Absheron's Greening Schemes and Their Environmental Assessment

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Abstract

This article examines issues relating to the sustainability of the vegetation cover on the Absheron Peninsula. This research examined the climatic conditions of the region, including its arid climate, strong winds, and the level of human impact. The region's green spaces have a direct positive impact on reducing dust levels and air pollution, regulating the microclimate and mitigating the 'urban heat island' effect. The report found that, despite the afforestation measures being taken, industrialisation, urbanisation, land degradation and water scarcity are having a negative impact on the development of vegetation cover on the peninsula. To tackle these problems, it is of the utmost importance to expand green spaces, reclaim land contaminated by oil, treat wastewater, and reduce atmospheric emissions. Consequently, the protection and scientifically sound management of green systems are regarded as a priority for ensuring the environmental safety of the Absheron Peninsula, mitigating the effects of climate change and promoting sustainable urban planning.

Keywords: Absheron Peninsula, green systems, environmental assessment, environmental sustainability, urbanisation, land degradation, greening, environmental protection, biodiversity, sustainable urban development.

1.Introduction

The Absheron Peninsula is situated in eastern Azerbaijan and is considered one of the country's most densely populated and industrially developed regions. The peninsula is characterised by a dry subtropical climate, low rainfall, high evaporation, strong winds and limited water resources. Annual rainfall of just 200-400 mm, whilst potential evapotranspiration exceeds 1,000 mm, is one of the main factors limiting the natural development of vegetation. Furthermore, as a result of many years of intensive development in oil production, oil refining, and other industrial sectors, the peninsula's natural landscapes have undergone significant anthropogenic changes, and a considerable proportion of the soil and vegetation cover has been degraded (Eyyubov, 1993).

For this reason, the creation and development of green spaces in Absheron is not only an element of landscape architecture, but is also of immense importance for maintaining ecological balance, improving air quality, reducing dust and air pollution, regulating the microclimate, and creating healthy living conditions for the population. In contemporary urban planning concepts, green systems are regarded as a key component of a city's ecological infrastructure, and their sustainable development is seen as one of the main means of mitigating the negative consequences of urbanisation (Agayev & Efkerov, 2007).

The scientific foundations for afforestation work on the Absheron Peninsula began to take shape in the middle of the last century. Research has shown that selecting species of trees and shrubs suited to the peninsula's soil and climate conditions, as well as assessing the adaptability of introduced plants, establishing protective tree belts, and creating park and landscape complexes significantly improve the effectiveness of afforestation. In this regard, the research carried out by T.S. Mammadov, U.M. Agamirov, and other Azerbaijani scientists played an important role in establishing the scientific basis for the afforestation of the Absheron Peninsula (Aslanov, 1992).

The development of green spaces in the Baku–Absheron conurbation is currently regarded as one of the key priorities for ensuring environmental safety, adapting to climate change, enhancing the sustainability of the urban environment, and meeting the population's recreational needs. Parks, gardens, boulevards, woodland parks, protective green belts along major roads, and specially protected natural areas contribute to the formation of a unified green infrastructure and play a crucial role in enhancing the resilience of the urban ecosystem (Aslanov, 2004).

2. Existing green spaces in the Absheron district

The existing green spaces in the Absheron District consist of landscape features shaped by the peninsula's complex natural and climatic conditions and are, first and foremost, the result of human activity. As the Absheron Peninsula is characterised by a dry, windy and semi-arid climate, natural forests and dense vegetation rarely thrive here. Soil salinisation, limited water resources and strong northerly winds hinder the natural spread of vegetation. Nevertheless, thanks in particular to the urban improvement measures carried out since the second half of the 20th century, extensive and varied green spaces have been created in the region.

There is virtually no natural forest cover on the Absheron Peninsula; however, to compensate for this, artificial tree belts and protective green belts have been created. The Absheron National Park and other green spaces play an important role in this regard. These areas were established primarily to prevent wind erosion, preserve soil fertility, and maintain biodiversity at a certain level. At the same time, the protective green belts created around industrial areas and major roads help to reduce air pollution and trap dust.

