

INVESTIGATION OF NATURAL CONDITION IN URBAN
LANDSCAPES OF PLAIN AREAS BASED ON GIS

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Abstract

Cities are major sources of carbon dioxide, nitrogen oxides and other toxic gases. Strong development of transport and industry is a major factor in the deterioration of the environmental situation in the city and surrounding areas. From this point of view, the topic we have studied is also very relevant. We have analyzed the current situation of the city of Imishli, located in the central arid area of the Republic of Azerbaijan – Mil plain, on the basis of modern technologies and have studied the previous situation on the basis of funds and literature, then have compared all the results. The factors affecting the environment in the city have been comprehensively analyzed. Density of constructions, population dynamics, the relationship between population growth and area expansion, the dynamics of vegetation cover, the impact of industrial and agricultural enterprises, transport on the atmosphere, hydrosphere and biosphere were studied.

Key words: cities, environment, remote sensing, satellite imagery, Landsat 5, 8, Sentinel 2

Introduction. Cities cover only 3% of the Earth. However, more than 55% of the world's population lives in cities [1]. Given that the core of the ecological crisis, the emergence of global environmental problems, is anthropogenic, therefore we must study cities.

Urban activities contribute to current environmental degradation, both within and beyond their boundaries [2]. These environmental impacts primarily result

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from energy and material use in cities (particularly in transport and buildings), increasing consumption patterns, including for food, and the generation and management of waste. Urban environment planning and management needs to consider ecological processes and nature-based solutions for all city inhabitants, both human and non-human [3].

Materials and methods. During the research, we conducted analysis based on GIS technologies using literature materials from previous years, satellite and space images of the area.

The area was vectorized using a plan drawn up in 1975, the acquired area was studied and the dynamics were analyzed by processing satellite and space images for 2010 and 2022.

Satellite images of 2010 and 2022 were processed and constructions were identified, the developed area of the city and development directions were studied. Also, as a result of the processing of these satellite images, the degree of vegetation cover was analyzed and the dynamics of planting, pastures, construction, water basins and vacant land in 2010–2022 were analyzed [4].

Results. The intensity of urbanization, pollution of air, water and soil, the use of large amounts of water for domestic purposes, as well as climate change create a number of biomedical problems [5].

The main sources of chemical pollution in cities (along with heating systems) are industrial enterprises, transport and the process of incineration of various wastes [6]. Industrial sources include: ferrous and nonferrous metallurgy, petrochemicals, construction materials, chemicals and other industries, as well as co-generation plants. The main pollutants in power plants are complete (sulphur and ash oxides) and incomplete (mainly carbon monoxide, hydrocarbons) combustion products, especially nitrogen oxides. Oil-burning thermal power plants emit almost no ash, but emit three times more sulphur dioxide [7].

Internal combustion engines consume significant amounts of oxygen and their exhaust gases contain more than 200 different chemicals [8]. The main part is carbon monoxide and its dioxide, nitrogen oxides, hydrocarbons and compounds of lead. It was determined that a car with an annual distance of 15 000 km received 4.4 tons of oxygen from the city atmosphere and emitted 3.3 tons of carbon dioxide, 0.5 tons of carbon monoxide, 0.1 tons of toxic hydrocarbons and 30 kg of oxide [3].

Urban traffic is the largest source of carbon monoxide (about 90% of total anthropogenic emissions) [9].

If we pay attention to the comparison of water consumption in Imishli region in 2005–2020, we clearly see the decline from 2005 (289 million m³) to 2018 (235.9 million cubic meters), then until 2020 (245.2 million m³) there is growth again. We can clearly see the same dynamics in the amount of water used for domestic purposes. Thus, while in 2005 this figure was 2 million m³, in 2019 it was 1.5, and in 2020 it was 1.6 million m³. The amount of water used for production

decreased to 2018 and amounted to 2.6 million m³, and in 2020 it was 5 million m³. However, an increase in the amount of water used in agriculture has been observed since 2015. In 2015, this indicator was 223.8 million m³, and in 2020 it was 236.4 million m³.

There is an increase in the amount of wastewater discharged in 2005–2010 (from 0.7 million cubic meters to 1.9 million m³), and a decrease (0.2 million m³) by 2020 [10].

Pollutants emitted into the atmosphere from stationary sources have increased steadily since 2005, from 0.2 thousand tons to 0.5 thousand tons, which is an increase of 2.5 times.

