

Article

Comparative Analysis of the Infrastructure of the City of Astana with a Sociological Survey of the Mental Well-Being of Citizens in the Context of the Sustainable Development of the Urban Agglomeration

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Abstract: Rapid urbanization entails complex problems not only in cities, but also within urban agglomerations. In modern landscape science, the greatest problems are primarily related to the ecological state of urban ecosystems. In this context, the most important task of urbanism is the interdisciplinary study of urban infrastructure in relation to the well-being of inhabitants, with a focus on the sustainable development of urban agglomerations. The aim of this study is to conduct a theoretical analysis of interdisciplinary research on the interactions between humans and the urban environment in the context of intensive urbanization, as well as to be an empirical study of the relationship between the real ecological state of the city of Astana, based on the use of geographical, environmental, cartographic, statistical, sociological, and socio-psychological research methods, aimed at identifying the mental well-being of citizens in correlation with their consumed urban ecosystem services using an associative psychological experiment, socio-psychological survey, and GIS mapping. As a result of this study, the authors have determined that the research hypothesis 1 “Spatial representations of the city’s geoecological state are interrelated with the mental well-being and satisfaction with urban ecosystem services of citizens depending on the area of residence” is confirmed. Additionally, a positive correlation has been noted among the key indicators and criteria of geoecological condition, mental well-being, and satisfaction with urban ecosystem services across different districts of the city.

Keywords: urbanization; sustainable urban development; urban ecosystem; mental well-being; urban ecosystem services; ecological balance



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1. Introduction

Rapid urbanization primarily leads to socio-psychological problems, which are then differentiated into other issues: social, environmental, legal, economic, and others. Consequently, humanity faces the challenge of creating sustainable cities [1]. Sustainable cities are interpreted as meticulously planned and managed, taking into account social, economic, and environmental impacts, to ensure a sustainable living environment for urban dwellers in the present and future [2]. In recent years, Kazakhstani cities have been participating in international rankings and striving to contribute to the promotion of global ideas for sustainable urban development. According to the 2024 City Quality of Life Index rankings, Astana is ranked 131st, while Almaty is ranked 159th, among 179 major cities globally [3]. According to another ranking of the best cities for living in, the Quality of Living City Ranking, Almaty ranked 177th among 231 cities worldwide, while Astana did not make

the list [3]. According to various urban sustainability indices, Kazakhstani researchers have determined that the Citizen Centric Cities Sustainable City Index most comprehensively aligns with the available indicative data for calculating the sustainability index of Kazakhstani cities [4].

In these indices, adaptive management and the use of ecosystem services, resulting from comprehensive monitoring of the urban environment aimed at improving the well-being and health of the urban population, serve as crucial indicators of sustainable urban development [5]. Therefore, for the social ecology of urbanizing areas, the most important task is to provide citizens with “healthy urban conditions”, resources, and ecosystem services [6].

Urban ecosystem services are interpreted in various ways, with one of the definitions being “the direct and indirect contribution of ecosystems to human well-being” [7,8]. This study focuses on the urban ecosystem services of the city of Astana and their assessment. It also explores their potential application for improving urban areas, considering specific natural resources’ potential, and enhancing the mental well-being of citizens as a component of the city’s human capital [9,10].

Currently, there are several classifications of ecosystem services; however, in the context of the urban ecosystem services of Kazakhstan’s cities, it is important to consider the legislative norms of the Republic of Kazakhstan. The task is to improve the quality of urban ecosystem services as they are directly dependent on the condition of the urban ecosystem. Consequently, the assessment of urban ecosystem services can also serve as an evaluation of the overall state of the urban ecosystem. Healthy ecosystems are the foundation of sustainable cities, influencing human well-being and economic activity. In modern integrated comprehensive studies, a city is interpreted as a social system composed of large and small social groups that are psychologically distinct [11–14]. The characteristics of urban areas determine the differences, the social status of residents, the ethnic composition of the population, and functional roles within the urban environment [15–17].

Rapid urbanization processes have become particularly active in the last three decades due to the relocation of the capital of the Republic of Kazakhstan to the city of Astana. This has led to the exacerbation of socio-demographic and socio-environmental problems in the city. According to national statistics of the Republic of Kazakhstan, the city’s population grew fourfold from 327,000 people in 1998 to 1,354,000 people in 2023 [18]. Moreover, according to the General Plan of the city of Astana, the population of the town is expected to increase to 2.5 million people by 2035 [19]. Due to these urbanization trends, scientists must comprehensively study both the physical spatial environment and the geo-ecological state of space with the corresponding urban ecosystem services, and socio-psychological and environmental factors should be considered first.

For the methodology of our research approach within the framework of geo-urbanism, social psychology, ecological psychology, civic geography, urban ecology, and sociology, the use of mental maps and psychological and sociological surveys to represent dominant perceptions of the city appears to be promising. In this regard, the main research questions are as follows:

- (1) What are the features of spatial and object representation of the ecological state of the urban environment and the services provided by urban ecosystems in relation to the mental well-being of city residents?
- (2) How do residents perceive Astana’s urban environment based on their residence and socio-economic status?

This article describes the results of a comprehensive interdisciplinary study on the state of urban ecosystems in the city and their correlation with residents’ mental well-being and satisfaction levels regarding urban ecosystem services.

2. Territory and Area of Study

Astana is located in the very center of the mainland of Eurasia, in the southeast of the modern Akmola region in the northern part of central Kazakhstan (Figure 1). Astana has been the capital of the Republic of Kazakhstan since 10 December 1997 [20].

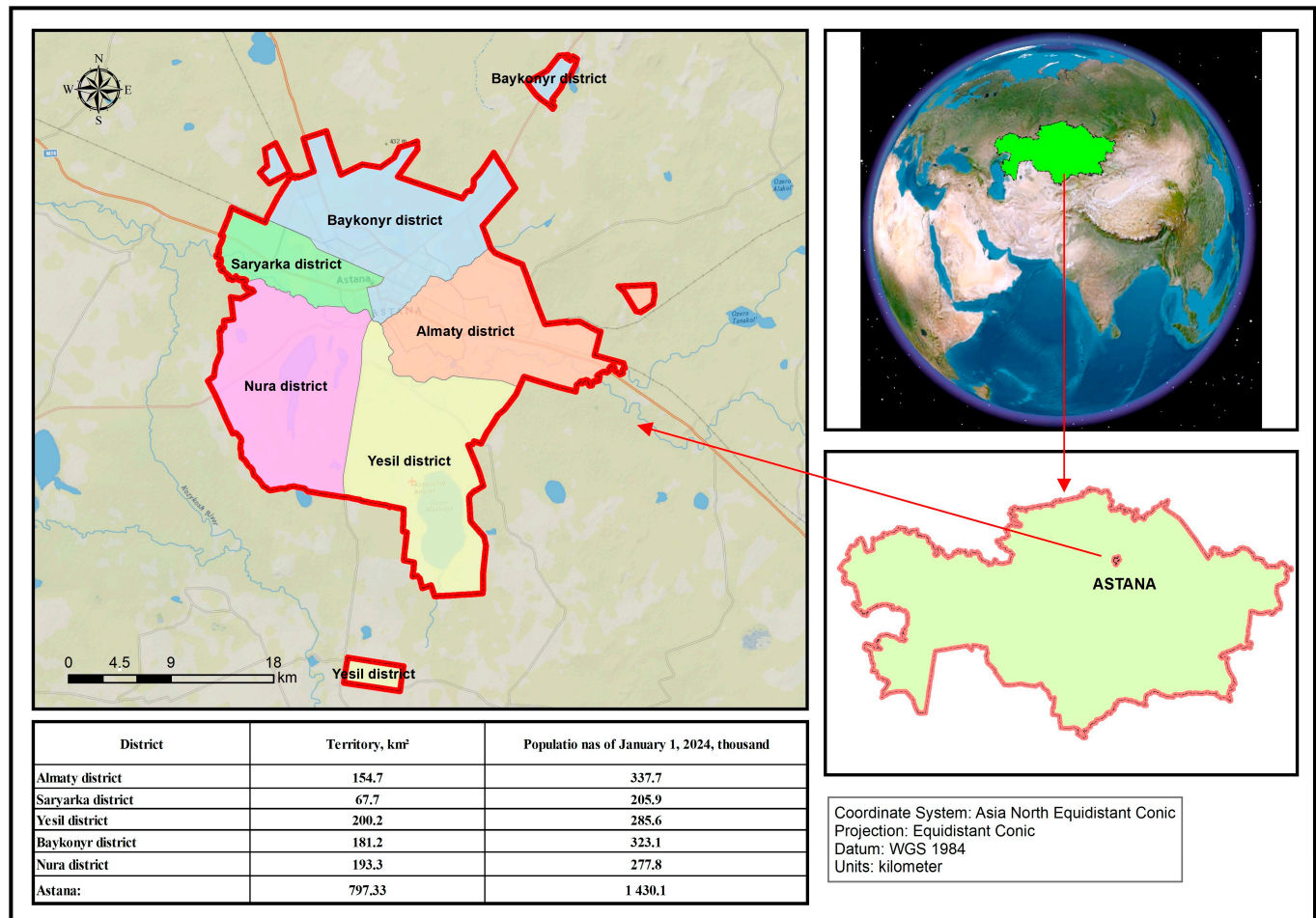


Figure 1. Study area.

