How local environmental restrictions affect environmental situation in urban system

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Abstract. The paper discusses the history of planning the city of Birobidzhan. Each consecutive Urban Master Plan continued its predecessor; however, none of the plans contained interesting architectural and compositional solutions. The environmental conditions (which are not to be ignored in urban planning) result in unfavorable geotechnical and environmental impacts. The left-bank part of the city is located in the floodplain and straddles an embankment prone to waterlogging. Embankment height varies from 1 to 5 meters. Embankment is prone to erosion. The right-bank part of the city lies on a slope; the environmental conditions here are better. Birobidzhan has an explicitly monsoon climate; the street layout prevents self-purification of the atmosphere. Environmental constraints are defined for the City of Birobidzhan; an environmental framework is proposed.

1. Introduction
In conventional geography, a city is a human settlement that drives the economic development of an area. From the standpoint of a systemic approach, a city is a system of interrelated and interdependent components: man-modified area repurposed to serve as a stationary human habitat; and human population. Natural and anthropogenic components of an urban environment are somewhat independent; however, they do influence each other, and that influence is not to be ignored in pursuit of optimal development. The natural subsystem determines the baseline quality of life. The anthropogenic subsystem includes man-made structures which are far less resistant than their natural counterparts.

A localized urban ecosystem features a high concentration of interconnected components of urban environment. Improper layout often has adverse environmental impacts. This is why it is relevant for modern researchers to seek ways to improve the current situation so as to balance the development of natural and anthropogenic subsystems. Such research can be component-specific or system-wide [1].

International scientists have long researched the issues of environmental monitoring, assessing and analyzing the outcomes of interactions between various environmental factors, modeling and examining the local environment. Noteworthy are papers by I.E. McHarg, who used map superpositions [2]; R.T. Eckenrode and R.A. Lehmann, who did sociological surveying [3-5], A. Little, Batelle, who devised information scaling methods; T. Krauskopf and D. Bunde, D. Forrester et al., who were engaged in computer simulation research [6-8]; L.B. Leopold and Sorenson, who used a matrix system [9,10]. Environmental research methods are described and classified in papers penned by R. Nichols, E. Hiemann, C. Duke et al. [11]. Some papers are devoted to individual components of
urban environment and relevant research methods [12-14]. Other authors devised hygienic assessment systems to calculate the disease-specific risks pertaining to the current or predicted local anthropogenic impact [15,16].

These methods, modified or not, are commonly used in state-of-the-art ecological research. Thus, V. Molnar, S. Szabo, B. Tothmeresz, and E. Simon analyze how air pollution affects plant biochemistry and morphology [17,18]. C. Small and D. Sousa address the matters of land cover conditions and how man affects it [19]. Frumkin, Hess et al. [20] consider the negative effects of the deterioration of geosystems due to intensive use of energy and resources. For Russia and other countries, such issues remain relevant as public transit planning [21], air quality analysis [22], drinking water quality [23,24], preservation of natural areas within urban ecosystems [25], and urban development [26,27]. Environmental research shows that the today’s urban planners have to revise the construction rules so as to compensate for certain drawbacks of the urban ecosystem by seeking to preserve and improve its components; such preservation and improvement is based on comprehensive consideration, analysis, and evaluation of local opportunities [1].

2. Main part
The research team has studied the City of Birobidzhan. The city is the center of the Jewish Autonomous Oblast. It occupies an area of 150 sq.km. Population within the city limits is less than 80 thousand people. It is therefore a medium-sized city by Russian standards. The settlement was founded in 1912 near the Tikhonkaya Station, Trans-Siberian Railway. In 1931, the settlement was renamed Birobidzhan; in 1937, it became a city.

The functional planning structure of Birobidzhan is one of a kind. Prior to the 1960s, it was a chaotic cluster of a few settlements scattered both sides of the railroad that ran along the Bira river. The first master plan was drafted by Lengiprogor, advised by Ch. Meyer; scheduled for implementation in 1965-1975, it was made with the downtown in mind. The basic idea behind the plan was to bring housing closer to the industrial areas. Birobidzhan developed neighborhood by neighborhood rather than house by house. Drafting of the first Master Plan coincided with the governmental Ordinance for the Suppression of Architectural Excesses. Ubiquitous urban planning was now focused on creating the simplest city layouts based on one or two standard houses. The best thing about the 1965 Master Plan was that it brought the city to the Bira River. Manors behind the railway were preserved.

The second Master Plan was approved in 1975 and scheduled for implementation by 2000; in 1990, it had to be rescheduled for completion by 2010. This document implied further housing development to the right of the Bira River. To that end, they planned a bridge. The new neighborhoods were to contain an amusement park and a stadium. However, they ended up constructing only the stadium. Panel buildings appeared to enrich the composition. Another objective was to rearrange the western warehousing area. Local actions were mostly based on the fundamental solutions contained in the first Master Plan, which were complemented with proposals to improve local community hubs. However, primary architectural and compositional sites were placed on the left bank. To combat flooding and waterlogging, the city planners decided to embank construction sites.

