Basic construction-ecological norms in urban systems and ecogeographic consequences of sustainable development of urban areas (in Sabirabad city representation)

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Abstract. Cities cover 3% of the earth’s surface, and Azerbaijani cities cover approximately 2% of the country’s territory. However, as in the world population, more than half of the population of Azerbaijan (52%) lives in cities. This is especially true for coastal cities. Goal: The purpose of the study is to assess the ecological consequences of the development of the Sabirabad city located on the river bank and to prevent future problems. The development and planning of the city of Sabirabad and its surrounding settlements, as well as their analysis, were reflected in the research work. At this time, satellite images of Sabirabad city for 1989, 2014, 2021, 2022 were processed. During the research, satellite images of August 2022 provided by AZERCOSMOS and satellite images of 2021 and 2022 obtained from Landsat 5, Landsat 8 satellites, and Google Earth were used. Studies of a period of about 50 years have been conducted, and territorial development of the city and surrounding settlements and future development forecasts have been prepared. 1:10,000 scale topo plans of the city of Sabirabad and its surrounding settlements from 1975 were used to accurately monitor the development of the borders, and the 2022 border was deciphered by us using satellite images provided by AZERCOSMOS and Google Earth. Also, the development of vegetation as a result of land use, the number and density of constructions in 2022, the absolute height of the relief of the city, the exposure of its slopes, and the density of roads were also analyzed and mapped. As a result of the research, it was found that the ecological situation is tense in Sabirabad urban landscape located on the banks of the Kura and Araz rivers. The reason for this is the denser settlement of the population along the river bank and the fact that the daily lifestyle of the inhabitants depends on the river waters. In recent times, the decrease in the water level in these rivers has aggravated the ecological situation. At the same time, the territory and population of the Sabirabad urban landscape continue to grow. Certain measures should be taken to reduce dependence on river water and reduce the impact of the population on the environment.

Keywords: urban landscape, planning, AZERCOSMOS, Landsat 5 and 8, NDVI, building density factor, road density factor

Основні будівельно-екологічні норми в міських системах та екогеографічні наслідки сталого розвитку міських територій (на прикладі м. Сабірабад)

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Анотація. Міста займають 3% земної поверхні, а міста Азербайджану займають приблизно 2% території країни. Однак, як і в світовому населенні, більше половини населення Азербайджану (52%) проживає в містах. Особливо це стосується прибережних міст. Метою дослідження є оцінка екологічних наслідків розвитку міста Сабірабад, розташованого на березі річки, та запобігання майбутнім проблемам. У досліджуваній роботі знайшли відображення розвитку міста Сабірабад і прилеглих до нього населених пунктів, а також їх аналіз. У цей час були оброблені супутникові зміни міста Сабірабад за 1989, 2014, 2021, 2022 роки. Під час дослідження були використані супутникові зміни серпня 2022 року, надані AZERCOSMOS, і супутникові зміни 2021 і 2022 років, отримані з супутників Landsat 5, Landsat 8 і Google Earth. Проведено аналіз за період близько 50 років, складено територіальний розвиток міста та прилеглих населених пунктів та прогноз розвитку на майбутнє. Для точного моніторингу розвитку кордонів використовувалися топографічні плани міста Сабірабад і його прилеглих населених пунктів у масштабі 1:10 000 1975 року, а кордон 2022 року ми розширили за допомогою супутникових зображень, наданих AZERCOSMOS і Google Earth. Також проаналізовано та нанесено на карту розвиток рослинності внаслідок землеукруп-
Introduction

Urban development and urban planning include the preparation, regulation and management of plans for cities and metropolitan areas (Buytaert, 2014). It serves to organize socio-spatial relations at different scales of government and governance (Forman, 2016). Urban planning is concerned with the social, economic and environmental consequences of defining spatial boundaries and affecting the spatial distribution of resources (Gupta, 2019).

Today, urban planning can be described as a technical and political process related to human well-being, land use control, urban environment design (including transportation and communication networks), and conservation and improvement of natural processes (Wang, 2018).

