IRSTI 87.29.37 https://doi.org/10.26577/JGEM.2023.v71.i4.02

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FACTORS OF FORMATION OF STEPPE LANDSCAPES OF AKTOBE REGION

The article is devoted to the study of regional features of the steppe landscape structure of the Aktobe region. For a comprehensive analysis of the studied territory, a specialized landscape geoinformation system of the regional level was formed using GIS technology. The spatial data base was based on the characteristics of the components of the natural environment of the studied territory, exposed to annual anthropogenic impact. For the purposes of landscape analysis of the territory, we have formed a specialized landscape geoinformation system at the regional level of GIS generalization, based on the ArcGIS10.4.1 software. By such a GIS system, we mean an interactive system capable of collecting, systematizing, storing, processing, evaluating, displaying and distributing data and acting as a means of obtaining on its basis new information and knowledge about space-time phenomena. The study consists of several stages: generalization of analytical data, creation of a landscape map using the tools of overlay layers of ArcGIS, where the layers characterize the landscape structure component-by-component, as well as SRTM satellite images were used to create a digital relief model of the Aktobe region. The obtained research results mapping the steppe landscapes of the Aktobe region serve as a basis for studying the ecological situation of the territory, as well as assessing the structure of the studied territory.

Key words: geosystem, landscape, anthropogenic factors, natural factors, steppe landscapes, GIS, landscape map.

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Ақтөбе облысының дала ландшафттарының қалыптасу факторлары

Мақала Ақтөбе облысының дала ландшафты құрылымының аймақтық ерекшеліктерін зерттеуге арналған. Зерттелетін аумақты кешенді талдау үшін ГАЖ технологиясын қолдана отырып, аймақтық деңгейдегі мамандандырылған ландшафттық геоақпараттық жүйе құрылды. Кеңістіктік мәліметтер базасы жыл сайынғы антропогендік әсерге ұшырайтын зерттелетін аумақтың табиғи ортасының компоненттерінің сипаттамалары негізінде жасалды. Аумақты ландшафттық талдау мақсатында біз ArcGis10.4. 1 бағдарламалық қамтамасыз ету негізінде ГАЖ жалпылаудың аймақтық деңгейінің мамандандырылған ландшафттық геоақпараттық жүйесін құрдық. Мұндай ГАЖ жүйесі арқылы біз деректерді жинауды, жүйелеуді, сақтауды, өңдеуді, бағалауды, картаға түсіруді және таратуды жүзеге асыра алатын және оның негізінде кеңістіктік-уақыттық құбылыстар туралы жаңа ақпарат пен білім алу құралы ретінде әрекет ететін интерактивті жүйе ретінде түсінеміз. Зерттеу бірнеше кезеңнен тұрады: талдамалық деректерді жинақтау, ArcGis қабаттарын қабаттастыру құралдарын пайдалана отырып, ландшафттық картаны жасау, мұнда қабаттар ландшафттық құрылымды құрамдас түрде сипаттайды, сондай-ақ Ақтөбе облысының рельефінің цифрлық моделін жасау үшін SRTM ғарыштық суреттері пайдаланылды. Зерттеу нәтижелері Ақтөбе облысының дала ландшафттарын картаға түсіру аумақтың экологиялық жағдайын зерттеуге, сондай-ақ зерттелетін аумақтың құрылымын бағалауға негіз болады.

Түйін сөздер: геожүйе, ландшафт, антропогендік факторлар, табиғи факторлар, дала ландшафттары, ГАЖ, ландшафт картасы.

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Факторы формирования степных ландшафтов Актюбинской области

