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Impact of Urban Landscaping on Improving the Sustainable Development of the Urban Environment. The Case of Nur-Sultan

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Abstract

For modern metropolitan cities, one of the important problems that need to be solved is minimizing the risks of critical environmental issues in the conditions of climate change and degradation of natural resources. Environmental problems of cities lead to a decrease in their natural potential and are now coming to the fore. The concept of the modern development of the metropolitan city necessarily includes measures to comprehensively address issues of urban landscaping, preservation of cultural and historical heritage, and the formation of a sustainable environment. In this paper, considering compliance with environmental, social, and governance principles and based on an expert survey, an analysis of the case "Management of landscaping of the city of Nur-Sultan" and statistical data of the Department of Environmental Protection and Nature Management of Nur-Sultan, the main problems of landscaping in Nur-Sultan (Kazakhstan) have been identified and the situation of green spaces has been analyzed, together with the possibilities of planning a system of urban landscaping. With the help of GIS technology, an assessment of green spaces has been made. Materials from space images of the Sentinel-2 satellite have been loaded into the GIS. It has been concluded that urban landscaping in Kazakhstan continues to be based on recreational standards, whereas ecosystem planning of sustainable cities is a recognized European strategic approach, and the leading trend is the transition from uncontrolled territorial sprawl to structural reorganization of urban areas.

Keywords: urbanization; sustainable development; landscaping; green areas; green space; green infrastructure; satellite images; calculation of the NDVI index.

JEL Classification: Q01; Q50; R11.

Introduction

Urbanization is a global trend that is experiencing rapid acceleration with a negative impact on the compositional, structural, and functional elements of biodiversity (Sandström *et al.* 2006, 43) and on the integrity of ecosystems, health, and well-being (McHale *et al.* 2015, 5211; Shaimerdenova *et al.* 2020, 65; Yu *et al.* 2017, 1304). It creates fundamental problems and, at the same time, unprecedented opportunities to increase the sustainability of urban systems (Elmqvist *et al.* 2015, 101), ensuring a balanced development, as solving an ever-growing variety of problems makes them more sustainable. At the same time, the environmental, social, and governance (ESG) approach is of particular importance in ensuring the sustainable development of the urban environment, which implies building all management work based on ESG principles: environmental protection, creating favorable social conditions, conscientious attitude with employees and customers and proper corporate management. In this connection, ESG factors are taken into account, such as the impact of investments on the environmental situation and the social sphere of the territory within which any investment project is implemented, as well as the assessment of the corporate management policy of the recipient of investments for compliance with the principles of social justice, environmental friendliness, and ethics (Childers *et al.* 2015, 3774).

In our study, we wanted to focus on the study of environmental protection factors (Balova *et al.* 2021, 1269; Sahak *et al.* 2018, 59). The basis of the landscape organization of the city territory is the creation of a unified landscaping system that performs environmental protection and environmental-forming functions, and the system of landscaped spaces is considered a catalyst and stimulator of a livable quality environment. Nevertheless, the process of urbanization leads to a decrease in natural and artificially landscaped areas in favor of development, as a result of which man-made impact increases, reducing the stability of urban landscapes.

According to the United Nations (UN) estimates, today 55% of the world's population lives in cities and urban settlements, and it is expected that by 2030 this figure will increase to 60%, and by 2050 to 68% (United Nations 2018). Urbanization trends are increasing, and therefore environmental problems are also growing, since cities are the main suppliers of pollutants into the atmospheric air, discharges into reservoirs, and suppliers of the resulting consumption waste (Shomshekova *et al.* 2020, 594). Thus, according to UN-Habitat, cities consume 78% of the world's energy and produce more than 60% of greenhouse gas emissions. At the same time, they occupy less than 2% of the Earth's surface (United Nations n.d.).

The above situation has completely changed the approaches to solving the issue of assessing the role of green spaces, made us look at the problem differently and improve ways to solve it, and showed that an objective assessment of the role of green spaces in an urbanized environment, it is necessary to take into account both environmental protection and environmental-forming functions, which together support and enhance environmental processes integrated into health and quality of people's lives (Tikhomirova and Tikhomirov 2022, 185). The analysis of urban landscaping systems (Badiu *et al.* 2016, 53; Kaldybayev *et al.* 2020, 4158) indicates the need for a new methodology of urban planning, which would allow forming an integrated approach to the use of natural resources at the local level from the standpoint of sustainable development (Sedova and Alekseev 2022, 856). The processes of urban development cause the development of negative consequences of human activity, which manifest themselves in the pollution and degradation of green areas that form the basis of the urban environment (Ilina 2015, 69; Kudrin *et al.* 2019, 58).

