Sustainable Development of Cities in the Context of Digital Transformation of the Construction Industry

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Abstract: The article discusses the features of the redevelopment of territories both in Russia and abroad, as well as the requirements for environmental planning of territories. The main information systems for environmental planning are identified, which can be used to analyze energy consumption, carbon emissions, natural ventilation, analysis of solar energy and lighting, acoustics and water use. However, the above information systems are designed for one type of analysis and cannot be used for others. The article presents the structure of the extended domain of the environmental planning information system, the use of which will create an ecological and socially developed space. The research was based on publications published in the international database Scopus and the bibliographic database of scientific citations.

1 INTRODUCTION

The term "Sustainable urban development" was first used by the UN Commission on Environment and Development in 1992. Today, the concept of sustainable urban development involves the balanced development of urban areas, the formation of the urban environment, considering the rational placement of industrial facilities, as well as the creation of jobs in harmony with the natural environment.

At the same time, it should be noted that over time, approaches and technologies to ensure the sustainable development of cities have changed significantly, while maintaining the basis of this concept.

In the context of digital transformation, changes have affected almost all areas of human life. The construction industry is no exception. Quite a lot of works (Zhang, 2023; Talbi, Souad, 2022; Gomaa, Schade, Bao, Xie, 2023; Baduge, Thilakarathna, 2022; Olsson, Arica, Woods, Madrid, 2021; Dallasega, Rauch, Linder, 2018) are devoted to the analysis of promising technologies in the conditions of digital transformation of the construction industry, while it is noted that information modeling technologies are the most in demand (Ginzburg, Adamtsevich, Adamtsevich, 2021).

Thus, the purpose of the presented study is to identify existing and possible problems that impede the integration of information modeling technology in the environmental planning of the city, as well as the development of the structure of the extended domain of the environmental planning information system, the use of which will create an ecological and socially developed space.

2 METODOLOGY

The research was based on publications published in the international database Scopus and the bibliographic database of scientific citation of the RSCI.

3 RESULTS

An analysis of the experience of foreign countries in the field of redevelopment of territories shows that much attention is paid to this issue, so in the works (Zheng, Masrabaye, 2023; Franz, Pahlen, Nathanail,

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Okuniek, Okuniek, Koj, 2007; Tometzov, Gregorov, Hroň, 2020; Green, 2018; Sousa, 2003; Thornton, Franz, Edwards, Pahlen, Nathanail, 2007; Pizzol, 2016) the emphasis is on the problem of redevelopment of brownfields territories. At the same time, redevelopment is understood as the process of restoring degraded territories. Another direction in redevelopment is the creation of creative clusters on the territories of unused industrial territories, which have begun to transform into urban spaces that are convenient for living from an infrastructural and environmental point of view.

An example is the harbor quarters with docks in Liverpool or the North Quarter in Manchester. The Granary complex has been built on the territory of London in the Barking and Dagenham districts, the redevelopment of the King's Cross district has been completed, and the redevelopment of the inactive coal station Battersea Power Station is planned.

Redevelopment is widely used in Europe as well. For example, in Germany, on the territory of one of the steel mills, the project of the East Hotel in Hamburg was implemented. Another example is the Olympic Park in Munich, located on the territory of a former military training ground.

In the United States, the redevelopment process is enshrined at the legislative level; in 1945, the state of California passed the California Community Redevelopment Law.

The largest redevelopment project in the United States is the Hudson Yards area, located in the west of Manhattan.

In China, five jet fuel containers at the former Longhua Airport in Shanghai have been converted into an arts and culture park.

In Japan, a striking example of redevelopment is the industrial corridor of Keinin, before the redevelopment, the territory was occupied by heavy industry, such as machine-building and shipbuilding plants, oil and gas processing industries. Currently, the territory is divided into 6 zones, on the territory of which there are research centers, light industry facilities, public and cultural facilities, exhibition centers, as well as the well-known Minato Mirai business district.

In Russia, there are also successful examples of redevelopment of territories, for example, the project for the transformation of a power plant on the banks of the Moskva River - GES-2. The building was built in the period from 194 to 1907, in the Yakimanka area.