Статья посвящена изучению региональных особенностей степной ландшафтной структуры Актюбинской области. Для комплексного анализа исследуемой территории была сформирована специализированная ландшафтная геоинформационная система регионального уровня с помощью ГИС-технологии. База пространственных данных составлялась на основе характеристик компонентов природной среды изучаемой территории, подвергающие ежегодному антропогенному воздействию. Для целей ландшафтного анализа территории нами была сформирована специализированная ландшафтная геоинформационная система регионального уровня генерализации ГИС, на основе программного обеспечения ArcGis10.4.1. Под такой системой ГИС мы понимаем интерактивную систему, способную реализовать сбор, систематизацию, хранение, обработку, оценку, отображение и распространение данных и выступающую как средство получения на ее основе новой информации и знаний о пространственно-временных явлениях. Исследование состоит из нескольких этапов: обобщение аналитических данных, создание ландшафтной карты с использованием инструментариев наложения слоев ArcGis, где слои характеризуют покомпонентно ландшафтную структуру, а также для создания цифровой модели рельефа Актюбинской области использовались космические снимки SRTM. Полученные результаты исследований картографирование степных ландшафтов Актюбинской области служат основой для изучения экологической обстановки территории, а также оценки структуры исследуемой территории.

Ключевые слова: геосистема, ландшафт, антропогенные факторы, природные факторы, степные ландшафты, ГИС, ландшафтная карта.

Introduction

At the end of the XX-th century, economic activity has significantly changed the natural landscapes within the borders of the Aktobe region. The anthropogenic impact on the environment has been a subject of extensive research, revealing significant consequences for ecosystems and natural processes. Anthropogenic activities, such as habitat destruction, overexploitation of resources, and introduction of invasive species, have led to a rapid decline in biodiversity. Species extinction rates have accelerated, disrupting ecosystems and diminishing their resilience. The release of pollutants into air, water, and soil, including industrial emissions, agricultural runoff, and plastic waste, has caused widespread environmental pollution. This pollution negatively affects human health, aquatic life, and terrestrial ecosystems.

Studying geosystems in conditions of anthropogenic impact is a difficult task. An integrated approach should be applied as a result of considerable complexity in the geoecological (landscape-ecological) study of geosystems. It should include several interrelated stages of the study (Lastochkin A.N., 2011: 980; Gel’dyeva G.V., Veselova L.K., 1992: 172; Homyakov P.M., Konishchev V.N., Pegov S.A., Smolina S.G., Homyakov D.M., 2000: 382).

Any type of human activity leads to changes in the components of the natural environment, but the magnitude of the impact depends on the type of activity and the scale of the impact. According to S.P. Gorshkov, the following types of anthropogenic activities can be distinguished: agricultural; forestry; water resources management; mining; communications and transport (outside the city); urban-industrial; entertainment and military.

In the historical process of human development, the anthropogenic impact on natural complexes has changed both in its intensity and in terms of impact factors. We use the concept of “anthropogenic load” When characterizing the anthropogenic impact on a certain time period (year) (Isachenko A.G., 2008: 320).

Anthropogenic load is a quantitative measure of the impact on the geosystem or its components, expressed in natural absolute or relative values and referred to the period during which the impact remained stable.

Anthropogenic modification is a change in one or two components of a natural geosystem under the influence of human economic activity.

Anthropogenic transformation is the creation of a new quality, the formation of a structural transformation of the natural geosystem with a radical change in its components.

Anthropogenic impact can affect various components of geosystems: soil, subsoil, vegetation, water bodies, fauna. It can have a different scale of impact (global, regional, local) and its intensity, the degree of danger, vary in the duration of exposure (long-term, short-term) and the nature of the impact (direct, indirect) (Muller F., Steinhardt U., 2003: 215-216; Isachenko A.G., 1980: 220).

As a result of anthropogenic impact on the landscape:

- the quality of landscape components deteriorates;
- inter-component connections in geosystems are broken or changed;
- the natural resources of the landscape are decreasing;
- environmental conditions are deteriorating;
- the quantity decreases and the quality of products deteriorates.

Materials and methods

Modern geosystems are usually divided into two main classes – natural and anthropogenic. Currently, on the one hand, there are no natural geosystems left that are not subject to anthropogenic influences to one degree or another, and on the other hand, there is a natural component in any anthropogenic system. Therefore, L.I. Mukhina considers the division of natural and anthropogenic principles of geosystems to be very conditional. In her opinion, the essence of modern geosystems is that they are NAG (natural-anthropogenic geosystems), having a dual qualitative certainty. The ecological situation in natural and anthropogenic systems depends on many factors: on natural conditions and the degree of resistance of geoecosystems to anthropogenesis, on the nature and intensity of anthropogenic impact on the environment, on the reaction of the population to the manifestation of anthropogenesis, etc.