In December 2008, the City Duma adopted the Rules of Land Management and Development in the City of Birobidzhan, Jewish Autonomous Oblast. No new architectural compositional solutions are present in the newly adopted Master Plan. Development is highly localized. Developed area is expanding, albeit quite slowly. Over the last 20 years, such expansion has been minimal. Lack of a foundation for the advancement of major industries is compensated by the increasing numbers of small businesses that use the existing industrial sites. Downtown redevelopment is based on changing the functional status of existing buildings or replacing the old wooden residential houses with stone buildings, mostly non-residential. Demolition of dilapidated structures and new housing construction renders the appropriateness of site selection questionable. Detached housing is on the rise. Apartment blocks are constructed by one; those are mostly standardized buildings.
Speaking of the possible urban development, it is noteworthy that out of 150 square kilometers the city has, it only occupies some 60. The eastern block of the city is the most conservative one, as it mostly contains highly localized settlements that appeared in the early days of the city. Another inhibitor here is the nature of the location itself (wet- lowlands). The downtown between the railway and the left bank of the Bira river is well-developed. Thus, main focus shall be made on the western neighborhoods (right bank) as well as on the left-bank northern and southern areas.

The bulk of the modern left-bank housing is located in the floodplain of the Bira river’s valley. Birobidzhan is geotechnically difficult to deal with, as stands on gravel grounds unsuitable for protecting the housing against frequent flooding. The optimal solution they found was to construct buildings on embankments. Thus, the urban construction sites were man-raised. Embankment height varies from 1 to 5 meters.

Embarkment is prone to erosion. As a result, slops and roadsides are exposed to continuous erosion. Frost heaving and suffusion compromises the tarmac. The uneven settlement of soils causes buildings to deform. They have recently begun replacing tarmac coating that reduces soil moisturization with pavingstone that lets atmospheric moisture seep in the soil, which increases overall soil humidity.

On specific feature of the built-up areas in Birobidzhan is that groundwater runs at a depth of less than 3 meters. Construction and further use of such areas makes the soil weaker and more prone to deformation, which reinforces adverse geotechnical processes. Evaluation of Birobidzhan’s proneness to flooding shows that the city is entirely located in areas prone to flooding; less prone areas are found in the west of the city to the right of the river [1].

Atmospheric self-purification greatly depends on whether streets and roads allow free passage of prevailing winds, on how tall the buildings, the terrain, and the urban trees are. In Birobidzhan with its apparent monsoons, the street layout hinders natural ventilation. Houses in the downtown are facing the carriageway and stand too close to each other. Precincts are all built-up, too. Considering the low wind speeds in winter and the prevalence of calm weather, natural air draft in the downtown is too week. Residential areas near Bumagina and Shirokaya streets along the Bira river are exposed to breezes and are far less crammed, making for better ventilation.

Historically, the city has expanded beyond its initially planned limits. It often expands spontaneously with no proper attention to ecology. Thus, when considering the prospects of Birobidzhan’s further development and defining the frameworks of site-specific land management, one must take into account the existing environmental restrictions: (1) proneness to waterlogging; (2) lowland, wetland location; (3) high level of radon in the soil; (4) dependence on the prevailing winds; (5) proneness to surface- and groundwater pollution; (6) most valuable natural landscapes and habitats; (7) habitats of protected species; (8) protected aquatic areas.

These restrictions are fundamental to guidelines on urban land use in redevelopment. Birobidzhan’s area has plenty of great opportunities to create an environmental framework at little cost. This requires land use regulations to be in place applicable to plots of undamaged or little-damaged structure, as well as guidelines on environmental improvement of built-up areas that could form a reference framework for redevelopment.

Urban Environmental Framework. Environment-forming sites: 1 the protected watershed of the Bira river; 2 the Avgustov deposit of underground waters; 3 perennial woods; 4 marshes; 5 the dendrology park; 6 the habitat of Cristaria tuberculata Schumacher, a IUCN Red Book species. Environment-stabilizing and sanitation sites: 7 parks, gardens, and localized green spaces; 8 are collective gardens; 9 cemeteries; 10 recreational ponds; 11 protected watersheds of small water bodies. Linear elements of sanitation and hygiene: 12 enclosed industrial areas; 13 plantings along the carriageways; 14 the protected area of railways and highways.

Land-use Regulations. Recommended land use: same as today 15 residential low-rises; 16 residential mid-rises; 17 industrial sites; 18 sites not suitable for residential housing; 19 promenade. Recommended future use: 20 residential low-rises; 21 residential housing of varying height; 22 industrial sites. Recommended land use: alternative 23 demolition of housing; 24 cleansing of the
areas for placing environmentally friendly facilities or residential mid-rises; 25 environmentally hazardous areas, reclamation required.

Other designations: 26 are water bodies; 27 are the city limits.

Figure 1. Legend.

3. Conclusion
For the city of Birobidzhan, the research team has created an environmental framework that comprises the following:

1. Environment-forming sites of special, recreational, or educational purpose. These help preserve the integrity of nature and keep it functioning. Such areas are large and form the core of the local environmental framework. Those include the Avgustov deposit of underground waters, the dendrology park with its adjacent woods, and the protected watershed of the Bira river.

2. Environment-stabilizing and sanitation sites of special or recreational purpose. Natural structures are somewhat deformed at such sites. Those include the city park, gardens and localized green spaces, collective gardening farms, cemeteries, and protected watersheds of small water bodies.

3. Linear sites that stabilize the environment and serve special sanitation- and hygiene-related purpose. Those feature artificial communities. They include the enclosed industrial areas, plantings along carriageways, and the sanitation area along the railway.

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