The current state of green spaces and their historical changes in Bukhara City

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Abstract. The article is based on the research and scientific results of the condition, size and quantity of green spaces in the city of Bukhara in the last 30 years. The study details the fact that green spaces are the main source of life for urban residents, as well as their important functions of protection from urban noise, recreation, environmental protection, aesthetics and even investment. The scientific conclusions and practical suggestions obtained as a result of research studies are also described in this article.

1 Introduction

The best way of decreasing the danger to ecology in sharp continental climate cities where winter is dry and chilly and summer is extremely hot, is to green these areas. In this case, green spaces which consisted of only plants temperate the atmospheric condition of the area. The green spaces are created in certain areas in the prescribed manner and serve for sanitary recreation and economy purposes. Green zones are often designed in the form of urban forests, forest-gardens, parks, avenues, parks, and are used for public recreation of the population, where there will be pools, beaches, coastal facilities and other recreational facilities.

Green spaces designed in the prescribed manner cause decrease of the temperature to 6-8°C and temperature on the surface of soil and roads to 15-24°C. The more plants are in the area and the taller these plants are, the cooler the temperature there will be. Besides that, by absorbing the radiation from the sun and by evaporating the water, green plants increase the air humidity, clean polluted air up to 85 %.

The standards of green places for cities are already designed. While World health organization suggests that 9 square meter space should be for each individual, world urbanization norms point out that at least half of the residential places should consist of green areas. Based on the conclusion of ecology scientists, 50 square meter green space produces the amount of oxygen for an individual. In some countries the exact norms and standards are set to make the green areas. For example, in Los Angeles 48.5 square meter green place must be for each person, in Cambridge, this amounts to the 46 square meter, in Washington 38 square meter, in Malaysia 20 square meter.

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According to the legislation of Uzbekistan, green areas for one person in the city should at least be 17-19 square meters, and in cities surrounded by the desert, at least 13-15 square meters.

In the Urban Planning Code of the Republic of Uzbekistan, the term "greened area" defines that the parts of natural areas are artificially organized gardens, parks and other facilities, including gardens, parks, avenues (squares), boulevards, residential and public and business areas and other areas, and their at least 70 percent of areas should be green areas and plants. This code recommends preserving existing green and water areas when creating gardens and parks in urban areas. Therefore, the standards are set to organize city parks on 15 hectares, 10 hectares in districts, 3 hectares in residential districts, and 0.5 hectares in avenues.

Modern urbanization process and the development of city infrastructure often cause to become green areas less and the disturbance of the balance of the city environment. Thus, the role of plants in cleaning the air, making comfortable living environment for people and their irreplaceable impact on maintaining the balance of environment is being forgotten.

The city of Bukhara, with its unique natural and climatic conditions, has its place in the history of world civilization. At the same time, the city's nature, climate, and location had a great impact on its development. Bukhara city is characterized by a sharp continental climate, short yet chilly winter, long and extremely hot summer, extremely low rate of air humidity, large differences in annual and daily temperature. For the uncomfortably located Bukhara city, climate change, global warming is serious ecologic worry. In the city where winter is dry and chilly and summer is extremely hot, the practical way of decreasing this ecologic danger is to make green the areas. In this case, green spaces which consisted of only plants temperate the atmospheric condition of the area.

During this study, the historical changes of green areas in the city of Bukhara in the last 30 years were compared and studied. Especially, how the share of green spaces in the city changed during the years 1991-2021, what were the reasons and causes for this, and what consequences and results were brought to it were mainly researched. The results of study help planning urbanization, rescue the eco-system of the city. Moreover, it can be of great help for decision-makers and researchers in this area.

2 Materials and methods

Bukhara is located in the lower reaches of the Zarafshan river, to the south-west of Uzbekistan. Bukhara city is 72.9-square kilometers regional center, currently 284.8 thousand people reside. 43 km of the city border is connected to the Bukhara district, and 15 km to the Kagan district (Figure 1).

In the research, National archive materials of Uzbekistan, Documents of the state archive of Bukhara region, Department of Ecology and Environmental Protection of Bukhara Region, archive materials of Bukhara city municipality and references of “Uzshaharsoz” institution on how general plan of Bukhara city is going to influence are used.

The scientific works of Sh.A. Hayitov, A.B. Niyazov, D.Sh Yavmutov, I.H. Hasanov about the nature, climate, ecological problems of the city of Bukhara and their causes and consequences were used. Scientific articles of Turdiev B, Mukhamedjanov A, Nowshin N. were studied in researching the concepts of green area and green city. The size, condition and types of plants planted in the city's green areas were taken into consideration based on the data of the Bukhara City Improvement Department for 1991-2021. More, additional materials were compiled on the basis of conversations and interviews conducted with representatives of older generation and historians.