All these factors determining the properties of geoecosystems as the living environment of people are distributed irregularly in the space of the geographical envelope. The role of technogenesis is great and diverse in the formation of ecological situations of natural and anthropogenic systems, which makes it necessary to know the regional features of technogenic impact on the natural environment and its management. There is a very close connection between the manifestation of anthropogenesis and the specifics of local physical and geographical conditions (Mil'kov F.N., 1986: 224).

Currently, the issues of regulation anthropogenic impacts on the landscape are relevant. considering the Current state of the problem of normalizing anthropogenic loads on the landscape, T.D. Alexandrova (Aleksandrova T.D., 1990: 46-54) notes the need to take into account the features of spatial differentiation of the geographical envelope, but does not concern the structure of anthropogenic modifications of the landscape itself. The spatial aspect of regulation is related to the regional features of the landscape structure, which determine the magnitude of the economic potential of landscapes, the possibility of using natural resources, taking into account limiting natural factors (primarily load resistance). There are interesting developments in the field of landscape regulation by V.V. Ryumin. They proposed the norms of the structure of the anthropogenic landscape, that is, the areas that certain landscapes can occupy in conditions of anthropogenic use.

Today, a new direction in geographical science is rapidly developing – the study of landscapes under conditions of anthropogenic impact, which makes it possible to assess the extent of the use of the natural environment. In addition, the study of the processes occurring in landscapes in connection with their economic development makes it possible to assess, provide and exclude harmful consequences and find ways to optimally use landscapes (Beruchashvili N.L., Zhuchkova V.K., 2007: 203-218).

For the purposes of landscape analysis of the territory, we have formed a specialized landscape geoinformation system of the regional level of GIS generalization (Dueker K.J., URL 4: 2023), based on the ArcGIS10.4.1 software. By GIS system is understood an interactive system, capable of collecting, systematizing, storing, processing, evaluating, displaying and distributing data and and acting as a means of obtaining on its basis new information and knowledge about spatio-temporal phenomena (Geospatial Analysis – a comprehensive guide, URL 1: 2023).

Several software products were used as means of entering information: ArcCatalog and its utilities – when entering spatial objects; Excel – digital data. The visualization process was provided by the ArcGIS software package, and spatial modeling and forecasting were provided by ArcMap programs.

The next step is to combine all the data into ArcGIS10.4.1 software (Tikunov V.S., 2005: 480). All information layers were combined within one database (Figure 1).