The geographical latitude of the city is $51^{\circ}08'00''$ N, and the longitude is $71^{\circ}26'00''$ E. The area of the territory is 797.33 km². Most of the land consists of low mountain slopes and a small hilly plain with an elevation of 300–500 m [21]. Astana is administratively divided into five districts. Astana is an enclave surrounded by the territory of the Akmola region, which is administratively not part of it. The city stands on a steppe plain. The relief of the territory it occupies consists of low terraces above the floodplain. The lowest elevation above sea level is located in the floodplain of the Ishim River and is 337 m.

3. Research Methodology

For the methodology of our research approach within the framework of social psychology, environmental psychology, civil geography, urban ecology, and sociology, it seems promising to use mental maps of the city and psychological and sociological surveys to display leading ideas about it. In our case, we are talking about a spatial subject representation of the geo-ecological state of the urban environment and consumed urban ecosystem services in connection with citizens' mental well-being.

From a socio-ecological and psychological point of view, how residents perceive Astana's urban environment is important. In many studies, the city is interpreted as a social–ecological–psychological system consisting of large and small social groups with

processes, states, and properties that differ depending on many factors [22]. In this regard, in this article, as a result of the analysis of international and Kazakhstani experiences in the socio-psychological, socio-ecological, and geographical study of urbanization processes in large cities, we analyze the factors and conditions for the sustainable development of the city of Astana influencing the mental well-being of citizens in correlation with the results of geoeological research and the infrastructure of urban ecosystems.

For urban eco-diagnostics of the studied area, images from the JSC “NC” Qazaqstan Garysh Sapary” website from the EOSDA LandViewer Sentinel-2 Land Cover Explorer satellites were used. The initial data also included statistical and cartographic data from the RSE “Kazhydromet”, the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, geographical atlases of the Republic of Kazakhstan, and data from environmental reference books.

The study of the relationship between the geoeological state of urban ecosystems, urban ecosystem services, and the mental well-being of urban residents was conducted in four stages. The research procedure of this study is presented in Figure 2.

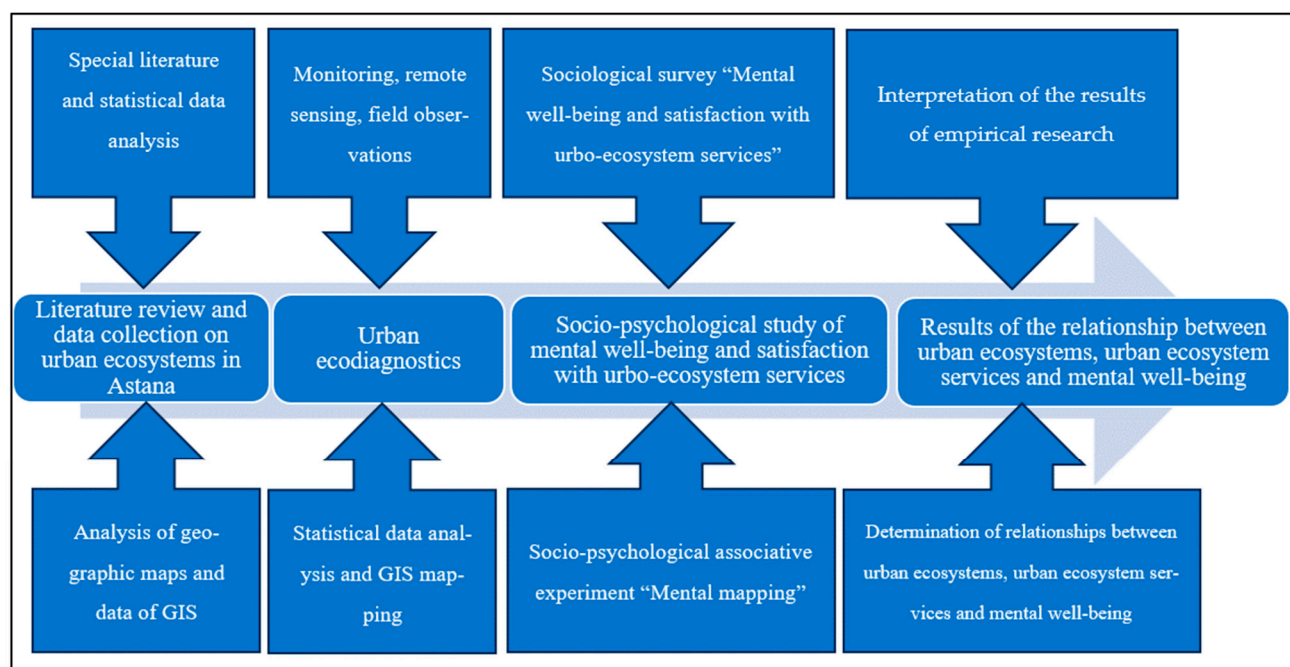


Figure 2. Research procedure (compiled by the authors).

In the first stage, based on a theoretical analysis of literature, statistical data, and analysis of cartographic materials, a description of the study area was compiled and geographic maps of the urban ecosystems of Astana were created using GIS technology (ArcGIS 10.8).

In the second stage, comprehensive urban eco-diagnostics were conducted using geoeological research methods: monitoring, remote sensing, field observations, analysis of statistical data, and GIS cartography of the geoeological state of Astana’s urban ecosystems.

A sociological survey and a socio-psychological associative experiment were carried out in the third stage. The associative experiment mental map of the city by Stanley Milgram and Kevin Lynch was used as a socio-psychological method [23,24] and a standardized questionnaire, “Warwick–Edinburgh Mental Well-Being Scale” [25]. This study used statistical and mathematical methods to process empirical data using the SPSS 27 program (Student’s *t*-test and Pearson correlation analysis). The empirical basis of this study was residents of Astana of different ages and living in all city districts based on a random sample, and 425 respondents took part in the study.

The fourth stage of the study was characterized by interpreting the results of empirical research and determining relationships between the data of urban eco-diagnostics and socio-psychological diagnostics of mental well-being and residents' satisfaction with urban ecosystem services of the city of Astana.

4. Results and Discussion

4.1. Literature Review

The modern stage of urban development necessitates a radical reassessment of environmental management principles based on sustainable urban development. According to the "Brundtland Report" of 1982, the idea of preserving the environment and resources for the needs of future generations was articulated as the concept of "sustainable development" [26]. From this perspective, sustainable urbanism enhances the quality of life, safety, and overall living conditions for people in the city [27]. Meanwhile, there is no universal model, form, or structure for sustainable urban development, as each city possesses its individuality, expressed in the "spirit of place" or "genius loci", as well as its unique identity [28]. However, the entire diversity of approaches and urban forms aims to find sustainable development based on ensuring an ecological balance between the state of the environment, urban ecosystem services, and urban infrastructure. In this regard, our research is based on the ideas of urban form, which, according to Silva [29], depend on the following predictors: spatial location, functionality of infrastructure, and appearance, which produce certain urban ecosystem services.

The consumption and production of urban ecosystem services in urban ecology depend on such a phenomenon as ecological balance [30]. Ecological balance a priori implies a rational ratio of territories used by urban ecosystems and natural landscapes; the reproductive capacity of the territory to reproduce atmospheric oxygen, water, soil, and vegetation; its geoecological capacity, coupled with biodiversity; the geochemical and biochemical activity used to create ecosystem services and goods and ensure self-regulation of urban ecosystems; and the resistance of territories to physical anthropogenic loads [31,32]. Ecological balance is maintained only under permissible anthropogenic loads that do not exceed the territory's capacity [33]. Consequently, urban eco-diagnostics of urban ecosystems and urban ecosystem services produced and consumed in the city are the main subjects of the study of modern towns [33].

In this study, the ecological balance of urban ecosystems is defined as the state of the natural environment in an urbanized area, in which self-regulation is ensured, along with the appropriate protection and reproduction of its key components—atmospheric air, water resources, soil-vegetation cover, and wildlife. As the theoretical basis for assessing the state of ecological balance in urban ecosystems in the context of the production and consumption of urban ecosystem services [34], we examine the primary conditions and indicators of ecological balance:

- (1) The reproduction of the critical components of the natural environment, ensuring their balance in energy flows within urban ecosystems, is reflected in indicators such as green infrastructure (forest plantations, parks, squares, avenues, canals, rivers, lakes, air, etc.);
- (2) The degree of geochemical activity of landscapes concerning the scales of industrial, transportation, and municipal waste pollution of urban ecosystems is expressed in indicators such as pollution of the environment by transportation, pollution from industrial waste, and pollution from municipal waste;
- (3) The correspondence between the level of physical resilience of landscapes and the strength of anthropogenic impacts is expressed through indicators such as population density within urban ecosystems;
- (4) The balance of biomass in undisturbed or minimally disturbed areas of the city, as expressed by indicators such as the biodiversity of the city's green infrastructure.