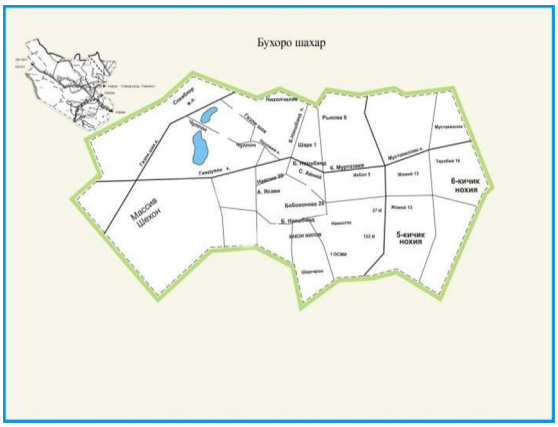

Fig. 1. The administrative-territorial map of the Bukhara city

3 Results and discussion

The climate of the region is characterized by low cloudiness, a lack of rain, and the presence of a thin layer of snow. In summer in Bukhara, humidity drops to 10% and temperature rises to +45+48°C. Considering that the air temperature +20+22°C and the relative humidity of the air should be around 40-60 percent for a normal life of a person, the city climate is not suitable for a normal life. Due to the city's daily life activities and the absorption and release of heat by concrete surfaces, the temperature of the area increases much further. Thus, the population of the city and its eco-system is damaged.

Moreover, Bukhara is considered one of the driest cities of the world. During 1991-2021 years, the average amount of precipitation is equal to 142 mm, that of evaporation is equal to 250 mm. Generally, the average rate of precipitation meets thirty percent of the annual demand. Therefore, places like these considered the driest ones.

In this case, the large number of green areas in the city helps to maintain the stability of the city's microclimate. One of the problems of Bukhara's urban planning in the last 30 years is related to the fact that the improvement and landscaping works do not have the desired result. Lack of greening along highways and engineering lines, lack of green spaces, lack of a green protective wall around the city are causing urban environmental problems.

When studying sources within the scope of research geography, it was stated that in the last 30 years, green areas of Bukhara occupied 2-3% of the city area (Table 1). Existing parks and green spaces are also unevenly distributed across the city, with major green areas located in the eastern and northern parts of the city, while the densely populated southern part lacks such areas.

As can be seen from the table, the volume of urban green spaces and their share per person have experienced a chronological decreasing trend in the last 30 years. At the beginning of the studied period, in 1991, there was 7.0 m^2 of green space per capita, and by the last year, 2021, this indicator decreased to 6.04 m^2. Therefore, the existing green spaces in the city do not meet the international organizations whose names and standards we have listed above, the conclusions and recommendations of scientific research, as well as the standards set by the legislation of Uzbekistan.

Table 1. The dynamics of changes in the share of green spaces per capita in Bukhara in 1991-2021

Years	Population	The share of green spaces (hectare)	Each person ($м^2$/a person)
1991	246.5	172.7	7.00
1998	258.8	178.6	6.9

2005	260.4	167.1	6.41
2010	269.0	181.3	6.73
2015	273.8	180.1	6.57
2020	280.6	171.5	6.11
2021	284.1	170.25	6.04

If we do a comparative analysis of the share of green spaces per capita in the cities of Bukhara and Tashkent, 20 years ago in the city of Tashkent there was 21.1 m^2 of green space per inhabitant, but in 2021 this number is 68.6 m^2, that is, during the period, this indicator increased by 3.4 times. In the city of Bukhara, we can see that this indicator decreased from 6.9 m^2 to 6.04 m^2, respectively. So, in the city of Bukhara, green areas have decreased by 0.86 m^2 in the last 20 years.

World health organization stated in its norms that green spaces in urban areas should be 50 square meters for a person, in big cities this amounts to 21 square meters. It can be seen that in the city of Bukhara, green areas in 2021 are 6.04 m^2 per capita, which is 8.2 times less than the standards of the World Health Organization. For information, it can be said that in 2020, the Swedish company "Husqvarna" announced the world ranking of green cities. In this rating, which includes 155 cities of the world, the US city of Charlotte takes the 1st place. 68 percent of the city of Charlotte is covered with green spaces, and each resident of the city has 560 m^2 of green space. The city of Bukhara lags behind the greenest city in the world by 93 times.