In 2019, the amount of carbon monoxide in the total amount of pollutants emitted from transport was 4.1 thousand tons, nitrogen oxides 0.7 thousand tons, and the amount of hydrocarbons 0.8 thousand tons. In 2020, we observe an increase in the total amount of these pollutants, which was found to be 6.7 thousand tons.

If we look at the amount of household waste collected by utilities, we see that in 2005 this indicator was 230 000 tons, and in 2010 it was 12 000 tons, then it decreased steadily every year and in 2020 it dropped to 4800 tons.

Our research area covers the city of Imishli and the surrounding area, located in the Mil plain on the banks of the Aras River. In order to study the area, both the city area and the area of the buffer zone at a distance of 5 km from the city were studied. The area of the city to be developed in 2022 is 22 km², and the buffer zone covers 213 km².

Imishli is located in the southern part of the Kura-Aras lowland. The climate of the area belongs to the type of temperate-hot semi-desert and dry steppe climate with dry summers. This type of climate is characterized by very low and low humidity, mild winters and dry summers. White wind is often observed in the area.

The annual amount of total radiation is 131.8 kcal/cm², and the amount of radiation balance is 45.4 kcal/cm².

The average annual temperature reaches 14 °C. Winter is mild. The average temperature of the coldest month is 1.6 °C, and the average temperature of the warmest month is 26.1 °C. In summer, the absolute maximum temperature sometimes rises to 40 °C. The average annual absolute minimum temperature is -11 °C, ranging from -9 °C to 16 °C during the year. Sometimes the absolute minimum temperature drops to -24 °C. The average annual temperature of the soil surface is 18 °C. During the year, the average monthly surface temperature varies between 2 °C and 34 °C.

The average annual relative humidity was 73%, ranging from 59 to 84% per year. Annual precipitation is 302 mm. However, the surface cover is subject to possible evaporation of 1000 mm per year.

The average annual wind speed does not exceed 2.2 m/s. East and south-east

winds blow in the area. The annual number of strong winds (more than 15 m/s) does not exceed 7 days. The number of white windy days reaches 24. The number of snow-covered days does not exceed 12. It rains only 0.5 days a year.

In order to analyze the spatial dynamics of the urban landscape, the city's plan for 1975 was vectorized, satellite and space images for 2010 and 2022 were processed. The inhabited area of Imishli covered 12.3 km² in 1975, 17 km² in 2010 and it covers 22 km² area now. The average annual growth rate of the area was 1.1% in 1975–2010 and 2.5% in 2010–2022. We come to the conclusion that the territory of the city has grown faster in the 21st century.

When studying the density of constructions in the urban landscape, space and satellite images from 2010 and 2022 were processed and it was concluded that the urban area was developed both in the formerly inhabited areas in the centre and mainly in the north as industrial enterprises and in the south-east as settlements (Fig. 1).

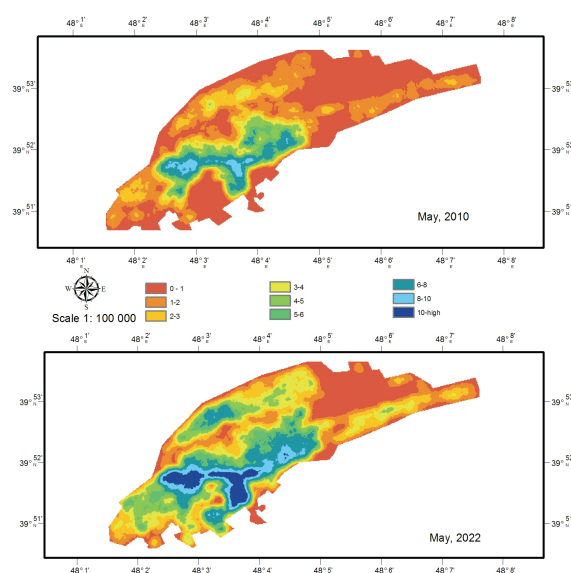


Fig. 1. The density of buildings in 2010 and 2022

If we look at the construction density map for 2010, we can see that the highest coefficient is 10, and in 2022 it is 13.78. The 0–1 coefficient increased 3 times in 2022, and the areas with a coefficient greater than 2 increased 2–3 times. Areas with increasing construction density are the central nuclear part of the city, where the main infrastructure is located.

