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Investigation of effects of land use and land cover on environment of urban landscape based on GIS

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Abstract

In the article, we have analyzed the territorial and population development of the Saatli urban landscape located in the Mugan plain in the territory of the Republic of Azerbaijan, and we have shown the results of its impact on the environment. For this purpose, a 1:10 000 scale topographic plan of the city dated 1975, and satellite and space images of the XX and XXI centuries were used. Based on Landsat 5 and 8 satellite data, the land use situation of Saatli City was analyzed. Land use in the urban landscape is affected by the relief of the area, morphometric indicators of the relief, climatic conditions and others. Therefore, we have studied these elements based on modern technologies. As a result of the analysis of the territorial development of the urban landscape, it was determined that the arable lands in the surrounding areas were replaced by construction sites, and even the 30-hectare oxbow lake of the Araz River was turned into a construction site. Intensification of land use in the urban landscape is closely related to population growth in cities. Population dynamics show that the city was included in the group of medium-sized cities in 2020.

1. Introduction

Cities cover 2% of the Earth's surface (Breuste and Qureshi, 2011). However, more than 50% of the world's population lives in cities [Arnaiz-Schmitz C. et al, 2018]. By the end of the century, this figure is forecasted at 70% (Mikadze, 2015). From this point of view, the study of cities, monitoring the dynamics of their development, and forecasting the future can be considered a topical issue of our time.

What is the city? This concept is perceived differently in different countries. For example, in Azerbaijan, a city is a settlement with a population of more than 15,000 and non-agricultural activities. There are 79 cities in the country. One of these cities is Saatli, which we studied in the article.

Cities are the most intensively developed settlements on the Earth (Forman, 2016). In this regard, their study is very important. Factors affecting urban settlement are classified as follows (Cheshmehzangi, 2015).

- historical factors
- use of natural resources
- construction of industrial enterprises

- administrative-management and trade-distribution function

- Establishment of resort-sanatorium economy
- labor resources

Cities have been studied both in terms of territory and population [Amanova, 2021, 2022]. The city of Saatli is located on the Mughan plain and forms the administrative center of the Saatli region.

2. Method

Our research is based on the processing of satellite and space images. In addition, a 1:10,000 scale topographic plan dating back to the 1970s was used to track the city's territorial development.

In order to determine the anthropogenic impact on the urban landscape, aerospace images for 1989, 2014 and 2022 were detected, construction sites were vectorized and analyzed. For the analysis of the level of urban development, satellite images for 2022 were detected by us and the surface cover was studied.

Images from Landsat 5 and 8 satellites were used to analyze the current and past situation in the vegetation and water basins.

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Based on the Digital Elevation Model of the city, maps reflecting the absolute height and exposure were prepared, analyzed in conjunction with the construction site map, and the role of these factors in the creation of construction sites was analyzed.

3. Results

The city of Saatli belongs to a group of cities descended from villages due to its favorable economic and geographical position due to its genetic characteristics (Fig. 1).

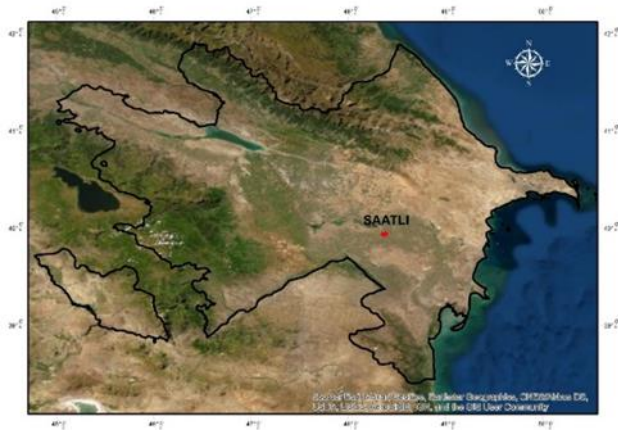


Figure 1. location of the investigation area within the Republic of Azerbaijan

Climatic conditions also affect settlement. High temperatures in the summer months require adaptation of the construction, operation of industrial enterprises and population to these conditions. High temperatures overheat the streets and walls of buildings, creating discomfort. In this case, the way out is to plant greenery, especially on the banks of the Araz River, it would be more expedient to increase the area of greenery.

The climatic factor affects the maintenance of the housing stock, the operation of enterprises, the cost of production processes. We come to the conclusion that the urban planning process should be linked to the climate.

The city of Saatli, located in the northern part of the Mugan Plain, has a temperate-hot semi-desert and dry steppe climate with dry summers. The total annual amount of total radiation is 133 kcal/cm², and the amount of radiation balance is 45 kcal/cm². The average annual temperature is 14° C. The average temperature of the coldest month is 1,4° C, and the temperature of the warmest month is 26,2° C. During the summer months, the absolute maximum temperature sometimes rises to 40° C. The average annual minimum temperature is -12° C. In the coldest months, the absolute minimum temperature is -26° C.