The study of urban landscaping processes is actualized by the problematic environmental situation in cities and regions of Kazakhstan, the growth of man-made and anthropogenic pressure (Shaimerdenova *et al.* 2020, 65), insufficient level of landscaping, and lack of systematic and reliable information (Yerkinbayeva *et al.* 2022, 115), which actualizes the need to study the impact of landscaping on the sustainability of the urban environment on the example of the metropolitan city of Nur-Sultan.

1. Literature Review

The issues of the influence of landscaping on increasing the sustainable development of the urban environment are studied by many scientists. They consider vegetation as an environmental restoration system that ensures the comfort of living conditions, regulates the composition of air and the degree of its pollution within certain limits, microclimatic characteristics of territories (Liu *et al.* 2019, 185), reduces the influence of the noise factor, enhances aesthetic perception, contributes to the elimination of the effects of the influence of urban thermal islands (Wang *et al.* 2019, 168) and climate change, and performs aesthetic and environmental functions (Ramos-Gonzalez 2014, 21).

According to Müller *et al.* (2013), an environmentally sound approach to the urban green space system, optimization of its structure, functioning, and use of green spaces is one of the effective and affordable means of

improving the urban environment. To ensure the optimization of the urban landscaping system, the need for long-term planning of territory landscaping is justified.

U. Lang (2014) believes that urban landscaping is an important component of sustainable urban development, which provides several services both at the national and local levels. It helps to define and maintain the identity of cities, increases their attractiveness, architectural and artistic accounting, and recreational opportunities, promotes competitiveness, forms the aesthetic framework of the city, and improves the quality of the urban environment and urban life.

K. Alawadi (2017) notes that over the past three decades, the study of parks and other elements of landscaping, rather than the landscaping system as a whole, has prevailed, but these areas in science have allowed accumulating systematic knowledge regarding objects of various functional purposes (Sagyndyk and Turekanova 2019, 46).

According to M. Luo (2014), cities require science-based solutions for urban development, in particular for the creation of green areas. Urban sustainability can be characterized as a holistic vision of environmentally, economically, and socially responsible urban planning, which ensures environmentally balanced development through a combination of different interests.

With the strengthening of ecologically balanced urban planning, the concept of a green city has become a worldwide ideal (Szumacher and Pabjanek 2017, 665), synonymous with sustainability (Tappert *et al.* 2018, 69), and landscaping is a fundamental part characterized by multifunctional land use.

The purpose of the study is to analyze the impact of landscaping on improving the sustainable development of the urban environment in the example of Nur-Sultan.

Objectives of the study:

1. to analyze the scientific literature on the problem of the impact of landscaping on improving the sustainable development of the urban environment;
2. to identify the main problems of landscaping in Nur-Sultan;
3. to analyze the situation in the green spaces of Nur-Sultan;
4. to consider the possibilities of planning an urban landscaping system.

2. Methods

The study analyzed data for 2015-2021.

The study took place in four stages:

- Stage 1: identification of the main problems of landscaping in Nur-Sultan;
- Stage 2: analysis of the "Landscaping management of the city of Nur-Sultan" case study;
- Stage 3: analysis of statistical data on landscaping for the period of 2015-2021;
- Stage 4: calculation of the normalized difference vegetation index (NDVI) of Nur-Sultan.