3. Structural and functional characteristics of existing green spaces in the Absheron District

In the Absheron District, green spaces are divided into three categories depending on their intended use, size, and location: public use, restricted use, and private use. The first group comprises the improvement of cultural and recreational parks, public gardens, boulevards and street landscaping within the town of Absheron, as well as the areas adjacent to public gardens and public buildings, and the landscaping of residential areas with two-storey and multi-storey blocks of flats. The second group comprises green spaces on the grounds of schools, hospitals, cultural and residential buildings, unique structures, private and residential properties, as well as industrial complexes in Absheron. The third group comprises other types of protective green areas (wind and snowbreaks, flood defences, protective and land-improvement areas, nurseries, etc.).

Absheron's green spaces form part of a comprehensive green network – a unified system of interconnected landscape features covering the entire city and its surrounding areas. The functions of this area include: ensuring a comprehensive approach to development and restoration; environmental protection; recreational use; and improving working and living conditions. The integrated green space comprises an inner zone (the urban development zone) and an outer zone. The inner zone comprises: neighbourhoods and districts; green spaces for various purposes; the improvement of streets, roads and squares; and the development of industrial estates. The outer zone comprises: suburban developments and industrial estates; holiday resorts and recreational areas (beaches, holiday villages, leisure facilities); green spaces (forest parks), gardens and nurseries; undeveloped (agricultural) land; and bodies of water.

Absheron is surrounded by ‘green belts’ – suburban forests. Green spaces can therefore either have an independent significance (such as forest parks) or be integrated into the urban fabric as an organic component.

In these new areas, the vegetation cover is extremely poor in terms of its composition and mesostructure, and fulfils virtually no ecological or ecosystem functions.

Microstructure refers to the arrangement of individual elements of landscape design: lawns, flowerbeds, shrubs and trees. The significance of individual microstructural elements is not consistent with economic, environmental and aesthetic considerations. The environmental value of costly and aesthetically pleasing elements of landscape design, such as flowerbeds and lawns, is low. The dense hedgerows, ponds teeming with vegetation and thick thickets make a truly impressive sight.

4. Criteria and methods for environmental assessment

As the Absheron Peninsula is home to approximately 40% of the country’s population and accounts for 70% of its industrial capacity, the majority of the country’s environmental problems requiring a solution are concentrated in this region. The main causes of environmental problems are soil contamination by oil and associated waters resulting from many years of oil and gas production and drilling operations, the formation of oil-contaminated artificial lakes and reservoirs due to ineffective management of associated waters, and the accumulation of oil refining waste. Wastewater is discharged into water bodies containing petroleum products, suspended solids, sulphate compounds, chloride salts, surfactants, phenols, and various heavy metals (Babayev, 2001).

Soil pollution is one of the main problems facing the Absheron Peninsula. On the Absheron Peninsula, which covers an area of 222,000 hectares, the total area of unused land is 33,300 hectares, of which up to 10,000 hectares are oil-contaminated.

The State Oil Company of the Republic of Azerbaijan owns 7,500 hectares of land contaminated with oil and petroleum products, as well as a further approximately 2,800 hectares of contaminated land. The degree of soil contamination ranges from 12% to 30–40% at a depth of 23 metres or more. The Absheron economic region, situated in the east of the country, comprises the Absheron, Khizi and Sumgait districts and enjoys a highly favourable economic and geographical position. The total area of the economic zone is 381,776 hectares, which accounts for 4.4% of the country’s total area. It is one of the most economically developed regions in the republic. The Absheron Economic Region borders the Kuba-Khachmaz Economic Region to the northwest, the Dagestan-Shirvan Economic Region to the west, and the Aran Economic Region to the southwest. To the north, east, and south, it is bordered by the waters of the Caspian Sea, which helps to expand transport links (Həsənov, 1966).