In Bukhara, the industry is developed, there are many industrial facilities. This requires increasing green spaces and plants. During the studied period, it can be observed that the industrial objects located in the city were indifferent to the greening of their surroundings, usually greening meant planting trees and making a lawn of the "Canada Green" plant in the visible part of the object. In addition, a large number of industrial facilities are located in the middle of residential areas, and sanitary protection zones are not established in most of them. In general, the sanitary protection zone in the city is very small compared to industrial facilities, that is, 494.81 hectares of the city territory, which is organized on an area of 12.85 hectares, is occupied by industrial enterprises, warehouses and bases, according to the law, the total sanitary protection zone of these facilities is 120 should occupy an area of more than one hectare. The fact that the industrial facilities are located in the middle of the population centers, the local population and the urban eco-system have suffered serious damage from them, and the consequences of this are still ongoing - this is a consequence of the cotton monopoly during the former Soviet Union.

Most of the industrial facilities are built during the former Soviet Union, while building their economic effectiveness is considered, yet their adverse influence to residents and to the environment were not taken into account. Even, in some places, clearly visible industry facilities of negative impact had been built in residential areas or near to them. Despite being classified as a heavy polluter, cotton gins, construction materials factories, oil factories, breweries, flour mills, and other similar industrial structures were left in the city, between residential areas, and continued their production even in the early periods of independence.

Since 2001, the attitude towards enterprises with a high degree of risk to the environment has changed, and a campaign to move them to the outskirts of the city or outside has begun. After that, the Bukhara cotton ginning plant was moved to the town of Galaasia, and the activity of the Bukhara oil plant was stopped.

Since 2016, large-scale construction works have been started in the city of Bukhara. In particular, many commercial and residential facilities have been built. This served for the reduction of green spaces in the city. As an example, the current Independence Street in the city can be cited. In 1991, more than 2000 large trees (over 6-7 m high) grew on this street,

but as a result of constructions and reconstruction works in this street, only about 200 trees remained. Such situation can be seen on example of A.Navoi street.

The boom in construction in recent years has led to the reduction of existing parks. In 2019, 7 recreational parks were operating in the city, which accounted for 81 percent (139.18 hectares) of green spaces in general use. To the north of "Old and Ancient Bukhara" park, a part of "Fathabad" and "Sitora" park has become a large construction area. So, at present, about 2 percent (about 150 hectares) of the city's territory consists of green areas.

Fig. 2. The map of “Old and Eternal Bukhara” garden in Bukhara city.

In 2017, work was revived to move industrial businesses in the city out of town or to another part of the city. Large producers, such as the Bukhara flour mill (JSC "Buxoro don mahsulotlari"), were also moved to another part of the city (address “Xalqlar do’stligi”). The resulting large and major polluting businesses were concentrated in an industrial area in the southeastern part of the city. Today, the issue of moving the remaining large polluting objects out of the city as well is on the agenda to preserve the historical importance of the city and ensure the balance of its environment. Also included in the General Plan of the city of Bukhara is a plan to surround the areas with industrial facilities with sanitary protection zones [16]. Under such conditions, it is advisable to expand green spaces in the city.

The most important aspect that can be seen in greening events during the independence period is that Greening and landscaping of cities is usually limited to landscaping around the city's prominent objects – houses of culture, the municipality and some administrative buildings, large educational institutions and hospitals. Around residential areas and public buildings, sanitary protection zones along industrial enterprises and highways, green spaces are almost unorganized and unattended. The lack of proper organization of greening work leads to droughts of the Urban Climate, increased dust and environmental pollution.

While broad-leaved trees were used in the greening of Bukhara in Soviet times, Coniferous trees have generally been used in greening events since the 80s and 90s of the last century. Coniferous trees produce little oxygen by absorbing noise, dust, and noxious air compared to broad-leaved trees. Mainly tree species that are not suitable for the climate of the area, such as spruce (juniper), Pine, Poplar, yulghun, tikandaracht, have been used a lot in this. These trees and shrubs develop poorly, losing their original condition as a result of unfavorable climatic conditions and transport and industrial waste. This, in turn, has its negative effect on the increase in dust and oxygen saturation in the composition of urban air. It is now returning to the tradition of planting climate-friendly plants and trees, and measures are being taken to reduce groundwater levels and ensure the quality of vertical drainage in order to ensure their germination.

It is desirable to create green protection walls that protect against wind and dust in the development and infrastructure of settlements around cities located in the desert and semi-desert zone. Therefore, on May 8, 2020, the decree of the Cabinet of Ministers of the Republic of Uzbekistan "On the establishment of a "green belt" - protective tree groves around the cities of Bukhara, Nukus, Khiva and Urganch in 2020-2021 at a total distance of 30 km" [18]. Today, more than 365,000 decorative and fruit trees have been planted in the city within the framework of the "Green Space" national project, and a ditch and other irrigation facilities have been repaired. However, no effective results have been achieved in creating a "green belt" around the city.