In St. Petersburg, on the territory of the old paper-spinning manufactory built in 1851, a creative space has appeared where fashion shows, concerts, music parties, etc. are held.

The examples described above indicate that at present the direction of the transformation of old territories into new clusters is actively developing.

At the same time, under environmental planning, this is a calculation, based on the principle of compiling an intersectoral balance, of the potential withdrawal of natural resources or territories without a noticeable violation of the existing ecological balance and without causing damage to one economic sector by others. Thus, the key task in the redevelopment of territories is the creation of an ecological and socially developed space.

At the same time, most of these projects were implemented using familiar technologies, the scientific and technical hypothesis of the presented study is the assumption that it is possible to reduce the costs of implementing projects through the introduction of Industry 4.0 technologies, in particular information modeling technologies or building information modeling (BIM).

The fact that the digital transformation of the construction industry has brought tools that will significantly reduce the time for redevelopment of the territory is confirmed by publications, for example, in (Hammond, 2023), digital tools for the redevelopment of old territories are considered. It is noted that the use of digital systems and products for decision-making on the redevelopment of territories has received wide recognition, both in publications and directly in the industry. The paper also presents the results of a study on the issue of digitalization and the use of digital tools in this direction, as well as ideas about the main problematic abandoned enterprises in which digital tools can increase the level of awareness of decision makers.

Based on geospatial data such as protected areas and species and biotope mapping, conflicts with planned technical structures such as buildings or infrastructure works are identified, and environmental measures are determined. The results of this process are documented and visualized in plans that describe all conflicts and activities associated with a particular construction project.

Therefore, integrating environmental planning into the BIM process means integrating digital representations of planned buildings or infrastructure works and a digital representation of their environmental context. While construction data comes from BIM development tools, the environmental context, including environmental conflicts and planned conservation measures, is maintained using geographic information systems (GIS). The main characteristic of the BIM method is that planning is done in at least 3D, with time and cost being two additional dimensions. For environmental planning, this leads to a shift from 2D planning to a multidimensional planning approach, which must be reflected in an appropriate information model. In general, the construction process requires data at various levels of detail.

Foreign experience in environmental planning is highly developed. The main information systems for environmental planning and analysis are:

✓ Autodesk® Green Building Studio;
✓ Integrated Environmental Solutions Virtual Environment;
✓ Bentley Hevacomp;
✓ EnergyPlus;
✓ DesignBuilder Simulation.

Most of these systems can analyze the following aspects:

✓ energy consumption,
✓ carbon emissions,
✓ natural ventilation,
✓ solar energy and lighting analysis,
✓ acoustics and water use.

So, the above information systems are designed specifically for one type of analysis and cannot be used for others. As a result, industry professionals may underutilize their capabilities when using these information systems. In the future, a common and integrated information system is needed to systematically analyze the overall environmental sustainability of a building and plan the environmental development of the area.

About urban space modeling, the most notable project in this area is The City Geography Markup Language (CityGML), which has been developing since 2002 and provides a data model for describing 3D city models, as well as a markup language like Extensible Markup Language (XML). A single data storage format unified for international use provides for the possibility of exchange between different systems.

In the CityGML data model, each object has its own description of the 3D geometry, as well as textures that define the qualitative characteristics of its surface. There are several classes of urban space objects (Chuhraev, Kobzeeva, 2022):

✓ landscape;
✓ buildings, bridges and tunnels;
✓ vegetation;
✓ reservoirs;
✓ transport cards;
✓ plots of certain land use;
✓ small architectural forms;
✓ typical city objects.

Figure 1 shows a variant (in the form of a UML diagram) for structuring elements in an environmental planning information system based on CityGML.