In the course of the theoretical analysis of the research topic, the following scientific provisions were identified as the theoretical and methodological basis of the study: the

provisions of environmental psychology [35,36], the provisions of the psychology of large social groups and group consciousness [37], the concept of the relationship between a person's mental well-being and the state of the surrounding natural and anthropogenic environment [23,38–41], the principles of urban morphology theory, which examines the relationships between urban infrastructure, the representation of urban space, and the construction and consumption of urban ecosystem services [42–44].

According to the theory of urban morphology, the idea of studying urban infrastructure in relation to land use, architecture, and urban ecosystem services is of methodological interest [42]. In this regard, Cowan identifies four approaches to the study of urban morphology: historical-geographical, typomorphological, spatial-morphological, and configurational [43]. Therefore, morphological studies of the city can be divided into four groups that examine different disciplines, such as geography, architecture, natural sciences, and philosophy. Urban historical geography considers representations of ideas about the urban environment. Typomorphological analysis is the subject of architectural study. Spatial analysis investigates urban forms from the natural sciences' perspective [45]. The philosophical focus of the analysis of urban forms studies the city as a social entity with images of unique societal identification [46].

Regarding the aforementioned methodological approaches, our approach to the study of the mental well-being of urban residents in relation to the ecological state of the urban environment is focused on spatial-analytical [47] and configurational approaches to urban morphology [48]. Therefore, the two other approaches, namely the historical-geographical and typomorphological approaches related to historical geography and architecture, will be disregarded. In studying urban space within the framework of the configurational approach, alongside urban forms of buildings and infrastructure, attention is focused on the philosophical and socio-psychological study of the city's image in people's consciousness linked to a specific locality. Simultaneously, we have conducted a spatial-morphological analysis of the city's residents' ecological-behavioral aspects of urban environment perception within the framework of a spatial analytical approach to urban morphology. In particular, based on the systematization of research on large cities alongside urban forms, we also identified urban processes, properties, and states of the mental and environmental well-being of the city as a carrier of group consciousness [49,50]. From this point of view, we have attempted to repeat the experiments of Stanley Milgram and Kevin Lynch [22,23] which were carried out in the 70s of the last century in Paris and New York [51], T.V. Semenova in the city of Samara [48] and the city of Uralsk, D.N. Sazonov in the city of Belgorod [52], and Osóch and Czaplińska in Szczecin, Poland [53].

In our research, we followed the ideas of Passmore and Howell to illustrate how the connection with the city's natural-anthropogenic environment contributes to individuals' well-being and psychosocial functioning [54]. In other studies, the city is interpreted as a social-ecological-psychological system consisting of large and small social groups that possess a combination of processes, states, and properties that differ depending on various factors [22,49].

4.2. Main Body

Based on the analysis of the results of statistical data, the results of field research using instruments and geoinformation satellite data from EOSDA LandViewer Sentinel-2 Land Cover Explorer for 2024, we have compiled maps characterizing the infrastructure of the city of Astana by administrative districts of the town: map of green spaces of the city of Astana according to NDVI (highlighting recreational zones) (Figures 3 and 4), a map of the ecological framework of the city's landscapes (Figure 5), a map of the functional zoning of urban ecosystems of Astana (Figure 6), and a map of ecological balance (Figure 7).

According to the NDVI map results, the city of Astana's vegetation cover ranges from −0.1 to 0.4, which shows an insufficiently high level of green space distribution. Next, based on the NDVI indicator, we compiled a map of the city's ecological framework.

The ecological framework is represented by urban areas with undeveloped vegetation and those not covered with artificial materials. The ecological framework of the city of Astana forms a single landscape and recreational zone, including forest parks, public gardens, the floodplain of the Yesil River, and the plantings of the “Green Belt” of Astana. Green spaces in the city make up 51% of the total area.

Analysis of the landscape map shows that a large area of the city is occupied by landscapes of urbanized, recently formed transaqueous landscapes on ancient alluvial loams (in the center of the city), an eluvial flat plain with arable land on meadow southern chernozem (in the east of the city), a transaqueous plain on meadow chernozem (in the south and in the east of the city), a flat sloping plain with arable land on southern black soil (in the southwest of the city), an industrial transaqueous landscape (in the north of the city).

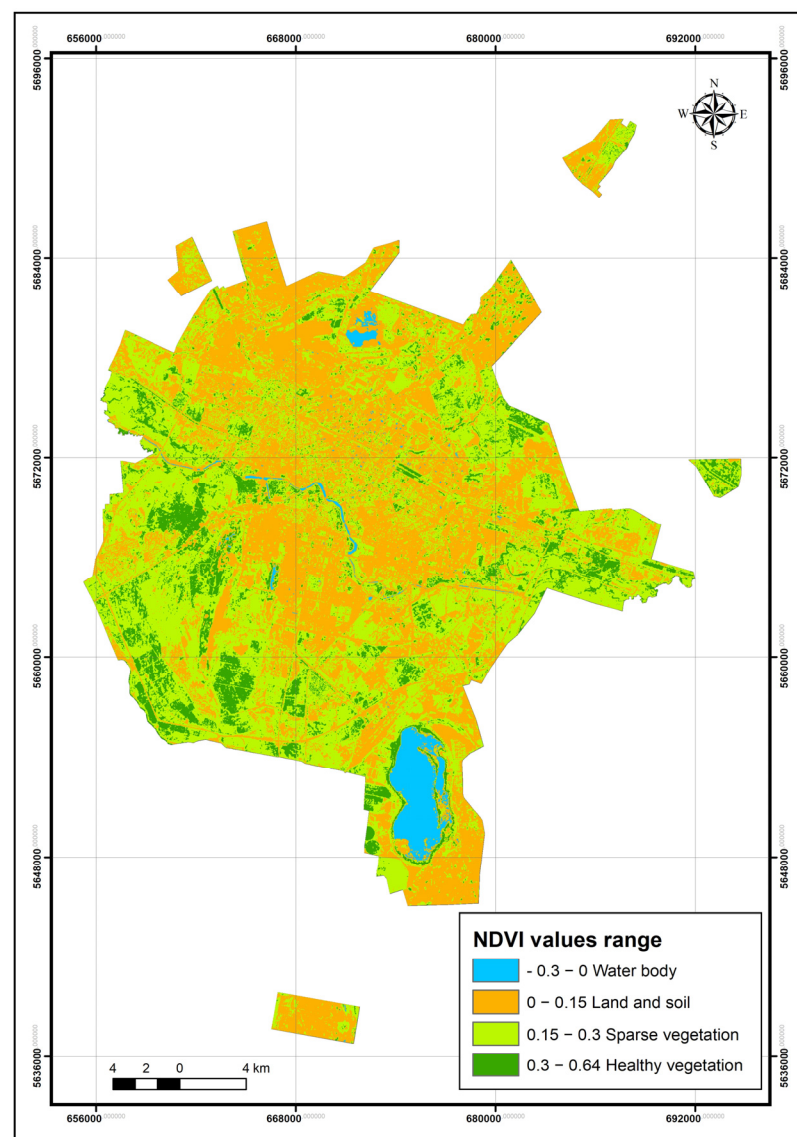


Figure 3. NDVI map of Astana.

Comparing the landscape map with the functional zoning map, the following administrative districts are identified with their functional purpose:

The Almaty region, located in landscapes 1, 3, and 6, is a residential urban ecosystem with numerous high-rises, low-rises, private houses, and urban aprons. The Almaty district received the name “Cultural District” since here on the right bank of the Yesil River along

Tauelsizdik Avenue, there are such cultural attractions of the city and the country as the “Palace of Independence”, “National Museum of the Republic of Kazakhstan”, “Palace of Peace and Reconciliation”, and the “Khazret Sultan Mosque”.

The Baikonur district—including landscapes 1, 6, 8, 10, and 11—is an industrial-technogenic urban ecosystem of the city with zones of production, storage, technogenic, and commercial activities with trade functions, service areas, and utility areas. Although the area is developing rapidly, measures are required to maintain ecological balance. Green building projects and the creation of new park areas are aimed at improving residents’ environmental situation and quality of life. The Baikonur district is the old city center with industrial enterprises.