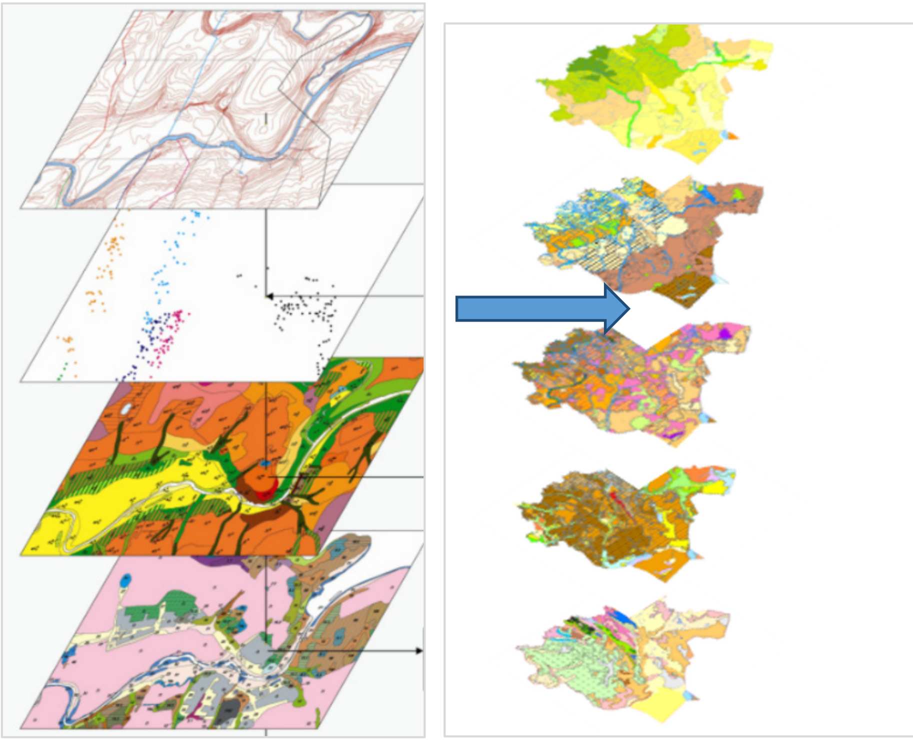

Figure 1 – Component-wise overlay of maps of creating a landscape map

At the stage of creating a landscape map, the principle of catenarity of the landscape structure was used. In the course of the work, the initial information was cleaned to remove small contours formed as a result of an inaccurate coincidence of boundaries transferred from maps created by different authors.

The Aktobe Region, is located in the western part of Kazakhstan. It is situated between approximately 47.5 to 53.5 degrees north latitude and 56.0 to 64.0 degrees east longitude. This region encompasses a diverse landscape that includes vast steppes, arid desert areas, and the Ural River, which serves as its western boundary. Aktobe Region is characterized by its strategic location in the western part of Kazakhstan, bordering Russia to the north and west, and several other regions of Kazakhstan to the east and south. The region's territory is 300,629 km2, population 904,469 people.

Results and discussion

Depending on the characteristics of the geographical location of the region, the nature of nature is determined by the sharply continental climate, the shortage and uneven distribution of water resources, and the predominance of arid and semi-arid landscapes. The diversity of natural conditions is characterized by the scale of the region's territory. Most of the region's territory is occupied by steppe plains; in the north are the southern spurs of the Ural Mountains. The Mugalzhar Mountains stretch in the central part.

The territory of Aktobe region is characterized by the predominance of hilly-plain spaces – plateaus and high plains. Figure 2 shows a physical and geographical map and the stages of creating the relief of the Aktobe region. To create a relief map, we used satellite images SRTM (Shuttle Radar Topographic Mission) – radar topographic survey, the coverage of which covers a large area of the earth's surface, with the exception of the northernmost, as well as oceans.

According to the original data of SRTM images, the necessary fragments for the study area were loaded using a grid-mapping (Figure 3).

1. Raster data sets were combined into one raster data set (ArcToolbox – Data Management – Raster – Raster Data Set – Mosaic)

2. Using the relief drawing function, we get an improved visual representation of the surface of the selected area (along the border of the Aktobe region) (Spatial Analyst – Surface – drawing)

3. Cut this study area from the images using the input objects as the cutting geometry

4. 4. The product of the image classification

5. 5. Construction of isolines for relief expression (Spatial Analyst –Surface – Isolines)

6. 6. The analysis of the obtained relief map of the Aktobe region allows us to conclude that the predominance of surfaces in the relief in the range of 100-200 m (more than 50% of the territory area). The maximum height is 650 m, the minimum height is up to 100 m (Novakovskij B.A., Permyakov R.V., 2019: 175).

In the west, the region's territory borders on the Caspian Lowland, in the south on the Ustyurt Plateau, on the southeast on the Turan Lowland, and on the north on the southern spurs of the Ural Mountains. Most of the region is a plain divided by river valleys 100-200 m high.