In the course of the study, the following methods were applied:

- analysis of scientific literature on the problem of the influence of landscaping on the improvement of sustainable development of the urban environment;
- an expert survey, based on the results of which the main problems of landscaping in Nur-Sultan were identified;
- 38 experts employed at the Department of Environmental Protection and Nature Management of the city of Nur-Sultan took part in the expert survey by e-mail. The experts were invited to express their own opinions online by e-mail regarding the nature and extent of the impact of landscaping on the environment, the negative consequences and risks of insufficient landscaping of the territory of Nur-Sultan, the causes of insufficient landscaping, as well as the indicators necessary for statistical analysis of the level of landscaping. Further, the ranking of expert opinions was carried out. The consistency of expert opinions was assessed by the value of the concordance coefficient. The determination of the concordance coefficient was carried out using the SPSS software.
- case method which was used to analyze the landscaping of the urban environment on the example of the case of Nur-Sultan based on the analysis of secondary sources;
- analysis of statistical data of the Department of Environmental Protection and Nature Management of Nur-Sultan for the period of 2015-2021, based on which the situation in the green spaces of the capital was obtained and analyzed;
- the use of geographic information system (GIS) for urban environmental research, including the calculation of the NDVI of Nur-Sultan.

To calculate the NDVI, one needs to download the following spectral channels of the Sentinel-2 satellite from the eos.com/landviewer free source: NIR (Near InfraRed; reflection in the near-infrared region of the spectrum), and RED (reflection in the red region of the spectrum). The raster calculator opens in the ArcGIS software and formula (1) is entered from the downloaded spectral channels.

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad 2.1$$

After the spectral index has been calculated, we get the NDVI raster with a scale from -1 to 1. The index values range from -1 to 1, which correspond to certain types of covering surfaces. Thus, using GIS technologies in the ArcGIS software, based on the remote sensing data of the Sentinel-2 satellite, NDVI was calculated and the total area of the landscaping of the city of Nur-Sultan for the period 2015-2021 was established.

3. Results

The register of identification of environmental problems of the capital of the Republic of Kazakhstan (KanalPriroda n.d.), including the state of atmospheric air, landscaping of the urban area, the quality of water bodies of the city, as well as the disposal of solid waste, showed that one of the current problems was insufficient landscaping of the urban area.

Based on an expert survey, the main characteristics of the problem of insufficient landscaping were determined for Nur-Sultan (Table 1).

Table 1. Components of the problem of insufficient landscaping in Nur-Sultan

No.	Components of the problem of insufficient landscaping		%*	Rank
1	Nature of the environmental impact	Mitigation of the microclimate in the city	87%	1
		Aesthetic appearance and ecological situation in the city	84%	2
		Participation in the processes of self-purification of the urban atmosphere	79%	3
		Correlation with the intensity of degradation (especially deflation) of urban lands	74%	4
		Correlation with the level of noise pollution	68%	5
	Negative consequences and risks	Dustiness of the air pool	87%	1
		Lack of comfortable recreational spaces for the urban population in the open air	84%	2
		High risk of degradation (especially deflation) of urban land	79%	3
		Increased risk of noise pollution due to the absence of natural noise screens along highways	76%	4
		Dryness of urban air due to low transpiration	74%	5
		Reducing the attractiveness of the urban landscape	68%	6
		The increase in the cost of maintaining green spaces	66%	7
3	Reasons	The irrational layout of green spaces, especially along highways	84%	1
		Insufficient introduction of advanced technologies in green construction to properly take into account the specifics of the natural and climatic conditions of the city	79%	2
		Violation of agricultural technology in the green construction of the city	76%	3
		Lack of proper accounting of green spaces	74%	4
		Low quality of landscaping works carried out	68%	5
		Lack of irrigation system	66%	6
		The lack of an adequate level of propaganda for the protection of green spaces during repair and construction works, as well as among the population	61%	7

Note: compiled based on an expert survey; * is the percentage of expert mentions; the value of the concordance coefficient $W = 0.85$ ($p < 0.01$), which indicates a strong consistency of expert opinions.

4. Case Study "Landscaping Management of the City of Nur-Sultan"

The construction of new capital in the Central Kazakhstan region set new tasks for the formation of a comfortable ecological environment for the urban population, where housing and communal services, transport and road facilities, and construction began to develop actively. Thus, according to the Nur-Sultan Development Program for 2021-2025, an annual increase in housing commissioning in the amount of at least 1.3% is envisaged to bring the housing provision index to 38.6 square meters by 2025, reconstruction of existing and construction of new public sector facilities by attracting investments from natural monopolies (AstanaBuild n.d.).