The Saryarka district, formed on landscapes 1, 2, 5, and 8, is distinguished by city parks, green spaces, utility and warehouse areas, and service areas. Significant areas of this district are occupied by natural areas, which makes it an important environmental barrier for the city. The district’s territory is important for preserving the city’s biodiversity, as it serves as a habitat for many species of flora and fauna. The area is dominated by plants and animals typical of the steppe zone, which presents a particular interest for scientific and ecological research. The Saryarka district is the most densely populated area. Despite the small area, the population is large, and the population density is the highest. Multi-story buildings built between 1933 and 1999 account for 60% of the area and require reconstruction.

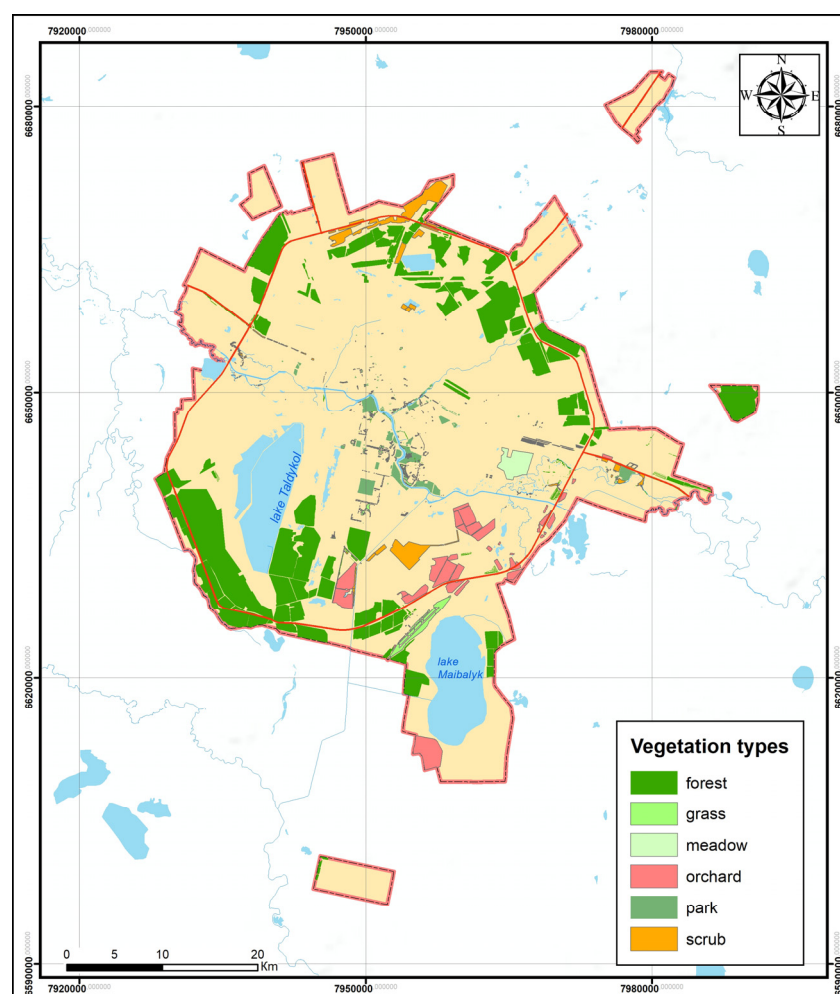


Figure 4. Ecological framework map of the city’s landscapes.

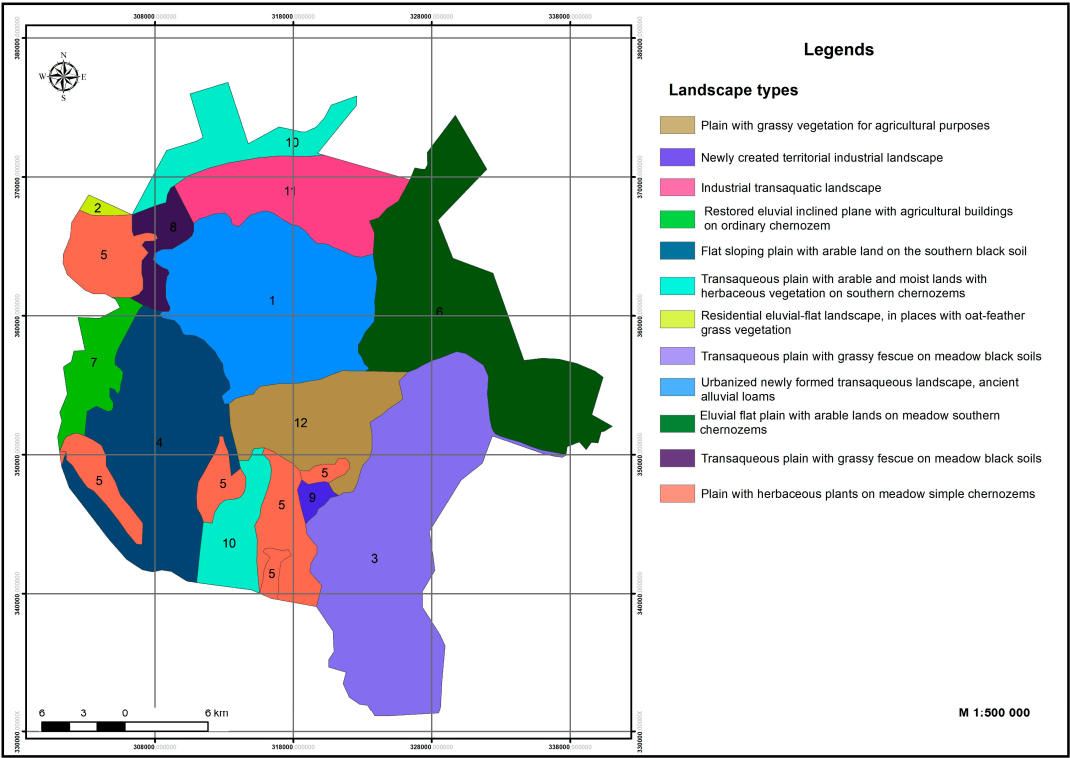


Figure 5. Landscape map of Astana.

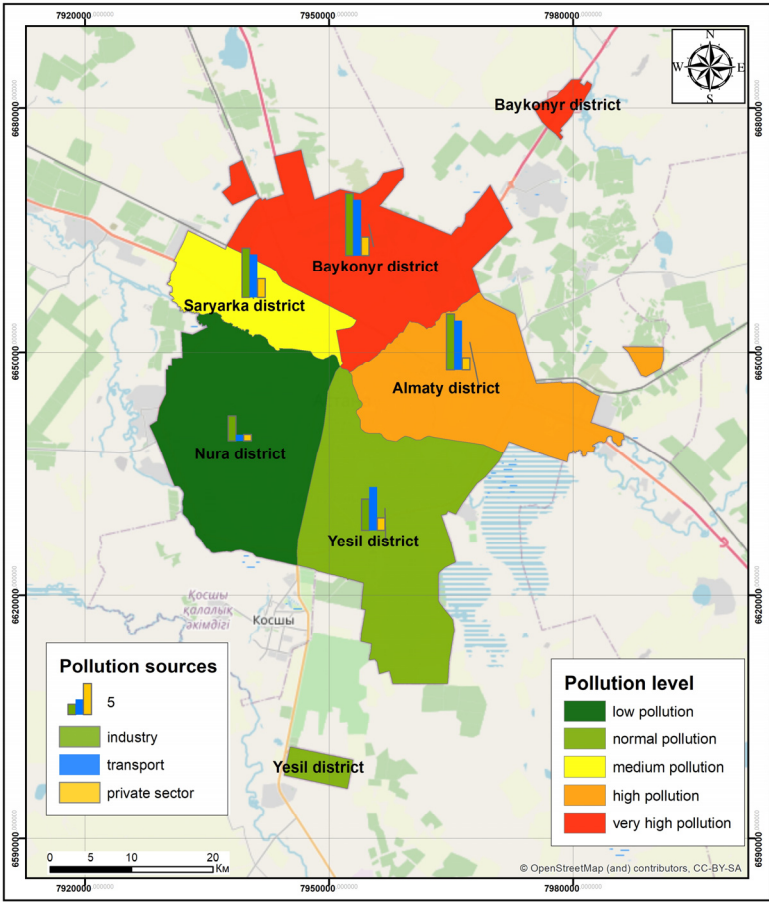


Figure 6. Functional map zoning.