Green plants and trees first of all play an important role in human health, as well as in stabilizing the city's climate and giving a natural appearance to the city. For this purpose, the Presidential Decree "On the Development Strategy of New Uzbekistan for 2022-2026" envisages "Goal 80: Ecology and environmental protection, improvement of the ecological situation in cities and districts, implementation of the nationwide project "Green Space", and "Organization of "public parks" for every 50-100 thousand inhabitants in city and district centers" [19]. It is necessary to always remember that the greening of Bukhara is a guarantee of the future sustainable development of the city.

Today, green spaces occupy about 2% of the city's territory. This indicator absolutely does not meet the sanitary rules and norms of planning and construction of residential areas in Uzbekistan. For this reason, the insufficient beautification of the territory, the lack of greening along highways and engineering lines, the absence of a green wall around the city, and the lack of green spaces remain one of the main environmental problems of the city.

In order to expand the green areas in the city, including the empty and neglected land areas in the historical part of the city, it should be given to potential entrepreneurs in order to create small "green areas" for the recreation of local residents and tourists. In this area, the entrepreneur will create small green landscape recreation areas for short-term recreation and leisure of residents and tourists. In doing so, he will also use trees and shrubs suitable for the area and optimize their irrigation system.

Transport infrastructure also plays an important role in the formation of the ecological situation in the city during the period under study. Urban transport system has grown significantly like other sectors. In 1991, the length of highways in the city was 53 km, and by 2021 it will be 102.6 km. As can be seen, the length of city transport roads has doubled over 30 years [12]. The correct establishment of the transport network within the city prevents the emergence of various environmental problems, and in the opposite case, it leads to the derailment of the environmental balance.

The total length of the intra-city transport network is 217.8 km, with a density of 0.80 km/km2. The discrepancy between the length and density of the highway network indicates that the city's road network is not sufficiently developed, so vehicles pass through narrow residential streets. Also, due to the absence of the Bukhara ring road, international roads A-380 (Guzor-Bukhara-Beyneu) and M-37 (Samarkand-Bukhara-Turkmanboshi) pass through

the central streets of the city. Deficiencies in the transportation system, underdevelopment of the highway network, long distances between sidewalks and parking places cause congestion and slow down the speed of vehicles, which in turn leads to the accumulation of gases from fuel combustion in the atmosphere and negative effects on the urban environment. In addition, the insufficient organization of beautification and landscaping works along the streets and highways has a negative impact on the city environment.

The city of Bukhara, like most cities of Uzbekistan, is distinguished by the radial structure of the street network. The streets of the historical part of the city have been preserved in their historically formed narrow and dense non-linear state, while the new streets have developed independently of the old city and are characterized by a rectangular structure of the street network. In 1997, on the occasion of the 2500th anniversary of the city, the streets of the old city were beautified, but no attention was paid to landscaping.

Since 2010, the streets of high-rise buildings in the south of the city's industrial zone and the streets around the historical center have been improved, and the highways passing through the area have been widened. In particular, S. Muradov, Afrosiyob, Nizami, Independence, Piridastgir, Namozgoh, M. Iqbal, Friendship of Peoples, A. Navoi, Q. Murtazaev, B. Naqshbandi streets and the Southern ring road were also beautified during this period.

So, in the period of independence, the city street network and highways were sufficiently regulated. In order to reduce the pressure of the system on the environment, it is recommended to increase protection zones from dust and noise barriers - green plants on main highways and streets [20].

During the placement and construction of objects in urban areas, it is necessary to calculate their impact on the environmental situation in advance and during the design period. The main task of modern urban planners and architects is to increase the living and working comfort of the buildings being created and to reduce the negative impact on the environment to a minimum level. Their effective solution is only to evaluate the problems in a comprehensive approach. Such problems include planning, construction, rational organization of sectors of the economy and places of residence and recreation, vehicles, industrial and sanitary protection zones, organizing solutions to noise, dust and other environmental problems.

As a result, it is required to organize the city territory from the point of view of architectural planning. In this case, it is necessary to correctly select and rationally form living and production zones, highways, administrative buildings, gardens and parks, cultural and household recreation centers, educational and recreational institutions, etc. Preservation of natural landscapes, green areas, increase of such areas play an important hygienic role. Green areas improve the natural and ecological environment in the city and improve the mood and health of a person.

4 Conclusion

Clean air is important for the purification of the city atmosphere, for the healthy life of the population, for the prevention of various diseases, and for the long life of a person. The main way to ensure clean air in the city is to green it. However, today, green spaces in Bukhara occupy only about 2% of the city area. This indicator absolutely does not meet the sanitary rules and norms of planning and construction of residential areas in Uzbekistan. During the research period, it was observed that greening works were poorly organized in the city, while the city area and population grew, green spaces and greened areas did not increase, but rather decreased.

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