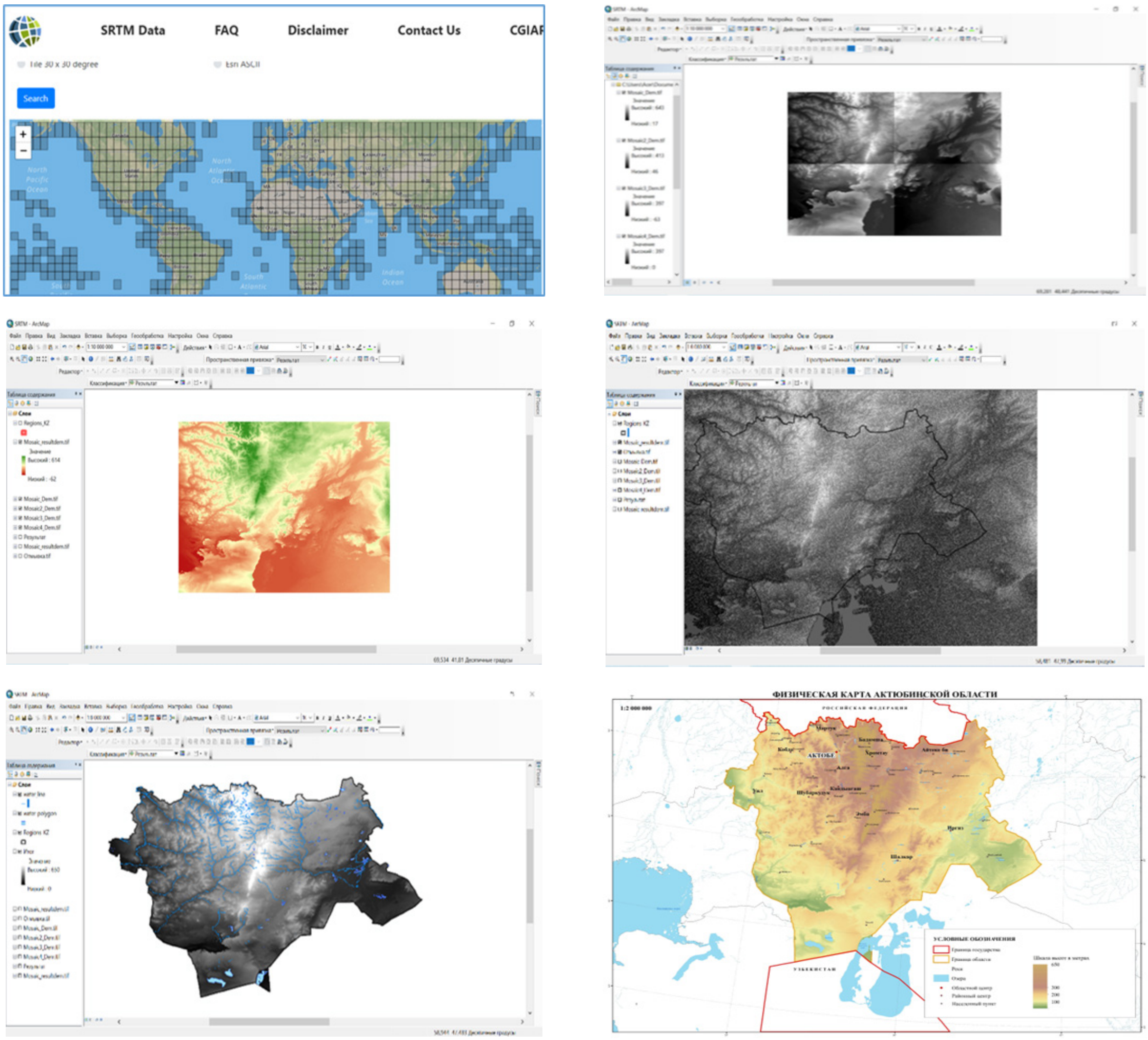

Figure 2 – Stages of creating a map and a map of the modern relief of the Aktobe region

The region's inland position and the severe continental climate have led to a scarcity of surface water resources. The hydrographic network in this area is associated with the catchment areas of the Caspian and Aral Seas, as well as regions lacking local river flow. With the exception of the Zhaiyk, Torgay, and Ulkeyk (Ulkayak) rivers, all rivers in the region originate within its boundaries. The total surface water resources are estimated at approximately 3.25 cubic kilometers in an average water year, consisting of 2.83 cubic kilometers of local runoff and 0.65 cubic kilometers in low-water years, including 0.41 cubic kilometers of local runoff.

There are more than 1,700 lakes in the region, of which 227 have an area of more than 1 km. The largest lakes are Zharkol, Baytakkol and Kurdym. Lakes for the most part are drainless shallow reservoirs, taking saucer-shaped depressions. Elongated lakes of erosive origin are located in the river valleys. Lakes, like rivers, are fed by atmospheric precipitation. In dry years, their level drops sharply, and some dry up completely, and in wet years they greatly increase in volume (URL 2: 2023).