Even in 2010, an unnamed oxbow lake (0.25 km²) in the southeastern part of the city dried up and became a residential area. It should be noted that this unnamed lake is an oxbow lake of the Aras River.

In order to analyze the relationship between inhabited area and absolute

height in the Imishli urban landscape, the Digital Elevation Model (DEM) of the area was developed, and the newly built areas were superimposed and analyzed in 2010–2022 (Fig. 2).

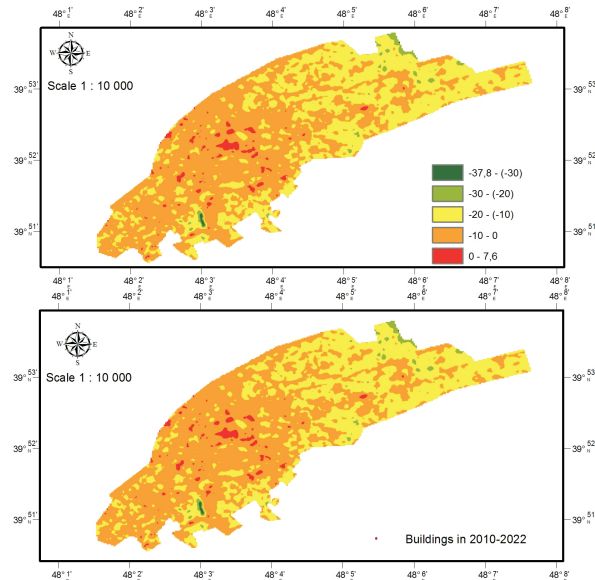


Fig. 2. The relationship between DEM and newly built buildings in 2010–2022

If we look at 2022, we see that more than 97% of the urban landscape is below sea level. More than half of the city of Imishli is located between $(-10) - 0$ m. Therefore, the most favourable conditions for development are the areas up to (-10) m above sea level.

The population of the urban landscape was 9.5 thousand in 1959, 17.8 thousand in 1970, 25.7 thousand in 1989, 31.3 thousand in 2014, 35.5 thousand in 2017, and 37 thousand in 2022. The average annual population growth was 2.3% in the 20th century and 3.5% in the 21st century.

The development of cities, both territorially and in terms of population and economy, affects the environment. The expanding urban area is destroying the surrounding pastures and agro-landscapes, resulting in food shortages in cities and suburbs. For this purpose, satellite images of the area from 1989, 2014, 2021 and 2023 were processed. The June 1989 image belongs to the Landsat 5, the images from June 2014 and June 2022 belong to the Landsat 8 satellite, and the image from June 2023 belongs to the Sentinel 2. Areas with a NDV index of less than 0 are water basins, cloudy areas, areas with 0–2 are vacant areas, and areas with more than 2 are construction and vegetation areas, which include crops, shrubs, gardens, forests and other areas. Given that the study area is located in an arid zone, we can note that the high coefficient corresponds to the agro landscapes.

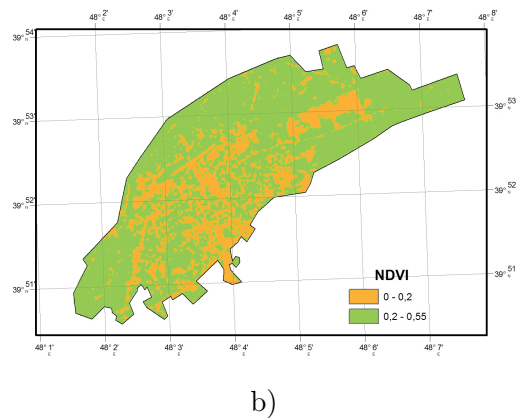
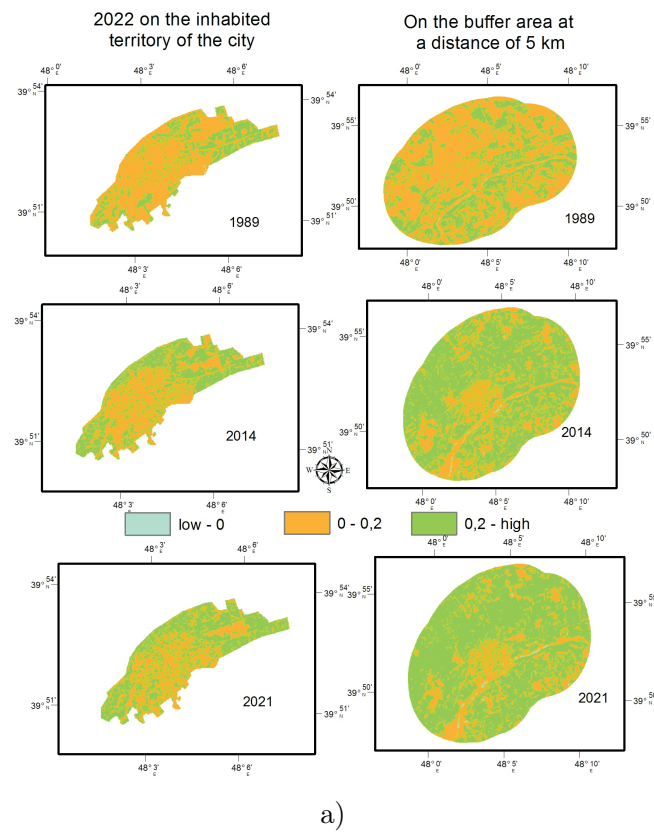