Buildings that do not conform to construction norms, buildings that are built without maintaining a distance between them, irregular proportions between natural and anthropogenic landscapes, and other reasons will cause inevitable problems in the future (Varoudakis, 2014).

As cities develop, so do surrounding villages and other settlements. At this time, it is important to properly plan and manage them because areas that are not properly planned and managed can cause important problems in the future. Especially during the territorial and population development of urban landscapes, the degree of impact on the environment should be taken into account. Unforeseen negative impacts can cause significant problems in the future such as land degradation, air pollution, water basin pollution, and more damage during emergencies. Therefore, the main goal of our study is based on the planning and analysis of Sabirabad city and surrounding settlements.

The tasks set during the research are as follows.

- Analysis of territorial development of Sabirabad city
- Analysis of territorial development of surrounding settlements
- Analysis of future development directions of Sabirabad city and surrounding settlements
- Analysis of population development of Sabirabad city and surrounding settlements
- Analysis of construction index in urban development and its evaluation
- Analysis of the ecological-building norm in the urban landscape

In order to investigate the ecological consequences of the development of cities, the dynamics of vegetation and the condition of suburban water basins, especially the Araz River and its oxbow lakes, were analyzed.

Our study area, founded in 1868, the city of Sabirabad, is located between the Kura and Araz rivers. In 1887, Ukrainians moved to the territory of the city, at that time 26 families were moved and settled in the territory of the city, and at that time it was called Petropavlovsk, and at the beginning of the 20th century it was called Galagayin. In 1920, it was named Petropavlovka settlement. Finally, in 1931, the name was changed to Sabirabad. The locality, which received the status of a settlement in 1952, received the status of city in 1959 (Amanova, 2022).

Research method

As we mentioned, during the study, the development of vegetation as a result of land use, the number and density of constructions in 2022, the absolute height of the city’s relief, the exposure of its slopes, and the density of its roads were analyzed and mapped.

Vegetation development as a result of land use was analyzed according to the NDV index, which is calculated according to the following formula.

\[
NDVI = \frac{(NIR - RED)}{(NIR + RED)} \quad (1)
\]

Here, NIR represents the near-infrared wavelength of the light spectrum (0.68 – 0.78 μm), RED represents the red region wavelength (0.61 – 0.68 μm), and NDVI (Normalized Difference Vegetation Index) represents the vegetation index value.

Number and density of buildings, road density maps and their analysis were prepared based on decoding of satellite images provided by AZERCOSMOS and Google Earth software.
Absolute height and aspect maps of the city relief and its analysis were made as a result of the Digital Elevation Model (DEM) processing of the area. ArcGIS, Google Earth, Excell and Corel Draw programs were widely used during the research.

**Results and their analysis**

Preparation of urban planning documents includes three main directions for environmental regulation:
1) zoning of territories;
2) compliance with the requirements of environmental protection, environmental safety and sanitary regulations;
3) assessment of the impact of urban planning objects on their environment.

In addition to zones with certain functional purposes (with a certain type of urban development use), zones with limited use for urban development activities are separated within the territory of urban settlements. These include the following:
- protection zones of cultural and historical monuments, historical-cultural complexes and objects;
- protected areas;
- zones of specially protected nature areas;
- sanitary protective zones;
- water protection zones and coastal protection strips;
- sanitary protection zones of water supply sources;
- territories affected by natural and man-made emergencies;
- zones of emergency environmental situations and ecological disasters.

As cities develop, functional zones also develop and expand, and the number of functional zones increases. According to city models, functional zones develop to different degrees. For this purpose, we have designed the model of the city of Sabirabad (Fig.1). Based on the model, it is possible to clearly see these nuclear zones and other functional zones. The city of Sabirabad, which we studied, partially conforms to Harris and Ullman’s urban model. The city first arose and developed along the Kura River, then the development of highways led to the creation of new nuclear zones. Thus, several nuclear zones have formed in the city. After the formation of the nuclear zone, it caused the formation of other zones around it.