One of the worst environmental problems facing Baku and the Absheron Peninsula relates to solid waste management. Air pollution is one of the main environmental problems facing Baku. In recent years, there has been an increase in the number of vehicles, a shortage of gas scrubbers and dust collectors designed to capture harmful substances emitted into the air, and a rise in the amount of harmful substances released into the atmosphere as a result of waste incineration. This poses a serious threat to the environment and human health, as it leads to atmospheric pollution. The Absheron Peninsula is home to more than 200 lakes with a total area of 3,325 hectares. Every year, 41.5 million cubic metres of wastewater are discharged into these lakes. These lakes have a negative impact on the environment, causing soil degradation and salinisation, the flooding of additional areas due to rising water levels, the release of hydrocarbons and other harmful substances into the atmosphere as a result of evaporation, and damage to settlements, businesses, roads and other infrastructure.

The lack of sewerage systems in some settlements means that domestic wastewater is discharged into the lake and surrounding areas, which further exacerbates the environmental situation. The areas of Absheron most heavily polluted by oil and petroleum products are Qaradag, Binegadi, Sabunchu,

Surakhany, Azizbeyov and Sabael. In addition, 142,300 tonnes of oil-contaminated sludge, generated at oil and gas production and processing facilities, are stored at industrial sites. The remaining areas of Absheron are considered environmentally safe. 12 August marks Caspian Sea Day. This date marks the entry into force of the Tehran Convention on the Protection of the Marine Environment of the Caspian Sea, signed by the five Caspian littoral states: Azerbaijan, Russia, Kazakhstan, Turkmenistan and Iran. The main aim of 'Caspian Day' is to protect the marine environment of the Caspian Sea from pollution, to conserve, restore and ensure the rational and sustainable use of the sea's biological resources, and to raise public awareness of these issues (İmanov & Ələkbərov, 2017).

More than 130 years of oil production on the Absheron Peninsula have left a distinct mark on its landscapes. As a result of prolonged, intensive, and excessive pollution by oil and petroleum products, the ecosystem of the Absheron Peninsula has been depleted, leading to the degradation of pastures and the formation of barren areas overgrown with withered shrubs and ephemeral plants. These oil-contaminated soils have long since been transformed into abiogenic landscapes, including oil-saturated bituminous soils.

The region's landscape has been almost entirely altered by human activity. The area of degraded and contaminated soil in this region is approximately 25,000 hectares. A significant proportion of the area is covered in hydrocarbons and bitumen, whilst vast tracts are contaminated with drilling mud. More than 18,000 hectares of land are contaminated with oil and petroleum products, and 1,300 hectares have become unusable solely as a result of waste from the chemical industry. It is known that 7,400 hectares of land have been contaminated by oil, of which 2,800 hectares require urgent clean-up. Pollutants penetrate the soil to a depth of 2–3 metres. Long-term soil contamination by oil and petroleum products, as well as its environmental consequences, indicate that this places an 'excessive burden' on arid ecosystems. Self-regulatory processes have long since proved insufficient to ensure the self-recovery of degraded ecosystems. As a result, the ecological balance in these ecosystems is being disrupted by ever-increasing anthropogenic factors (IOM, 2024).

Soil has the ability to accumulate these mutagenic substances. Polycyclic aromatic compounds with confirmed mutagenic activity accumulate in oil-contaminated soils and become concentrated in significant quantities within their microzones. Consequently, it is reasonable to expect the soil itself, as a natural substrate, to exhibit mutagenic activity. The available data (Ismailov, 2006) show that oil-contaminated soils in Absheron contain polycyclic aromatic compounds, including naphthalene, phenanthrene, dibenzothiophene, fluoranthene/pyrene, benzo(a)anthracene/benzo[a]pyrene, and PAHs, and their concentrations exceed the MPC (calculated as benzo[a]pyrene) by a factor of thousands.

Soil pollution goes hand in hand with the pollution of surface and groundwater. There are over 200 natural and artificial water bodies on the peninsula, many of which are contaminated with oil and petroleum products. The area of water bodies contaminated by petroleum products exceeds 2,000 hectares. These include, in particular, Lake Zigh, Lake Boyukshor and many others.

The concentration of polycyclic aromatic compounds in the coastal waters and sediments of the Caspian Sea, which exceeds the maximum permissible concentration by a factor of a thousand, indicates their potential carcinogenic and mutagenic effects on aquatic biota. In the oil-contaminated soils and water bodies of this region, self-regulating processes have long since been disrupted, which prevents the natural recovery of these ecosystems through natural processes (Kərimov, 2004).