Fig. 3. Indicator of surface appropriation based on NDV index in
a) 1989, 2014 and 2021 based on Landsat images, b) in 2023 based
on Sentinel 2

In the buffer zone of the urban landscape, the minimum indicator was -0.01 in 1989, 0.012 in 2010, and -0.01 in 2022, and the maximum indicators were 0.49 ,

and 0.56, respectively (Table 1). According to the dynamics of 1989–2022, we see that most of the vacant land was appropriated by the population in 2022 and turned into construction and arable land. The expansion of backyards has also led to the expansion of individual fields and gardens in these backyards. Processing of Sentinel 2 satellite images shows that there are no areas with a negative index in 2023. The total area of the places where the index is up to 0.2 is 6 sq km, and the areas where the index is 0.2–0.55 are 16 sq km. Processing of Sentinel 2 satellite images shows that the water basin has completely disappeared by 2023. This is identical to the results of field research.

T a b l e 1

Table 1. Dynamics of NDV index in the territory of the city and in the buffer zone in 1989–2023 (in km²)

Date	Place	NDVI			Indicators of NDV index
		low-0	0–0.2	0.2-high	
06/1989	Within the border	0.1	15.6	6.3	–0.01–0.49
Landsat 5	Within the buffer zone	0.6	135.7	76.7	–0.08–0.49
06/2014	Within the border	0.01	11.4	10.59	0.012–0.44
Landsat 8	Within the buffer zone	0.6	68.6	143.8	–0.09–0.49
06/2021	Within the border	0.05	9.9	12.05	–0.01–0.49
Landsat 8	Within the buffer zone	1.1	56.4	155.5	–0.14–0.56
06/2023 Sentinel 2	Within the border	–	6	16	0–0.55

In 1989, 5 ha of solid waste was allocated for the discharge of fecal water in the city of Imishli, and in 2018, an additional 1.0 ha was allocated. The actual area is 8.91 hectares. The volume of imported waste is 60 m³/day. The solid waste landfill is located about 50 m from the settlement, in the area of the river-bed of the Aras River [11]. The area is not fenced, the gate is not buried, warning signs are not installed, there is no access control, waste is not sorted, placed without a system, piled up and burned. Stray dogs, large and small cattle are found in the area. Fecal water and waste generated during production at the Imishli sugar plant are brought to the landfill from the Agammadli village of the region.

In 2006, the Imishli Sugar Company, the largest sugar processing plant in the South Caucasus, was opened in Imishli with the investment of Azersun Holding. A total of \$ 97 million has been invested in the plant. The plant processes 300 000–350 000 tons of sugar a year, with 1000 tons per day. After an additional investment of \$ 10 million, the plant's processing capacity is expected to increase by another 50%.

In addition, there is a distillery with a daily production capacity of 13 tons of alcohol in the city and surrounding areas, a plant of vegetable oils with a capacity

of 200 tons/day, a mixed feed plant with a capacity of 600 tons/day, a reinforced concrete plant, Muradkhanli oil field and other enterprises.

All the industrial and agricultural enterprises mentioned and not mentioned, transport and cargo transportation are the main factors polluting the environment in the urban environment.

Conclusion. The expansion of the city's territory has led to a reduction in pastures and arable land. The construction of individual houses has led to the expansion of gardens and fields in the backyards. The city's territory has almost doubled in the last 47 years.

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