To improve the various ecosystems of the city, the city leadership proposed to develop the existing landscaping system by creating ecologizing cores, *i.e.* large green areas that would contribute to improving the ecological state and the formation of a high-quality urban and suburban environment.

Since the construction of the capital is being carried out in combination with the rapid quantitative growth of the population, the growth of which in 23 years has amounted to almost 850 thousand people, and as of May 1, 2021, 1199,083 residents officially live in Nur-Sultan, the issue of qualitative improvement of the ecological situation in the city, one of the aspects of which is landscaping, becomes very relevant.

The first serious program (the General Scheme of landscaping) was developed in 1967. Then, when Nur-Sultan (Astana) became the capital, a master plan was developed by Orta, and subsequently, another master plan developed by the Japanese firm Yamas was adopted. Of course, there were landscaping schemes in those master plans, but the landscaping was always considered only as an addition to the master plan, and not as an important part of it. As a result, the landscaping scheme included a protective and decorative system of landscaping along streets, alleys, inside blocks, and courtyards.

Currently, the landscaping of Nur-Sultan is carried out under the General Development Plan until 2030. Its concept is to form an Eco-city, harmonize the process of urbanization with nature, and create a comfortable environment for residents. At the same time, the objective of the formation of green corridors or, in other words, the spatial community of landscaping arrays, has been set. In addition, around the city of Nur-Sultan, under the General Plan, active construction of the green belt is underway (a project of mass afforestation around the city of Nur-Sultan).

As a result of the implementation of the developed landscaping concept, the so-called green wedges, having their content and considering the prevailing climatic conditions, have been identified. The entire territory of the city, between the buildings and the adjacent lands of the Yesil River, is a green area, *i.e.* development areas alternate with green corridors within it. Thus, the green corridors reach the city center, forming a continuous forest park zone, which is within walking distance from any developed part of the city.

Table 2. Landscaping statistics in Nur-Sultan (Astana) (*incrementally*) (GU Upravlenie n.d.)

No.	Name	Years						
		2015	2016	2017	2018	2019	2020	2021
1	Trees and shrubs, pcs.	369,317	601,324	745,102	889,014	1,022,992	1,154,439	1,243,233
2	Hedge, running meters	141,782	146,673	155,493	155,536	166,904	171,526	182,345
3	Flower beds, m ²	144,330	174,330	187,480	239,120	299,590	312,600	324,670
4	Lawns, m ²	6,570,257	7,270,257	7,713,500	799,300	811,500	825,730	836,988

Thus, per inhabitant of the capital, the area of green spaces in 2021, despite significant population growth, reached 17.9 m² whereas in 2015 it was 14.7 m², with a total urban planning norm of 19.0 m² per person.

In addition, according to the latest information, 15326,067 trees and shrubs grow on the territory of the green belt.

The data on landscaping is confirmed by the results of the use of GIS, according to which the obtained values of the calculation of the NDVI index are within:

- 0.4-0.6, highlighted on the NDVI raster by orange class, correspond to poor and sparse vegetation in form of trees and shrubs; according to statistics, the area of this class equals 221.1 km² (22,110 ha), which occupies about 29% of the administrative territory of the city;

- 0.6-1, highlighted on the NDVI raster by the red class, correspond to dense vegetation; according to statistics, the area of this class equals 183.8 km² (18,376 ha), which occupies about 25% of the administrative territory of the city.

Thus, the total green area in Nur-Sultan for 2021 based on remote sensing data and GIS technologies equals 404.9 km² (40,486 ha), which is about 54% of the administrative territory of the city.

5. Discussion

It should be noted that the solution to the problems of landscaping in Nur-Sultan (Table 1) is impossible without proper urban planning, the purpose of which is a city with an ecologically sustainable urban environment suitable for life (Liu *et al.* 2019, 185). According to the definition of several authors (Sagyndyk and Turekanova 2019, 46; Szumacher and Pabjanek 2017, 665), landscaping is aimed at fulfilling several goals, contains recreation and conservation of biodiversity, and simultaneously performs aesthetic and cultural and any other role compatible

with the sustainable use of the territory. The leadership of Nur-Sultan is still trying to solve the problems of landscaping by increasing the number of urban green spaces, but success in achieving sustainable development depends on the joint promotion of the idea of green infrastructure and other environmental solutions (Badiu *et al.* 2016, 53). Therefore, according to the authors, the planning of the urban landscaping system of Nur-Sultan should become the basis of ecological urban planning (Luo 2014, 11446) and be based on local culture and unique customs, preferences, and natural and cultural features.