According to calculations, in terms of forest area per capita, which is the main source of oxygen in the atmosphere, the Absheron District lags behind the national average. Azerbaijan (0.006–0.1 hectares in the region compared with 0.14 hectares nationally). The area of woodland per capita on the Absheron Peninsula (mostly planted) is several times lower than in other regions of the country and the former USSR, at 3 hectares (Bukhtinov, A.D. et al., 1981).

The area of coniferous woodland in this region (Eldarica pine and others) does not exceed 20,000 hectares; 10,000 hectares are taken up by orchards, villages, settlements, etc. At the same time, 1 hectare of

coniferous forest releases 30 tonnes of oxygen into the atmosphere per year, deciduous forests release approximately 16 tonnes, and agricultural land and meadows release 3–10 tonnes per year. In this regard, an assessment of the environmental situation reveals extremely low indicators of the region's reproductive potential: a mere 0.8 million tonnes of oxygen produced per year, with an index of 0.04; as for water resources – 10.5 million m³, which corresponds to a reproductive potential index of 54.0 for water resources (the lowest figure in the republic). The region's low reproductive potential stands in stark contrast to the very significant anthropogenic (accounting for around 70 per cent of industrial capacity and over 40% of the population, with the region's population standing at around 2.8-3.0 million) and technogenic impacts, which are exacerbating environmental problems. The population density averages between 1,200 and 1,400 people, which is 13-15 times higher than the national average. The annual growth rate of 1.6% corresponds to a population doubling time of 40 years.

Calculations show that on the Absheron Peninsula, carbon emissions into the atmosphere exceed the amount absorbed by natural ecosystems by approximately 1.8 million tonnes per year. On the other hand, only 3-4% of the peninsula's oxygen requirements for industrial purposes and natural processes are met (Ilkin, 2002).

Table 1. *Natural factors determining the self-purification capacity of the environment on the Absheron Peninsula.*

Favourable natural factors	Negative factors of natural origin
Wind. The average number of days on which wind speeds exceed 15 m/s is 50–114 m/s. High rate of organic matter turnover	Climatic drought (which has an extremely negative impact on the rate at which microorganisms break down pollutants, and results in low vegetation biomass) Small ecosystem size Low levels of natural biodiversity lead to high vulnerability to pollution Low oxygen sequestration capacity – just 0.8 million tonnes per year Sparse vegetation cover (in spring and autumn, only 20–30 % of the area is covered by natural ephemeroid vegetation); Rise in the groundwater level (by 5–15 metres over the last 20 years) Absence of a general groundwater level, poorly developed hydrography, high mineralisation Low bioclimatic potential Hydrothermal regime Absence of surface water and watercourses Highly mineralised, polluted and eutrophicated water bodies Characteristic unstable interrelationships between individual landscape components, with no mutual compensation between them

According to Table 1, carbon dioxide emissions in the country totalled 27.94 million tonnes, whilst carbon sequestration by the country's entire forest sector did not exceed 0.8 million tonnes, which represents just 3.2%. This means that the oxygen from the atmosphere consumed in this region as a result of industrial and natural processes is literally 'drawn' from neighbouring geographical areas – the Caspian Sea (through the photosynthetic activity of phytoplankton) and the foothills of the Greater and Lesser Caucasus.

An analysis of the natural, climatic and biological factors in the Absheron region shows that, overall, the number of adverse natural factors hindering self-purification significantly exceeds the number of natural factors promoting the self-purification of the environment (Table 2).

Low natural biodiversity, resulting in high sensitivity to pollution, and sparse vegetation cover (only 20–30% coverage by natural ephemerals in spring and autumn), a rise in the water table (by 5–15 metres over the last 20 years), high groundwater salinity, low bioclimatic potential, the absence of surface runoff, and other indicators are factors hindering the self-purification of landscapes under conditions of ever-increasing anthropogenic and technogenic pressure.

In accordance with the classification proposed by M.A. Glazovskaya (1988), we analysed the factors characterising the detoxification potential of man-made products in the natural environment and soils of Azerbaijan (Mammadov, Ismailov, 2006).