As we mentioned, our research area covers the city of Sabirabad. The city is located mainly below sea level in the Kura-Araz plain (Fig. 2). Our research area is one of the important agricultural regions of the country, located in a harsh climate with a semi-desert and dry steppe climate, where the average annual precipitation is low and possible evaporation is high.

If we pay attention to the territorial development of settlements located around the city of Sabirabad, we can clearly see that the territory of all settlements has expanded (Fig. 3). Yeni Novruzlu, Novruzlu, Balakand, Bulagli, Mamishli are among the settlements whose territory has expanded the most during the years 1975-2022. The city of Sabirabad grew by 56.8% and reached 1191.7 ha (Table 1). The development of settlements has been in different directions. In general, we can note that the northern and eastern directions are dominant. This can be explained by the proximity to rivers and transport routes in those directions.

Beylik, Kurkandi and Hasanli settlements stand out for their relatively weak development, which is due to various reasons. Thus, the fact that the settlement of Kurkandi bordered the city of Sabirabad in the southern direction prevented its expansion in that direction, and in the eastern direction it was mainly surrounded by agro-landscapes.

In other directions, the fact that it is bordered by the Araz River has relatively prevented the expansion of the village area. The main reason for the poor development of the other two settlements is their distance from Sabirabad, the center of the district.
Balakand settlement has expanded mainly in the southern direction and by 164.5%, Balvar settlement has expanded mainly in the northeast direction and by 52.3%, Beylik settlement has expanded mainly in the north, northeast direction and by 38.2%, Bulagli settlement has expanded almost in all directions and by 141.6%, Javad has expanded mainly in the northern direction and by 105.8%, Asasdli has expanded almost in all directions and by 139.7%, Hasanli has expanded mainly in the northern direction and by 41.8%, Kurkandi has expanded mainly in the eastern direction and by 39.7%, Mamish settlement has expanded mainly in the north-northeast direction and by 125.9%, Novruzlu settlement has expanded almost in all directions and by 151%, Galagayin settlement has expanded mainly in the east and west directions and by 51.2%, the settlement of Suguvushan has expanded mainly in the northern direction and by 142.8%, and the settlement of Yeni Novruzlu has expanded mainly in the southern direction and by 274.3%. Among these settlements, Balakend, Balvar, Bulagli, Javad, Asadli, Hasanli, Kurkendi, Mamish, Galagayin, Sugovushan are included in the Sabirabad administrative district, and others are included in the Saatli administrative district.

If we give a forecast of future development, we can say that the settlements that can develop mainly in the northern direction are Balakand, Balvar, Beylik, Javad, Asadli, Hasanli, Sugovushan, and the settlements that can develop mainly in the southern direction are Yeni Novruzlu, Novruzlu, Galagayin and Sabirabad. (Table 1).

During urban planning, the absolute height of the relief and aspect of relief are among the main indicators (Fig. 4). For this purpose, if we pay attention to the absolute height of the relief in the city of Sabirabad, it becomes clear that the majority of the research area is located at an altitude of (-10)-(-5), which is 46.8%. Then the areas with (-5)-0 m absolute height cover 28.8% of the area. Areas above sea level account for only 0.5% (Fig. 5). If we pay attention to the density of population settlement and construction, the location of the main socio-economic facilities, it is precisely the areas with a height of (-10)-(-5) m that have been more widely adopted.

To analyze the roads in Sabirabad city, all the roads in the city area were vectorized and mapped, based on which a road density map was prepared (Fig. 6). It was determined that the total length of the roads is 150 km. The highest indicator of road density is observed along the main line passing through the city.
### Table 1. Statistical indicators of the territory dynamics of Sabirabad city and surrounding settlements in 1975-2022