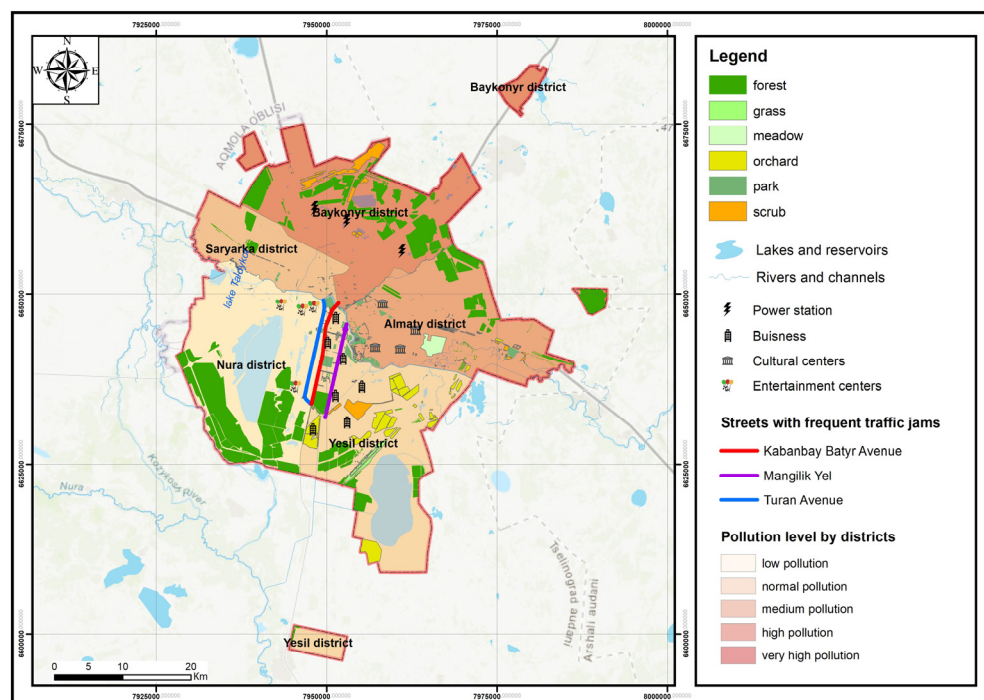


Figure 7. Ecological balance map of Astana.

The Yesil district, located in landscapes 3, 8, 9, 10, and 12, is marked by the predominance of the engineering and transport infrastructure zone: the airport zone, the zone of highways and utilities, city parks, tourist and recreational areas, urban green areas, and residential urban ecosystems. The Yesil district is the modern administrative and business center of Astana. It includes many modern architectural buildings, including high-rise buildings and government buildings. Green areas such as the Presidential Park and Nurzhol Boulevard play a key role in creating a favorable ecological. They help reduce carbon dioxide levels and improve air quality. Yesil district is a “comfortable area”. This area is considered the safest in the city, as special attention is paid to the arrangement of courtyards, recreational areas, tourist attractions, underground parking, and video surveillance systems.

Nura district—an area located in landscapes 4, 7, and 10, is a recreational and emerging residential urban ecosystem with city parks and green spaces of the “Green Belt of Astana”. This area forms new residential landscapes with new multi-story residential developments mixed with industrial developments. Land reclamation is being actively carried out in the Nura region, which helps restore natural vegetation and improve ecological balance. Nura district is a “promising area”. This area is recently identified as one of the most promising in tourism and recreation.

For the purpose of urban environmental diagnostics of the city districts, based on the analysis of statistical data and field studies of air, soil, and water pollution in the districts of the city of Astana in terms of the volume of pollutants from waste from the industrial, transport, and private residential sectors, we have included Table 1 and a map of environmental pollution by district Astana city. Following Table 1, we have compiled a map of environmental pollution by district of Astana (Figure 6).

The environmental pollution map illustrates the contamination levels in various districts of Astana and the sources of this pollution. Among the districts, the most polluted areas in terms of soil cover, vegetation, and atmospheric air are found in the Baikonur district. One of the main reasons for this is the location of three thermal power plants in the northern and northeastern parts of the city. According to official statistics for Astana, 47% of pollutants come from industry, 46% from emissions of the transportation system, and only 7% from waste generated by the private sector.

Table 1. Sources of pollution in Astana city districts [30].

Sources of Pollution	Baikonur District	Almaty District	Saryarka District	Yesil District	Nura District
Waste from the industrial sector, (tons)	25,964	19,864	16,953	9056	6127
Waste from the private residential sector, (tons)	3369	2566	2056	2785	607
Emissions from transport, (tons)	19,873	18,683	16,566	14,156	1091
Territory, km ²	181.2	154.7	67.7	200.2	193.3
Population as of 1 January 2024, thousand	323.1	337.7	205.9	285.6	277.8

Based on a detailed analysis of data on urban eco-diagnostics and urban ecosystem services, we have compiled a map of the ecological balance of the city of Astana (Figure 7). When creating the ecological balance map of Astana, the analysis covered green spaces in the districts, natural parks, population density by district, air quality in the areas, sustainable sources of impact on it, and anthropogenic sources. Based on the results of the map analysis, it was determined that the highest level of ecological balance among the districts of the city of Astana is occupied by the Nura district, the Yesil district is in second place, the Almaty district is in third place, the Saryarka district is in fourth place, and the Baikonur district is in fifth place. These conclusions are due to air quality, volumes of pollutants, population density, urban ecosystem services provided by natural, recreational, cultural, and tourist sites, and the quality of district infrastructure.

A total of 425 respondents participated in an empirical socio-psychological study of mental well-being and satisfaction with urban ecosystem services in Astana. All of them were residents of Astana, of which 226 were female and 199 were male. Regarding age, 65% of respondents were adults aged 18 to 62, and 35% were retirees. Three main groups were identified based on social and professional status: university students (36%), adults aged 24 to 62 years (34%), and retirees (30%). There were no significant differences in income levels among the respondents.

The following hypotheses were identified as experimental hypotheses:

Hypothesis 1. *Spatial representations of the geo-ecological state of the city are interconnected with the mental well-being and satisfaction with urban ecosystem services of citizens, depending on the area of residence.*

Hypothesis 2. *Spatial representations of the ecological state of the city are interconnected with the citizens' mental well-being and satisfaction with urban ecosystem services, depending on the socio-business status.*

At the first stage of the socio-psychological study, to determine spatial representations, a projective psychological technique called “drawing up mental maps” was carried out. The aim was to mentally map the geo-ecological state of urban ecosystems in the city of Astana and determine citizens' level of satisfaction with urban ecosystem services.

Analysis of the ratio of respondents' mental maps shows no large differences in the content and types of mental maps in age and social and business status (Figure 8). Among middle-aged residents, schematic maps and cultural-historical maps stand out, which indicates an established urban identity and the linking of objects to the city's environmental characteristics with the city's geo-ecological standard. The image of the city's environmental representation is expressed in proportionality, logic, and structure. Compared to students, middle-aged residents have a more excellent representation of sketch maps and a decrease in sketch maps. Compared to pensioners' cards, middle-aged residents have a decrease in cultural-historical cards and personal-value cards. For middle-aged residents, cultural and business objects come to the fore, which can be associated with professional needs and constant communications. In terms of content, adult respondents in the maps note environmental problems related to overcrowding of the city, increasing speed of travel, increasing traffic jams, vertical expansion of the city, marginalization of urban migrants,

lack of urban ecosystem services such as green spaces, lack of recreational and cultural facilities. The most informative are the maps of the elderly and pensioners, since they are the city's indigenous inhabitants, are well aware of its history, and are carriers of culture. In terms of content, their maps particularly present such environmental problems as a lack of green spaces, places of recreation, tourist and recreational areas, green play areas for children, lack of culture, alienation of young people, aggressiveness of the urban environment, many vehicles, gas pollution in the central streets of the city, high cost of services, including recreational, medical and environmental services, and crime rates in the peripheral areas of the city. Among the positive aspects of environmental representations, one should note the increase in the green belt of the city, the emergence of new parks and alleys, the improvement of the aesthetics of the new city center—the left bank, good automation and digitalization of the city, free travel in public transport for pensioners, quality of medical services, and a higher standard of living in new areas on the left bank of the capital.