Furthermore, for the first time, we have taken into account the microbiological factor in determining the 'resilience' and 'quality' of soils, which determines their ability to self-purify in the event of contamination by organic substances. We carried out an analysis of the resource potential that ensures landscape stability in Azerbaijan, including biogenic (microbial and phytocenotic) reserves. It was found that the relative role of microorganisms and plant biomass in landscape self-purification processes in the Absheron district is comparable to that observed under other soil and climatic conditions.

The biogenicity indices of the grey-brown soils of the Absheron Peninsula averaged 50, whilst those of dark loamy soils (100), loamy (90), and grey soils (80), as well as for the grey soils of the Absheron region. It suffices to note that the amount of carbohydrates absorbed by desert plants during the growing season on the grey-brown saline-alkali soils of the Absheron district was 8.2–41.4 and 613–2,192 g/ha, respectively, compared with other districts of the republic.

As a result, anthropogenic pressure on natural habitats from various pollutants (hydrocarbons, atmospheric emissions, soil pollution, surface and groundwater pollution, etc.) remains at a relatively high level, close to the critical threshold. The reproductive potential of this area does not allow it to effectively 'offset' anthropogenic pressures compared with other regions of the country.

Although Azerbaijan's climatic and soil conditions generally create favourable conditions for the retention of organic pollutants in soils and water systems, the Absheron region, the Absheron region, along with the Kura-Araz Plain, is characterised by relatively unfavourable hydrothermal parameters due to a lack of natural moisture and low biogenicity. It is both possible and necessary to use modern technologies to regulate physico-chemical parameters with a view to optimising the hydrothermal regime, which will improve the biogenic capacity of the soil cover and, consequently, enhance self-purification processes. For example, the use of modern biotechnologies for the remediation of oil-contaminated soils in the Absheron district requires artificial irrigation, which, in turn, creates favourable conditions for an increase in the population and activity of certain groups of microorganisms capable of breaking down petroleum hydrocarbons (Mammadov et al.,2022).

All other things being equal, the most favourable conditions for the landscape to clean itself – including from oil pollution – in this region are observed in spring and autumn, when there is a favourable combination of temperature and humidity. Furthermore, in the Absheron District, conditions for the landscape's self-purification are more favourable in its eastern part, where the soils are less clayey and less alkaline, have higher nutrient content and a more favourable combination of heat and moisture, whilst the northern part is further away from the negative impact of oil production facilities.

An environmental assessment is the process of identifying, examining, describing and analysing the potential significant direct and indirect effects on the environment that may result from a planned or ongoing activity, or from a document being drafted. The purpose of an environmental impact assessment is to prepare the materials required for decision-making regarding the implementation of the planned activity or draft document, in line with the aims and objectives of the Republic of Azerbaijan's environmental legislation.

Environmental impact assessments, depending on their type, are organised and carried out in accordance with the Environmental Code and the methodological guidelines approved by the competent environmental protection authority.

Table 2. *Assessment of the area based on environmental indicators.*

Indicator	**Environmental assessment categories for sites**			
	Normal (N)	Risk (R)	Crisis (K)	Disaster (B)

The state of natural ecosystems	Satisfactory	Unsatisfactory	Loss of stability	Complete loss of stability
Ecosystem productivity	No reduction	Significant decline	Steep descent	Complete loss
Direct indicators	Below the maximum permissible concentration	Slight exceedance of maximum permissible concentrations	Significant exceedance of MAC	Exceeds the MAC by 20–50 times.
Soil degradation	5 %	5–20 %	20–50%	>50 %
Mental health of the population	Satisfactory	Partial deterioration	Serious health risk	Significant deterioration

Depending on the subject of the assessment, the environmental assessment is carried out in the following forms, as shown in Table 2.

- Strategic environmental assessment;
- Environmental impact assessment;
- Transboundary impact assessment;
- Environmental assessment under a simplified procedure.

The condition of this area is assessed on the basis of criteria and indicators used to evaluate the ecological condition of natural ecosystems.