Temperatures above 5° are only 4900-5000°, and temperatures above 10° are only 4400-4500° C. The average annual relative humidity is 74% and varies between 60-85% during the year. Possible evaporation is 900-1000 mm per year. The average annual wind speed is 2,2 m/s.

Such favorable climatic conditions are among the factors contributing to the development and expansion of the Saatli urban landscape in the lowlands. The combination of temperatures above 5 and 10 ° C, the low number of snow and hail days, and the low average annual wind speed create favorable conditions for agriculture in the city. At the same time, the large number of sunny days in the plain relief makes it convenient to build solar power plants within the green economy. Taking into account the hydropower potential of the Araz River, we can say that there are favorable opportunities for the construction of small hydropower plants. However, due to the recent drought, it would be appropriate to delay this work to some extent.

The level of groundwater in the city is also one of the factors influencing the development of the area and the territorial organization of the economy.

The relief of the plains makes the slopes less sloping, which creates conditions for the development of agriculture and animal husbandry. From this point of view, we can note that Saatli is one of the cities of agricultural purpose.

If the area of Saatli city was 8,9 km² according to the topo plan of 1975, in 2022, based on the decoding of aerospace images, it was found that the city area expanded to 18.4 km² (Fig. 2). This means that the average annual area growth is 2,27%. If we look at the direction of expansion of the city, we see that it is expanding mainly in the south-west and north-west. This is due to the existence of rural settlements in other directions, resulting in limited opportunities for expansion and the water canal passing through the area. If we look at the space image, we can see that the city has arable land in the south and south-east. This will lead to problems with food supply, destruction of fertile lands, provision of fodder base for livestock in urban landscapes.

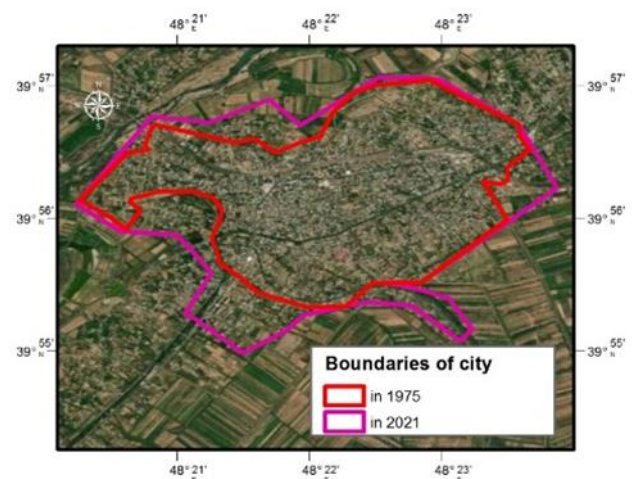


Figure 2. Dynamics of boundaries of Saatli city in 1975-2021

Most area of Saatli urban landscape is below sea level. Based on the results of the map compiled on the basis of the Digital Elevation Model of the area, we determined that 0,5% of the urban area is below (-25) m, 1,6% at a height of (-25) - (-20) m, 17,4% at a height of (-20) - (-

15) m, 51,2% at a height of (-15) - (-10) m, 2,7% at a height of (-10) - (-5) m, 26% at a height of (-5)-0 m, and 0,5% at a height of 0-3.4 m. The most optimal height for the population is the area with an urban landscape (15) - 0 m.

Based on the DE model, a map showing the aspect in the urban landscape was compiled. Based on the results, we can say that the urban area is almost evenly distributed on all aspects.

If we pay attention to the population dynamics of Saatli city in the XXI century, we can see that the population has increased from 16 thousand to 20.1 thousand in the last 20 years, which shows that in 2020 the city has received the status of a medium city. Over the past 20 years, the average annual population growth was 1.2%.

Urban development has a strong impact on the environment. Developing cities affect water, land, vegetation and the atmosphere. For this purpose, we have studied the damage caused to the environment by the dynamics of the territory and population within the urban landscape.

As a result of decoding the aerospace images of Saatli for 2000 and 2022, we found that the number of constructions has increased in 22 years. In 2000, the area with a construction density coefficient of 0-1 was 7,78 km², but in 2022 it was reduced to 3,33 km². Areas with a coefficient greater than 1, on the other hand, have increased. For example, areas with a coefficient of 1-2 increased by an average of 50%, areas with 2-3 increased by 200%, areas with 3-4 increased by 7 times, areas with 4-5 increased by 5 times, and areas with more than 5 increased by 2 times. These figures show that construction in the Saatli urban landscape, which is the study area, has been growing rapidly for 22 years.

4. Conclusion

The area of the urban landscape has increased by 106% in 47 years, which means that the average annual growth is 2,27 %.

The average annual population growth in the city was 0,9-7,4% in the XX century, but dropped to 1,2% in the XXI century.

During 2000-2022, the number of constructions in the city increased by 1162 units and reached 2124 units.

In order to prevent environmental pollution in the city, it is expedient to clear the forest strip along the banks of the Araz River.

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