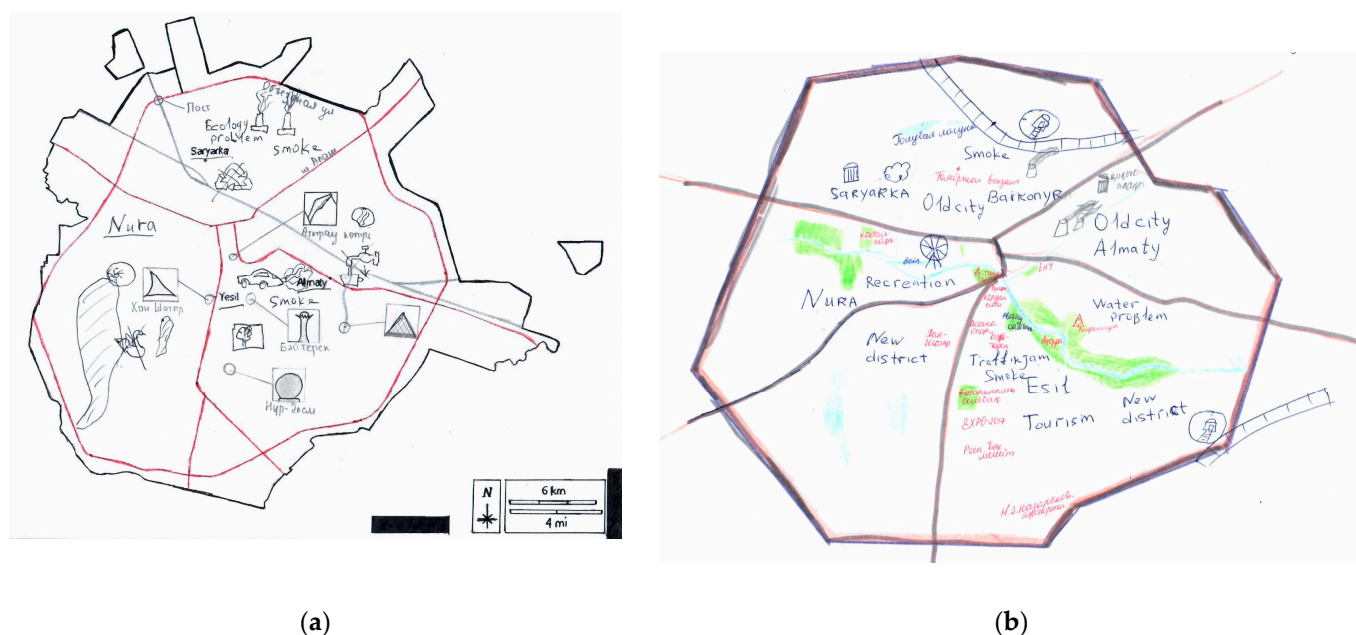


Figure 8. Mental maps (a) of a resident of the left bank (new center) (45 years old, male); and (b) of a resident of the right bank (old center) (66 years old, female).

There is a significant differentiation in the mental ecological maps of the city between residents of the city center and those on the periphery. Due to their complex and intense lifestyles, residents of the central districts tend to have quite intricate geo-ecological spatial representations. The negative aspects include uniform architecture, urban noise, depersonalization, overpopulation, the “grayness of the city”, the sadness of new buildings, apathy, aggressiveness, fast pace, traffic jams, and a lack of green spaces. On the positive side, they perceive material well-being, ecological cleanliness, cultural landmarks, tourist attractions, safety, well-maintained areas, places for recreation (parks), comfort, modern homes and buildings, high-rises, etc. While residents of the city's peripheral areas tend to have relatively simple ecological spatial representations due to the monotonous and slow pace of life, these representations can be negative—characterized by emergency conditions, ecological danger, dirt, gloom, poverty, boredom, garbage dumps, depressive slums, old houses, lack of recreational parks, tourist and recreational centers, economic backwardness due to low income levels, crime rates, poor living conditions, insufficient lighting, smoke from heating during the cold season, uncollected garbage, and a lack of cultural and sports facilities, among others. On the positive side, they may view their area as a quiet neighborhood with a slow pace calm rhythm of life, offering solitude. Overall, the

mental representation of the geoecological state of the city and satisfaction with urban ecosystem services is primarily influenced by the factor of living in a specific area of the city. This is because people spend most of their time in the central areas and can describe the ecology of the city center—which is significant for their daily lives—more thoroughly. In contrast, life in the peripheral areas, especially in the “old town” on the right bank of Astana, seems to slow down, and ecological problems related to infrastructure, urban ecosystem services, and safety become more pronounced. At this stage of the experimental research, Hypothesis 2 is not confirmed.

In the second stage of the socio-psychological research, the survey method “Warwick–Edinburgh Mental Well-Being Scale” was conducted [24]. To measure the level of mental well-being of urban residents, respondents answered 14 questions in the questionnaire. Participants rated their responses on a 5-point scale (from 1—never to 5 always), with the highest score indicating the highest level of mental well-being. The results of the mental well-being study conducted with respondents living in the central and peripheral city areas are presented in a comparative graph in Figure 9.

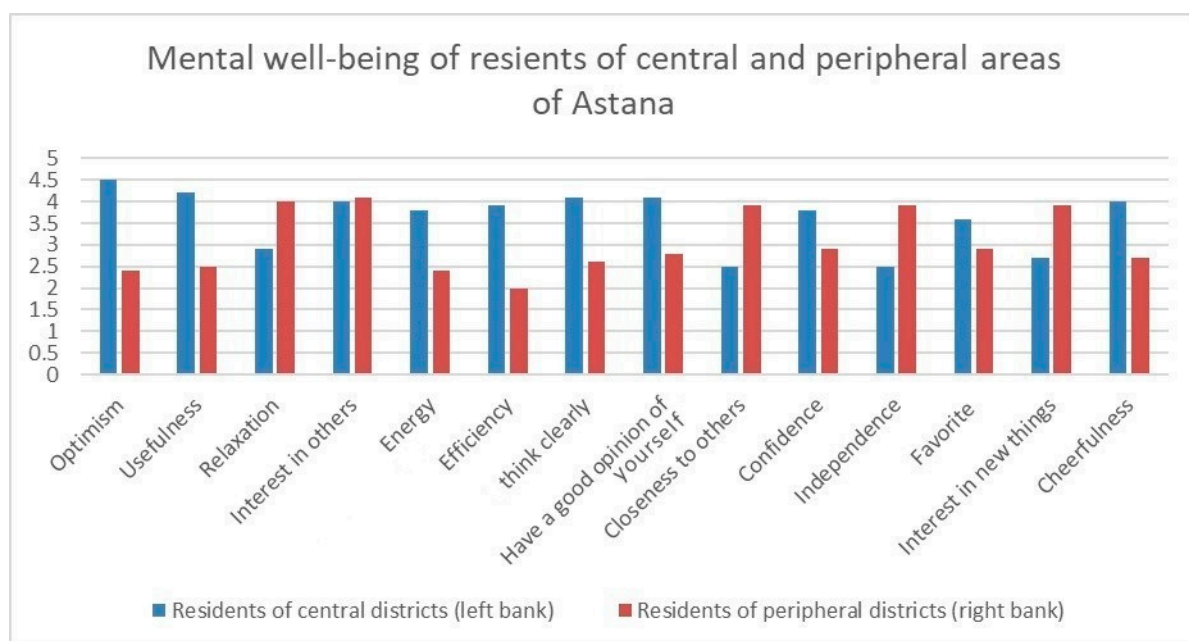


Figure 9. The mental well-being of residents of central districts and peripheral districts of Astana.

As shown in Figure 10, the mental well-being scores across 14 scales for residents of central areas of Astana range from 2.5 to 4.5 points, while for residents living in peripheral areas on the right bank of Astana, the scores range from 2 to 4.1 points. In both samples, the highest level is observed on the “Optimism” scale (center—4.5, periphery—3.9). This indicates that despite existing problems, residents maintain an optimistic outlook on life in both groups. The greatest differences in the data are observed on the “Problem Solving Effectiveness” scale (center—3.9, periphery—2). Additionally, large differences in indicators are observed on the “Usefulness” scale (center—4.2, periphery—2.5), the “Cheerfulness” scale (center—4, periphery—2.7), and the “Energy” scale (center—3.8, periphery—2.4). Thus, residents of peripheral areas experience more stress and fatigue, as well as feelings of inadequacy and uselessness in helping others solve life’s challenges, possibly due to the lack of infrastructure development in their residential areas and time spent commuting to work on the left bank. Meanwhile, on scales such as “Relaxation” (center—2.9, periphery—4), “Interest in new things” (center—2.7, periphery—3.9), “Independent opinion about things” (center—2.5, periphery—3.9), and “Proximity to other people” (center—3.4, periphery—3.9), residents of peripheral areas show higher mental well-being scores.

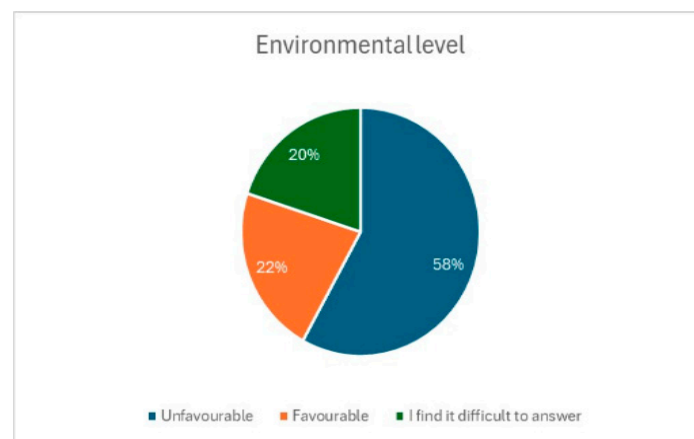


Figure 10. Environmental level.