<table>
<thead>
<tr>
<th>№</th>
<th>Settlement</th>
<th>The administrative district to which it belongs</th>
<th>area (ha)</th>
<th>Dynamics</th>
<th>Directions of development in 1975-2022</th>
<th>Future development forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Balakand</td>
<td>Sabirabad</td>
<td>104</td>
<td>275.1</td>
<td>171.1 / 164.5</td>
<td>S N-W, S</td>
</tr>
<tr>
<td>2</td>
<td>Balvar</td>
<td>Sabirabad</td>
<td>58.5</td>
<td>89.1</td>
<td>30.6 / 52.3</td>
<td>N-e N, S, E</td>
</tr>
<tr>
<td>3</td>
<td>Beylik</td>
<td>Saatlı</td>
<td>106.1</td>
<td>146.6</td>
<td>40.5 / 38.2</td>
<td>N, N-E N, S</td>
</tr>
<tr>
<td>4</td>
<td>Bulagli</td>
<td>Sabirabad</td>
<td>78.8</td>
<td>190.4</td>
<td>111.6 / 141.62</td>
<td>In all directions In all directions</td>
</tr>
<tr>
<td>5</td>
<td>Javad</td>
<td>Sabirabad</td>
<td>318.9</td>
<td>656.2</td>
<td>337.3 / 105.8</td>
<td>N N, E</td>
</tr>
<tr>
<td>6</td>
<td>Asadli</td>
<td>Sabirabad</td>
<td>129.9</td>
<td>311.3</td>
<td>181.4 / 139.7</td>
<td>In all directions N, S, E</td>
</tr>
<tr>
<td>7</td>
<td>Hasanali</td>
<td>Sabirabad</td>
<td>128.7</td>
<td>182.5</td>
<td>53.8 / 41.8</td>
<td>N N, S</td>
</tr>
<tr>
<td>8</td>
<td>Kurkendi</td>
<td>Sabirabad</td>
<td>140.7</td>
<td>196.6</td>
<td>55.9 / 39.7</td>
<td>E</td>
</tr>
<tr>
<td>9</td>
<td>Memishler</td>
<td>Sabirabad</td>
<td>193.4</td>
<td>436.8</td>
<td>243.4 / 125.9</td>
<td>N, N-E W</td>
</tr>
<tr>
<td>10</td>
<td>Novruzlu</td>
<td>Saatlı</td>
<td>134.5</td>
<td>337.6</td>
<td>203.1 / 151</td>
<td>In all directions S, W</td>
</tr>
<tr>
<td>11</td>
<td>Galagayn</td>
<td>Sabirabad</td>
<td>447.1</td>
<td>676.1</td>
<td>229 / 51.2</td>
<td>E, W S</td>
</tr>
<tr>
<td>12</td>
<td>Sabirabad</td>
<td>Sabirabad</td>
<td>760.1</td>
<td>1191.7</td>
<td>431.6 / 56.8</td>
<td>N-E, S-E S-E</td>
</tr>
<tr>
<td>13</td>
<td>Sugovushan</td>
<td>Sabirabad</td>
<td>77.5</td>
<td>188.2</td>
<td>110.7 / 142.8</td>
<td>N N-W, S-E</td>
</tr>
<tr>
<td>14</td>
<td>Yeni Novruzlu</td>
<td>Saatlı</td>
<td>61.1</td>
<td>228.7</td>
<td>167.6 / 274.3</td>
<td>S S-W</td>
</tr>
</tbody>
</table>

### Fig. 4. Absolute absolute height (a) and aspect (b) in Sabirabad city

### Fig. 5. Statistical indicators of the absolute height of relief in the city of Sabirabad
center, which, of course, is related to the location of the Central Business District. As you move away from the core, the density of roads decreases. These areas are mainly areas with low-rise courtyard houses.

In 2022, studies were carried out after the map reflecting the construction density ratio of the city was drawn up as a result of the decoding and processing of individual residential houses, buildings, public catering facilities and other construction buildings, construction sites in the city of Sabirabad (Fig. 7). It should be noted that this type of research was conducted by us for the first time in the country. It is also clear from the map that the Central Business District, which represents the areas surrounding the highway, and the surrounding areas have a high density of construction.

The density of construction varies from 0-14, so that the areas with a high coefficient cover an area of 53 ha, mainly in the central part of the city. Areas where the coefficient is less than 4 cover 62% of the study area. Areas with a coefficient of 0-2 cover 29.3% of the study area, areas with a coefficient of 2-4 cover 32.9% of the study area, areas with a coefficient of 4-6 cover 19.4% of the study area, areas with a coefficient of 6-9 cover 13.9% of the study area, and areas with a coefficient of 9-14 cover 4.5% of the study area (Fig. 8).