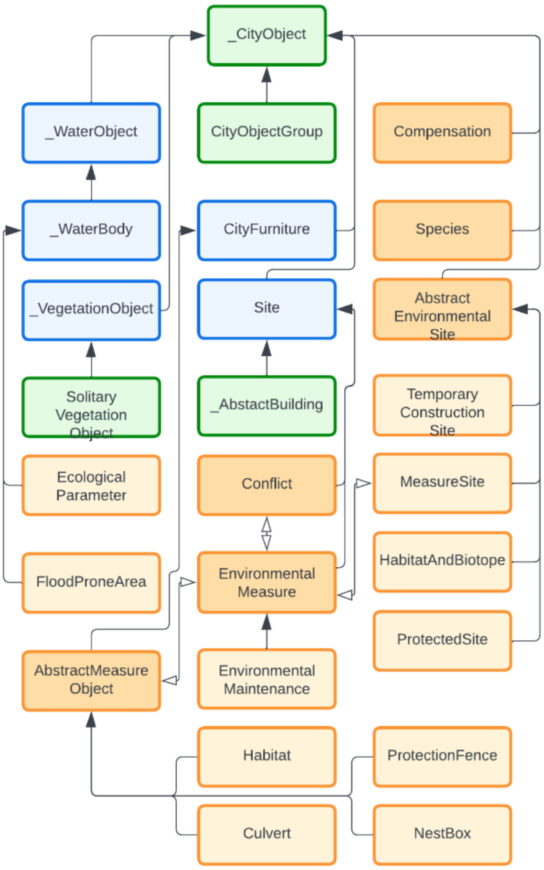

Figure 1: Extended domain structure of environmental planning information system.

Figure 1 shows the structure of the extended domain of the environmental planning information system, where newly created elements are highlighted in orange; in green - existing CityGML classes extended with attributes; in blue - extended classes of the main CityGML module.

Environmental planning in Russia, now, consists of several laws regulating "green" construction.

In 2010, "Green Standards" were created by the Federal Agency for Technical Regulation and Metrology and STO NOSTROY 2.35.4–2011 "Green Building". Buildings residential and public. Rating system for assessing the sustainability of the habitat.

The Green Building standard supplements the general terms in the field of standardization, which are established by the GOST R 1.12-2017 standard in force in the Russian Federation. The main basic criteria of the "Green Building" standard. Buildings residential and public. Rating system for assessing the sustainability of the habitat" are:

1. Comfort and quality of the external environment.
2. The quality of the architecture and layout of the facility.
3. Comfort and ecology of the internal environment.
4. Quality of sanitary protection and waste disposal.
5. Rational water use.
6. Energy saving and energy efficiency.
7. Use of alternative and renewable energy.
8. Ecology of creation, operation and disposal of the object.
9. Economic efficiency.
10. Quality of project management training.

However, both in foreign and in domestic standards of green building, the essence of ecological planning of the city is by no means described and established by any regulations. These standards, in general, establish norms for the design of buildings and structures, but do not relate to the issues of integrated development of territories and their greening, including through pre-designed landscaping.

In this regard, it is proposed to highlight the main functions of BIM for sustainability analysis, which will form a clear picture for the modernization of the domestic environmental planning process:

- energy efficiency analysis;
- analysis of hydrocarbon emissions;
- analysis of the natural ventilation system;
- analysis of lighting conditions;
- analysis of water use;
- heat consumption analysis.

Thus, the analysis of compliance with the environmental planning norm will include an assessment of collisions between the designed building and the environment, geospatial data, as well as data on the impact of the construction object on the environment during the operation phase.

4 CONCLUSIONS

The conducted research shows that the greening of urban space can be used to implement the concept of sustainable development.

However, examples of real management decisions in the redevelopment of territories indicate the absence of a holistic view of the balance of interests as a method of solving the environmental problems of the city.

When carrying out the redevelopment of territories, it is advisable, on the one hand, to use the historical experience of the development of urban systems, and on the other hand, to use promising digital technologies.

The lack of a strategic vision of urban problems leads to the fact that huge financial costs for greening cities fall primarily on the arrangement of relatively small green areas, which positively affects the appearance of the urban environment, but does not solve environmental problems and does not ensure its improvement of the urban environment.

At the same time, information systems in environmental planning will serve to provide visual information regarding the performance and construction process, and thus enable project participants such as designers, contractors and owners to make more environmentally friendly decisions.

It is important to emphasize that such informational systems should be aimed specifically at the integrated development of territories or combine several construction or redevelopment projects for general and cumulative work on environmental planning. The article presents the structure of the extended domain of the environmental planning information system, which will reduce not only financial costs, but also the timing of the creation of an ecological and socially developed space.

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