This indicates that residents of peripheral areas interact more closely with their neighbors, as they often live in private homes and low-rise buildings and are less intensely involved in the mass activities observed in the city center. Additionally, they are not as accustomed to new infrastructure and cultural, recreational, and sports facilities, which may explain their favorable reception of innovations in their area.

As seen from the Table 2, residents of the central areas of Astana show a positive correlation between the mental well-being score for vigor and the effectiveness score ($r = 0.415$; $p = 0.01$), confidence ($r = 0.383$; $p = 0.05$), and closeness to other people ($r = 0.351$; $p = 0.05$). There is also a positive correlation between the optimism indicator and the loved one indicator ($r = 0.377$; $p = 0.01$). There is a negative correlation between the indicator beloved and the indicator “I think clearly” ($r = -0.398$; $p = 0.05$). In addition, a negative correlation is observed between the indicator for relaxation and cheerfulness ($r = -0.398$; $p = 0.05$) and that for interest in new ($r = -0.363$; $p = 0.05$).

This means that the higher the level of vigor, the lower the scores for interest in new things and relaxation among residents of the central areas. This indicates that despite their vigor and energy, they face issues related to accumulated fatigue, the threat of chronic urban stress, depersonalization syndrome, and apathy.

The Student’s *t*-test was used to determine the differences in mental well-being scores between residents living in central and peripheral areas of the city. The results are presented in Table 3.

According to the results of a survey conducted using the “Warwick–Edinburgh Mental Well-Being Scale” method, it was revealed that respondents living in central areas on the left bank of Astana, when compared to residents living in peripheral areas of the right bank of Astana, have big differences, in particular, better mental well-being on such scales as “Optimism” ($t = 4.978$; $p = 0.000$), “Usefulness” ($t = 6.736$; $p = 0.000$), “Efficiency in solving problems” ($t = 4.938$; $p = 0.000$), “I think clearly” ($t = 5.728$; $p = 0.000$), “Have a good opinion of myself” ($t = 4.706$; $p = 0.000$), and “Cheerfulness” ($t = 5.248$; $p = 0.000$). These results demonstrate that respondents living in peripheral areas have problems in the psychological sphere; in particular, they are more pessimistic, experience difficulties in solving everyday problems, have a reduced level of self-esteem and usefulness for others, and as a result, they experience stress and are not cheerful enough.

Table 2. Correlations between Warwick–Edinburgh mental well-being scales according to Pearson correlation.

Pearson Correlation														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Optimism	1													
2. Usefulness	0.165	1												
3. Relaxation	−0.283	−0.168	1											
4. Interest in others	0.141	0.236	0.077	1										
5. Energy	−0.044	0.322	0.279	−0.129	1									
6. Efficiency	0.006	0.166	−0.149	−0.124	0.415 **	1								
7. I think clearly	−0.088	0.426 **	−0.051	0.309	−0.218	−0.054	1							
8. Have a good opinion of yourself	0.194	0.194	−0.059	0.022	0.239	−0.219	−0.161	1						
9. Closeness to others	−0.084	−0.249	−0.244	0.000	0.351 *	0.326 *	0.305	0.071	1					
10. Confidence	0.012	0.118	0.168	−0.039	0.383 *	−0.097	−0.039	−0.045	−0.311	1				
11. Independence	0.242	0.000	0.228	−0.116	−0.145	−0.081	0.152	0.263	−0.073	0.000	1			
12. Favorite	0.377 *	−0.187	−0.138	0.257	−0.044	0.180	−0.398 *	−0.106	0.000	−0.047	−0.183	1		
13. Interest in new things	0.018	0.082	−0.363 *	0.246	−0.309	0.129	0.363 *	0.047	0.039	0.000	0.145	0.097	1	
14. Cheerfulness	0.188	−0.086	−0.357 *	−0.043	0.080	−0.217	−0.287	0.235	−0.236	0.157	0.293	0.034	−0.156	1

* Correlation 0.05. ** Correlation 0.01.

Table 3. The degree of differences in indicators of mental well-being of citizens living in central and peripheral areas of the city according to Student’s *t*-test.

	Test for Independent Samples								
	Livigne’s Test for Equality of Variances			<i>t</i> -Test for Equality of Means					
	F	Meaning	T	CT.CB.	Meaning (Double-Sided)	Average Difference	Mean Square Error of Difference	95% Confidence Interval for the Difference	
I’m optimistic	0.372	0.546	4.978	38	0.000	1.65000	0.33146	0.97899	2.32101
			4.978	37.680	0.000	1.65000	0.33146	0.97880	2.32120
I’m useful	0.825	0.369	6.736	38	0.000	1.70000	0.25236	1.18913	2.21087
			6.736	35.659	0.000	1.70000	0.25236	1.18803	2.21197
I’m relaxed	0.099	0.755	−3.803	38	0.001	−1.10000	0.28928	−1.68562	−0.51438
			−3.803	37.998	0.001	−1.10000	0.28928	−1.68562	−0.51438
I am interested in others	1.744	0.194	−7.755	38	0.000	−1.75000	0.22566	−2.20682	−1.29318
			−7.755	34.917	0.000	−1.75000	0.22566	−2.20815	−1.29185
I’m energetic	0.651	0.425	4.960	38	0.000	1.35000	0.27217	0.79901	1.90099
			4.960	36.215	0.000	1.35000	0.27217	0.79812	1.90188

Table 3. Cont.

	Test for Independent Samples								
	Livigne's Test for Equality of Variances		t-Test for Equality of Means						
	F	Meaning	T	CT.CB.	Meaning (Double-Sided)	Average Difference	Mean Square Error of Difference	95% Confidence Interval for the Difference	
								Lower	Upper
I solve problems effectively	0.005	0.944	4.938	38	0.000	1.25000	0.25314	0.73755	1.76245
			4.938	37.335	0.000	1.25000	0.25314	0.73725	1.76275
I think clearly	0.970	0.331	5.728	38	0.000	1.45000	0.25314	0.93755	1.96245
			5.728	34.906	0.000	1.45000	0.25314	0.93605	1.96395
I have a good opinion of myself	0.455	0.504	4.706	38	0.000	1.30000	0.27625	0.74075	1.85925
			4.706	36.727	0.000	1.30000	0.27 625	0.74012	1.85988
I feel close to other people	0.405	0.528	−4.918	38	0.000	−1.40000	0.28470	−1.97634	−0.82366
			−4.918	37.594	0.000	−1.40000	0.28470	−1.97654	−0.82346
I'm confident	0.152	0.698	2.922	38	0.006	0.85000	0.29087	0.26116	1.43884
			2.922	37.888	0.006	0.85000	0.29087	0.26111	1.43889
I have my own opinions about things	0.018	0.894	−5.549	38	0.000	−1.45000	0.26132	−1.97902	−0.92098
			−5.549	37.139	0.000	−1.45000	0.26132	−1.97942	−0.92058
I'm loved	0.006	0.939	2.870	38	0.007	0.70000	0.24387	0.20631	1.19369
			2.870	37.926	0.007	0.70000	0.24387	0.20627	1.19373
I'm interested in new things	1.139	0.293	−4.366	38	0.000	−1.20000	0.27482	−1.75635	−0.64365
			−4.366	34.459	0.000	−1.20000	0.27482	−1.75823	−0.64177
I feel cheerful	0.001	0.972	5.248	38	0.000	1.35000	0.25726	0.82920	1.87080
			5.248	37.966	0.000	1.35000	0.25726	0.82918	1.87082

Meanwhile, according to the results of this survey methodology, it was found that residents of central regions have a lower level of mental well-being on the scales of “Relaxation” ($t = -3.803$; $p = 0.000$), “Closeness to others” ($t = -4.918$; $p = 0.000$), “Independent opinion about things” ($t = -5.549$; $p = 0.000$), and “Interest in new things” ($t = -4.366$; $p = 0.000$). The identified differences between the samples show that citizens from the peripheral areas have developed certain psychological stereotypes regarding the environment, and they are calmer about problems and more relaxed. They are also more friendly and have fairly close relationships with their neighbors; they have their own opinions, which are not similar to the crowd’s opinions, and they show interest in innovations and look forward to improving their current life situation. Residents of the central areas are more susceptible to urban stress due to the high pace of life, alienation, crowd phenomena, and urban neurosis due to the high population density in the city center. No significant differences were found on the remaining scales of the questionnaire.

At the third stage of the socio-psychological study, we conducted a sociological survey, “Geo-ecological well-being of the city of Astana”. The questionnaire includes 46 questions based on adapting the criteria and indicators of the Citizen Centric Cities Sustainable City Index and the Quality of Life Index. From 02/20/24 to 03/20/24, a sociological survey was conducted among residents of five administrative districts of Astana. 227 respondents took part in the survey.

More than half of the respondents (58%) generally consider the environmental situation in Astana to be unfavorable, 22% of survey participants consider the city’s ecology to be quite favorable, and 20% find it difficult to answer (Figure 10).