Satellite images of 2000 and 2022 were analyzed to monitor the dynamics of anthropogenic impact on the city (Fig. 9). If we pay attention to the satellite image covering the city of Sabirabad and a part of it, we will see that a part of the Araz River, which once covered a large area in the southwestern part of the city, has been drained and drawn into the construction area. This, of course, will cause microclimate changes in the near future. As we know, urban landscapes are the main cause of climate changes.

As we know, the creation and expansion of green zones during the construction and development of cities is one of the issues of special importance. From this point of view, we can say that the development of sustainable cities and the expansion of green zones
are also important for our research area. For this purpose, Landsat 5 and 8 satellite images of Sabirabad city from 1989, 2014 and 2022 were processed (Fig. 10). If we pay attention to the maps, we will clearly see that the green areas are expanding and the species composition is getting richer.

**Fig. 9.** Drainage of the water basin due to anthropogenic effects around the city of Sabirabad and used under construction (a- in 2000, b- in 2022)

Note: the image was processed using Google Earth software

**Fig. 10.** Dynamics of NDV index in Sabirabad city
It is possible to find areas where the index is negative and higher than 0.4 in 2021. If we pay attention to other indicators, we will see that areas with an index of 0.2-0.3 especially increase in 2021. Areas with an index of 0-0.1 have continuously decreased since 1989, areas with an index of 0.1-0.2 decreased sharply until 2014, but continued to decrease relatively in the following period, areas with an index of 0.3-0.4 increased until 2014, then decreased (Fig. 11). This was influenced by various factors. It should be noted that although the area of these places has decreased, if we take into account that the indicators of the index correspond to individual landscapes, it is known that the areas with an index of 0-0.15 mainly indicate empty areas and areas without vegetation, which means that these areas have decreased over the past years and are replaced to construction sites, infrastructure and parks. The areas where the index is above 0.2 are the areas where vegetation is present, which proves that the area of greenery is increasing. The decrease in the area of higher index areas indicates that the area of crops and trees in private courtyards has decreased.

The urban area is dominated by a mild-hot semi-desert and dry desert climate with dry summers. In the study area, semi-desert plants are spread on grey-meadow soils, and desert plants are spread on saline soils in separate areas. As a result of anthropogenic effects, large areas of wormwood semi-desert are used under cotton and grain crops.

Maps belonging to 3 different years were compared for analysis (Fig. 12). The results were evaluated in 4 categories. This includes areas of underdevelopment, areas of weak, moderate and strong development.

A comparison of 2014-1989 shows that 67.5% of the study area has poor development (Fig. 13). In 19.6% of the territory, development lag is felt, which mainly includes backyard areas. As we mentioned, crops and trees in these areas were replaced by construction, and as a result, vegetation was destroyed, so the indicator of the index also decreased. The areas with moderate and strong development have expanded, which, as we said before, shows the expansion of green areas in cities, especially parks. Of course, this development is not evenly distributed across the urban landscape.

The population of Sabirabad city is 31.4 thousand people as of January 2022. 15.4 thousand of them are men and 15.7 thousand are women. If we pay attention to the number dynamics of the population, the growth of the population in 5-year periods was different. Thus, this indicator was 33.2% in 1990-95, 5% in 1995-2000, 1.8% in 2000-2005, 1.8% in 2005-2010, 2010-2015 observed with an increase of 5% in 2015-2019, 3.4% in 2015-2019, and 0.6% in 2019-2022 (Fig. 14).
Conclusions

The city of Sabirabad grew by 56.8% and reached 1191.7 ha. The population of Sabirabad city has increased by 56% in 32 years.

The rapid exploitation of the territory along the highway and along the Araz River has led to the drying up of the oxbow lakes of Araz River, soil and vegetation degradation.

The expansion of the city has led to the destruction of the surrounding farmlands and pastures. This may lead to food shortages in the future.

References