In this case, indicators such as crop yields, soil fertility (humus content), soil acidity (pH), and so on are used (Museyibov, 2003). Parameters are the boundaries of the intervals corresponding to the values of the indicators. The criteria are defined as a set of indicators characterising the deterioration of the environment and public health.

The state of the natural environment and the quality of human living conditions are characterised by the following criteria:

– air, water and soil pollution;

– depletion of natural resources;

– degradation of ecosystems.

The quality of the natural environment is assessed in general terms in the light of general environmental and health and hygiene requirements. The Baku Master Plan up to 2040 was recently presented to the public; it covers a wide range of issues relating to the development of green spaces on the Absheron Peninsula. The plan places particular emphasis on green spaces as a key component of the city's well-being.

A sufficient amount of greenery helps to create a favourable microclimate. After all, in large towns and cities, when dust levels fall, it becomes easier to breathe, and the overall environmental situation improves. Furthermore, green spaces help city dwellers to reduce their stress levels.

Having a sufficient number of green spaces is particularly important in densely populated cities such as Baku. Population growth naturally leads to an increase in the number of vehicles, which is one of the main causes of air pollution. All available plots are being built on, with the result that there is less and less space left for green spaces.

The lack of green spaces in Baku has always been a pressing issue, caused by several factors: the dry and windy climate, water shortages, and the construction of numerous high-rise buildings in recent decades, which has been accompanied by the illegal felling of trees and a disregard for urban planning regulations. At the end of last year, Azerbaijan's State Agency for Environmental Assessment once again warned

construction companies that fail to comply with regulatory requirements would not be granted permits. However, local environmentalists note that the condition of the city's green spaces is improving, pointing out that more and more trees are appearing along roads, in parks and in squares, and that tree-planting campaigns are held regularly. Most importantly, the trees being planted are suited to our climate, which significantly improves their chances of survival in challenging conditions. The capital's flora has also become more diverse. Nevertheless, there are not enough green spaces, so it is hardly surprising that the proposed Baku Master Plan for 2040 places particular emphasis on them. According to the document, the plan is to allocate 8 square metres of green space per resident in the capital. This number seems reasonable and achievable. According to international standards, the recommended amount of green space is between 5 and 15 square metres per person. This is in accordance with the 'Standards for the Greening of Residential Areas', approved by the Cabinet of Ministers of Azerbaijan by Resolution No. 1 of 5 January 2018.

5. Conclusion

The results of the study show that, on the Absheron Peninsula, green infrastructure plays an important role in improving the ecological condition of the environment and ensuring the sustainability of ecosystems. Given the region's arid climate, strong winds, and high level of human impact, green spaces are regarded as one of the key environmental factors in protecting the soil, water resources, and the atmosphere. It has been established that vegetation helps to protect the soil from erosion, improve its structure and maintain its fertility. At the same time, vegetation plays an important role in regulating the water balance, helping to increase the infiltration of precipitation into the soil, reduce surface runoff and replenish groundwater reserves. For the Absheron Peninsula, where water resources are limited, these characteristics are of particular ecological significance.

Research findings show that green spaces also make a significant contribution to improving air quality. Plants absorb carbon dioxide and release oxygen, trap dust particles and other atmospheric pollutants, reduce noise levels, regulate the microclimate, and help mitigate the 'urban heat island' effect.

An environmental assessment has shown that, despite the afforestation measures implemented in recent years, the current state of green spaces in some areas of the Absheron Peninsula is insufficient to ensure environmental sustainability. Industrialisation, urbanisation, land degradation and limited water resources continue to be the main factors hindering the development of green spaces and causing adverse changes to the structure of ecosystems. Furthermore, the expansion of greening programmes in the region, the remediation of oil-contaminated land, improvements to wastewater treatment technologies, the reduction of atmospheric emissions and the adoption of more environmentally sustainable approaches to urban planning are regarded as important measures for improving the state of the environment.

Consequently, the protection, expansion and scientifically sound management of green spaces on the Absheron Peninsula can be regarded as one of the key priorities for ensuring the region's environmental security, mitigating the effects of climate change and implementing the principles of sustainable urbanisation.

Author's contribution

The sole author is responsible for conceptualizing, collecting, and analyzing data, and writing and editing the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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