According to the survey results, Astana’s most environmentally safe districts are the Almaty district and the Yesil district, with an average of 28.1% and 27.7%. Saryarka district was rated 23.2%, Nura district took fourth place at 12.4%, and Baikonur district scored 8.6% in the environmental well-being ranking.

The most polluting factors in urban ecology are household waste (49%), air pollution from transport (30%), and construction waste (21%) (Figure 11).

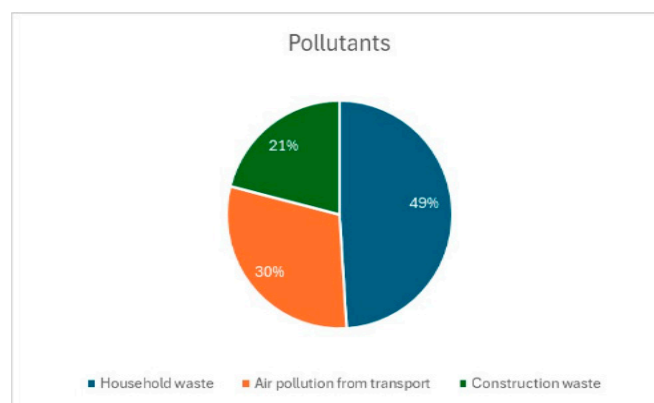


Figure 11. Pollutants.

In response to the question “Which district of the city do you consider to be the most environmentally polluted?”, the respondents indicated that the most polluted area is the Baikonur district (32%), followed by Almaty (30%). The third place is occupied by the Saryarka district (24%), followed by the Yesil district (9%), and finally, the Nura district (5%) (see Figure 12).

According to respondents’ answers, the area with the most polluted atmospheric air is the Yesil district—64.3%. The second place is the Baikonur district—56.7%. The third is the Almaty district—39.5%. The fourth is the Nura district—27.1%. In last place is the Saryarka district—24%.

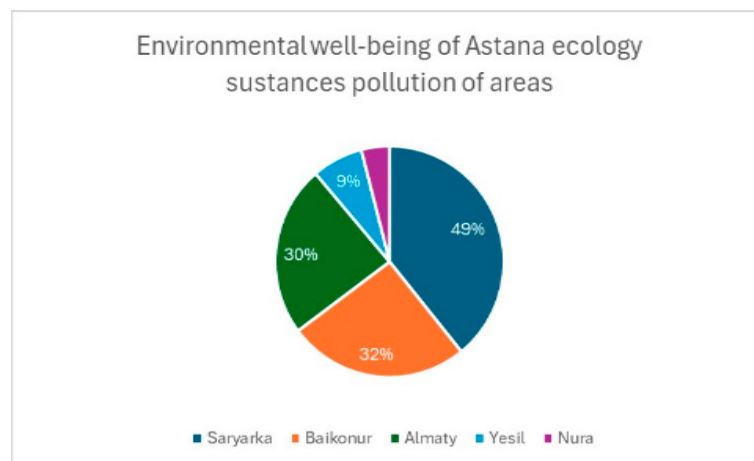


Figure 12. Environmental well-being of Astana ecology substance pollution of areas.

Responding to the question “Do you believe there are sufficient social and recreational infrastructure facilities (such as cultural parks, botanical gardens, alleys, squares, tourist bases, cultural and entertainment centers, etc.) in your area?”, 43.5% of respondents expressed dissatisfaction with the quality of green spaces and their intended purposes.

When asked what suggestions they can offer the local authorities to preserve the favorable environmental situation in the city, the respondents propose the following solutions: improve the environmental culture of the population; listen to people’s suggestions and spend more time on landscaping; introduce a waste recycling program and increasing the number of waste sorting facilities; create and maintain parks and green spaces in the city to improve air quality and the overall well-being of residents; increase the number of bus fleets by 2–3 times, establish traffic with smart interchanges; apply fines for pollution; solve problems for the long term; transition road transport and buses to environmentally friendly fuel; work towards the gasification of one-story houses, and allocate bicycle paths.

The results of the questionnaire survey “Geoecological well-being of the city of Astana” conducted in the city’s administrative districts show that the city’s most environmentally safe district is the Yesil district, followed by the Saryarka district in second place. The Nura district ranks third with 19%, the Almaty district comes fourth with 14.3%, and the Baykonur district finishes last with 7.1%. Accordingly, the most polluted areas are the Baikonur and Almaty districts. At the same time, the Yesil is the most polluted in terms of atmospheric air.

4.3. Discussion

Comparing the results of urban eco-diagnostics of the geoecological state of urban ecosystems, the quality of urban ecosystem services, and a socio-psychological study of the geoecological state of urban ecosystems and urban ecosystem services in connection with the mental well-being of residents of Astana, a positive correlation is noted for the main indicators and criteria. In particular, attention should be focused on the fact that, according to the results of urban diagnostics and socio-psychological research, the most environmentally safe and comfortable from the point of view of urban ecosystem services and favorable from the point of view of mental well-being is the Yesil region, the Nura region is in second place, and the Almaty region closes the top three. However, there is some discrepancy in the results of the study; for example, the Esil district is the most polluted in terms of atmospheric air, according to the subjective perception of citizens, and the Almaty district is the second most polluted in general after the Baikonur district. This can be explained by the fact that the largest number of respondents lived in the Almaty and Yesil areas and they did not have enough opportunities to compare their area of residence with other areas of the city. As a result of this study, valuable recommendations and proposals were received to improve the geo-ecological state of the city of Astana, improve

mental well-being, and increase the level of satisfaction with the urban ecosystem services of residents of the city of Astana.

The comparative analysis of the results of this interdisciplinary study with other studies in urban studies, social psychology, environmental psychology, civil geography, urban ecology, and urban sociology demonstrates a great interest in further study of the problems of urban agglomerations and megacities. In particular, attention is focused on the possibility of using GIS mapping, mental mapping, and psychological and sociological surveys to display the leading perceptions of the spatial-object representations of the ecological state of urban infrastructure and consumed urban ecosystem services in connection with the mental well-being of city dwellers. In this regard, John Jamir Benzon R. Aruta argues that the influence of the connection between nature and material well-being on the mental well-being of city residents is exacerbated in the process of environmental degradation and urbanization [55].

From an eco-psychological point of view, how the residents perceive the urban environment is important. In this regard, this article, as a result of the analysis of international and Kazakhstani experiences of socio-psychological, socio-ecological, and geographical study of urbanization processes in the context of sustainable urbanism, analyzes some factors and conditions for the sustainable development of the city of Astana, influencing the mental well-being of citizens in correlation with the results of geo-ecological research and urban eco-diagnostics of urban ecosystems. However, further research is required to consider the correlation between other factors affecting the mental well-being of citizens and satisfaction with the state of urban infrastructure, depending on health status, income level, demographic factors, etc.

5. Conclusions

Summarizing the results of the experimental study of the socio-psychological aspects of the spatial representation of the geoecological state of the city in relation to the mental well-being of citizens and the level of satisfaction with urban ecosystem services based on the data obtained by diagnostic methods and urban eco-diagnostics, it can be concluded that the level of spatial representation of the geoecological state of the city primarily depends on the district of residence in the city; namely, the residents of Astana living in the central districts of the left bank of the capital have more meaningful and structured geoecological mental maps and a higher level of mental well-being and satisfaction with urban ecosystem services. According to the results of the study using two diagnostic methods, we confirmed Hypothesis 1—“Spatial-objective representations of the ecological state of the city are interconnected with the mental well-being of citizens depending on the area of residence” and rejected Hypothesis 2—“Spatial-objective representations of the ecological state of the city are interconnected with mental well-being citizens depending on their social and business status”.

Thus, citizens living in the central areas of the city with the closest connection with the outside world based on a detailed spatial subject representation of the ecological state of the urban area have the highest level of mental well-being and are more satisfied with the consumed urban ecosystem services and the urban ecosystems of the city in general. Although residents of peripheral areas connect with the natural environment, they are not sufficiently satisfied with urban ecosystem services due to existing problems with amenities and safety. Consequently, they may experience more urban stress and are prone to marginalization.

The results of this study can be used in planning to improve the urban infrastructure of the city of Astana, as well as by special city services responsible for improving the urban environment and the quality of urban ecosystem services. As limitations in the study, one can note the lack of openness and contact of respondents, which can be explained by their busyness and lack of time, as well as the difficulty in bypassing the peripheral areas of the city; for example, the Koktal, Lumber Factory, and south-east areas.

This study is longitudinal, and at the next stage, it will be necessary to study in more detail the most problematic administrative districts from the point of view of geo-ecology and the psychological well-being of people, in correlation with official statistical data and specific urban ecosystem services in city districts, to solve the socio-psychological and socio-ecological problems of the districts with the definition of recommendations for local executive bodies of administrative districts.

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