In some countries, through the planning system, activities that contribute to the creation of a natural environment are encouraged. For instance, development in the city center is stimulated to reduce expansion into new territories, protect agricultural land, preserve wildlife areas, and control the density of development. Muller *et al.* (2013) believe that it is the activity of planners that form urban biodiversity.

The development and implementation of a sustainable development strategy is a complex process that requires changes in government priorities and cultural norms that must balance the requirements of social, economic, and environmental sustainability (Alawadi 2017, 353; Tsenina *et al.* 2022, 63).

Various landscaping functions are implemented not only by increasing the green area, as in Nur-Sultan, but also by using a well-thought-out rational unified continuous system of green zone placement, associated with the architectural and planning structure of the city, where the increase in the density of buildings and communications reduces the role and opportunities for the development of street and inter-block green zones. However, usually, in residential quarters of Nur-Sultan, standards for planting density are not observed, and due to construction, the total number of trees and shrubs is reduced by half.

The key principles of the modern Theory of urban green space planning (Szumacher and Pabjanek 2017, 665; Tappert *et al.* 2018, 69) are multifunctionality, integration, communication, and strategic approach. A promising practice is an urban consolidation, a growth management policy aimed at economic growth by compacting the built environment, which leads to more efficient use of modern infrastructure and services, while simultaneously providing their benefits, such as protecting green space on the outskirts of cities.

To achieve sustainable urban development, landscaping planning should be integrated into urban development based on international guidelines, such as green area per person. According to the World Health Organization (WHO) recommendations, to ensure an environmental effect and achieve other benefits, each city should provide at least 9 m² of accessible, safe, and functional urban green space for each person (Russo and Cirella 2018, 2180), and WHO considers 50 m² to be the ideal amount (Elmqvist *et al.* 2015, 101). According to US standards, the sufficient green area is 18 m² per person, according to the EU norms it equals 26 m² per person (Alawadi 2017, 353), and according to the UN standards 30 m² per person (Khalil 2014, 526). In Nur-Sultan, the area of green spaces per inhabitant of the capital in 2021 was 17.9 m², which corresponds only to the minimum international standards.

As an opportunity to use international experience in solving landscaping problems, one can mention the experience of China, where landscaping planning for a long time focused only on compliance with norms and technical issues, although it should have been considered within a specific socio-cultural context (Zhang *et al.* 2018, 780). However, the emergence of the concept of green infrastructure, which includes the green space of the city, both private and public (gardens, meadows, forests, parks, churchyards, as well as rivers, wetlands, and the like), has changed the approach to landscaping: from individual urban green areas to coordinated spatial green networks of a certain quality and structure (Balova *et al.* 2021, 1269; Sahak *et al.* 2018, 59).

The concept of sustainable development and the theories of new urban planning in China are the driving forces behind the planning of the urban landscaping system, where the concept of sustainable development emphasizes the long-term perspective of planning a multifunctional green space integrated into other urban functions. Zhang *et al.* (2018) point to the growing emphasis on environmental aspects of planning, the transition to independent environmental planning of the urban landscaping system, and the emphasis on practical consequences. Thus, a plan for the development of urban parks, forestry and agriculture, reservoirs, and infrastructure has been integrated into the three-level landscaping system of Beijing (Liu *et al.* 2019, 185).

Since the 1990s, China has had clear detailed national and professional regulations on urban green space planning, in particular standards and classification of urban land types, and a national competition for the title of National Garden City has been introduced. This experience can be successfully applied in solving the problems of urban landscaping in the Republic of Kazakhstan.

However, the Chinese urban landscaping system planning, as well as the Kazakh one, is still characterized by insufficient attention to multifunctionality at lower planning levels, focus on the image of the city and the visual effect of urban green space, and focus on quantitative rather than qualitative aspects.

