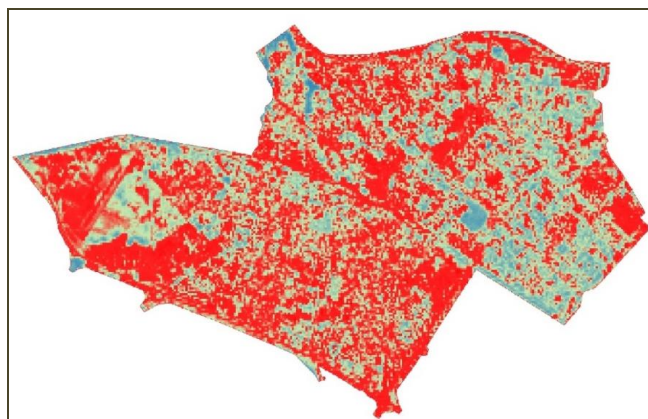
analysis of the time-varied space images of the Tyumen area (2014 and 2020) confirmed the dynamics in the state and use of urban land (Figure 8).



**Fig. 8.** Timeless Space Images of Tyumen (left 2020, right 2014).

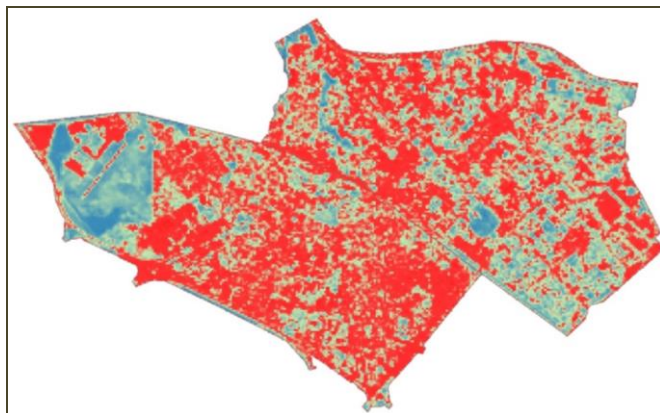
As a result of our research using space imagery, the following were obtained and presented:

- Data on urban expansion.
- Construction of index images of the planning areas of the city of Tyumen based on the index NDBI 2013 and 2021. (Figures 9 and 10).



**Fig. 9.** Index image of NDBI 2013. Central and Southern planning areas (on Lipovka N. A.).





**Fig. 10.** Index image of NDBI 2021. Central and Southern planning areas (on Lipovka N. A.).

The updated database will provide [3, 6, 7, 14-16]:

- The process of creating an electronic urban (territorial) information and analytical space, allowing to build on the basis of the key principles of landscape and urban planning a territorial model of interconnected and interdependent supporting frameworks of the city, reinforcing the degree of maximum possible sustainable development of the multifunctional system of the city, his land complex.
- Development of a set of socio-economic measures to create a comfortable urban environment, as well as to preserve the internal dynamic balance of the natural-territorial complex.

## 5 Conclusion

The fact that the converted natural and territorial complexes of cities do not have the stability of their subsystems was confirmed by the data (space images, soil surveys, environmental monitoring) and, on the other hand, by the data obtained required on the basis of the established scientific potential in the field of urban planning and landscape planning, forecasting and GIS-technologies, to decide on the choice of scientific approach, methods and technologies for the formation of urban information and analytical space [3-7, 9, 10, 13-16].

The conclusions are that:

- On the basis of the analysis of multifunctionality of the city of Tyumen, the second parts of the article propose a methodology for the study of urban land use, built on the provisions of systemic, complex, frame, landscape, socio-economic and ecological approaches.
- Landscape, ecological, geographical and socio-economic factors (their indicators) in the formation and development of urban land use have been adopted as priority evaluation criteria.
- In ranking the urban area by a set of factors, functional and ecological zoning, the method of comparative analysis and the cartographic method were used.
- Urban clusters with different levels of urban environment and changes in the natural-territorial complex of the city.
- The aims and tasks of creating an urban (territorial) information and analytical space providing for:
  - Improvement of spatial and planning organization of the city, development and improvement.

- Changes in land use and building regulations, as well as in the master plan of the city.
- Development of a set of environmental protection measures.
- Effective management of the land and property complex of a large city.

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