Conclusion

Solving the problems of landscaping and improving the sustainable development of Nur-Sultan requires new approaches and methods for evaluating the landscaping system and its effectiveness, improving the methods of inventory and certification of green spaces, the introduction of GIS technologies, and the creation of data banks and digital maps of urban green spaces. The main way of forming a sustainable urban environment is the improvement of landscaping systems that will provide both environmental protection and environmental-forming functions and will contribute to achieving optimal ecological, sanitary, hygienic, and aesthetic effects on people's life.

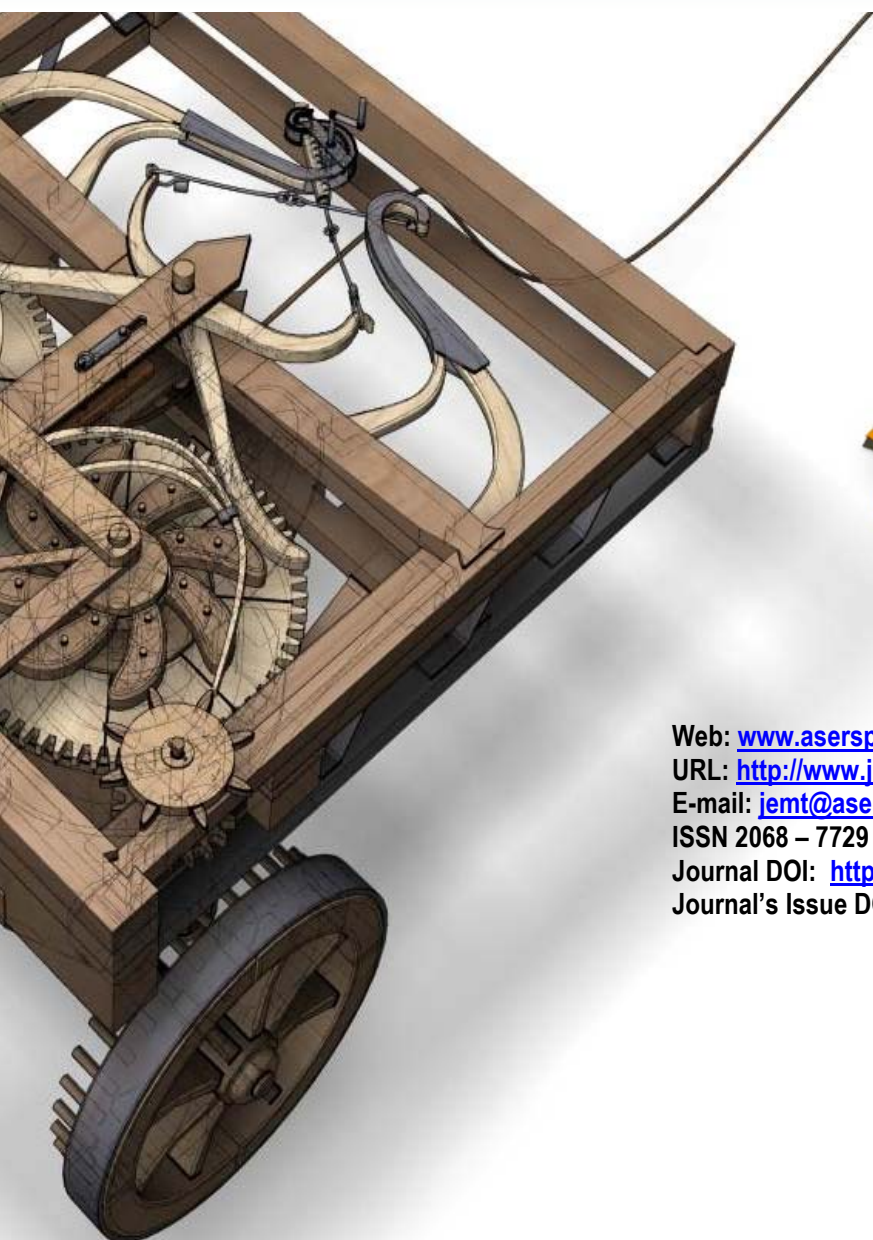
At the same time, urban landscaping in Kazakhstan continues to be based on recreational standards, whereas ecosystem planning of sustainable cities is a recognized European strategic approach, and the leading trend is the transition from uncontrolled territorial sprawl to structural reorganization of urban areas.

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