Due to the water content of the Irgiz and Torgai rivers, all lakes are subject to significant fluctuations in the hydrological regime. The size and depth of lakes depend on the degree of their filling with water. The phenomena of swelling and overflow are cyclical.

In dry steppe conditions, all rivers of the territory under consideration play an important role as a source of water supply to settlements, land irrigation and livestock irrigation.

The main rivers of the region are Sagiz (510 km), Kobda, Emba (712 km), Ulkayak (349 km), Ilek (623 km). There are large rivers Torgai (825 km), Oil (800 km), Zhem (712 km), Yrgyz (593 km), Or (314 km) within the territory of the region.

The steppe region encompasses over 50% of Aktobe Region's land area and encompasses the Podural and Torgai plateaus, as well as the Mugalzhar massif. This vast expanse can be further categorized into four subzones, running from north to south:

- Arid steppe, featuring feather grass on southern chernozem soils.
- Moderately dry turf-grass steppe, characterized by dark chestnut soils.
- Dry xerophytic grass-turf-grass steppe, found on chestnut soils.
- Wormwood-turf-grass steppe, distinguished by its presence on light chestnut soils.

Xerophytes predominate among the forbs: Galium, Potentilla, Phlomoides tuberosa, noble yarrow, etc. There are a number of salt–tolerant species: Artemisia lercheana and Artemisia glauca, Kochia, Goniolimon tataricum, Tanacetum millefolium, Galatella. Feather-grass steppes are distributed in small hills on shaded soils, the vegetation of which included Stipa rubens, pennata, capillata, as well as Festuca, Helictotrichon desertorum, Koeleria и forbs (Rachkovskaya E.I., Ogar' N.P., Marynich O.V., 2012: 850-861).

Along with shrubs (Calligonum, Nitraria, sand acacia, astragalus) and black and white saxaul, semi-shrubs (teresken, Kochia, Artemisia and steppe grasses – Stipa pennata, Stipa capillata, sareptana, Festuca beckeri) take a large part in the vegetation cover.

Couch grass, reed, smallweed, Bolboschoenus, Carex, Puccinellia, Aeluropus predominate in meadows.

The latitude of the region's territory from north to south and from east to west, the flatness of the relief, the unevenness of the lithological and geological structure and the variety of conditions for the formation of groundwater determined the nature of the soil cover of the region. groundwater. territory. Aktobe region. For the region, as well as for the whole of Kazakhstan, a characteristic feature of soils is a strong complexity associated with the diversity of soil-forming rocks and the variety of conditions for the formation, formation and movement of groundwater. One of the main characteristics of soils in the region is the precise determination of the latitudinal zone of their territorial position.

Among the natural regionally specific factors that have a significant negative impact on the ecological situation, it is necessary to single out desertification, which a number of settlements are located in the zone of influence.

At present, the Aktobe region holds the leading position in Kazakhstan in terms of the magnitude and extent of human-induced influence on the natural environment. This prominence can be attributed to the enduring repercussions of historical industrial and agricultural activities within the region, ongoing robust hydrocarbon production, and the discernible effects of global environmental perturbations affecting the Aral ecosystem in this area.

The Aktobe region boasts abundant mineral resources, contributing substantially to Kazakhstan's mineral reserves. This region holds exclusive deposits of various minerals: 46.2% of the nation's chromite ores, 28.3% of nickel, 12% of titanium, 5.9% of cobalt, 5.6% of zinc, 3.6% of copper, 1.8% of gold, and 1.8% of bauxite. Mining activities have been ongoing for numerous decades, and the extensive scale of these operations has led to significant environmental pollution. (Website of Akimat of Aktobe region, URL 3: 2023).

At present, the primary contributors to environmental contamination in the Aktobe region encompass activities such as oil extraction, oil refining, transportation operations, chemical manufacturing, as well as the food, meat, and dairy industries, along with transport-related activities. In recent years, drilling, well development, and oil production have proceeded continuously. Throughout this period, oil fields and their surrounding areas have experienced substantial anthropogenic pollution, with the most significant impacts observed in the degradation of soils, contamination of groundwater and surface waters, as well as the disruption of local ecosystems.

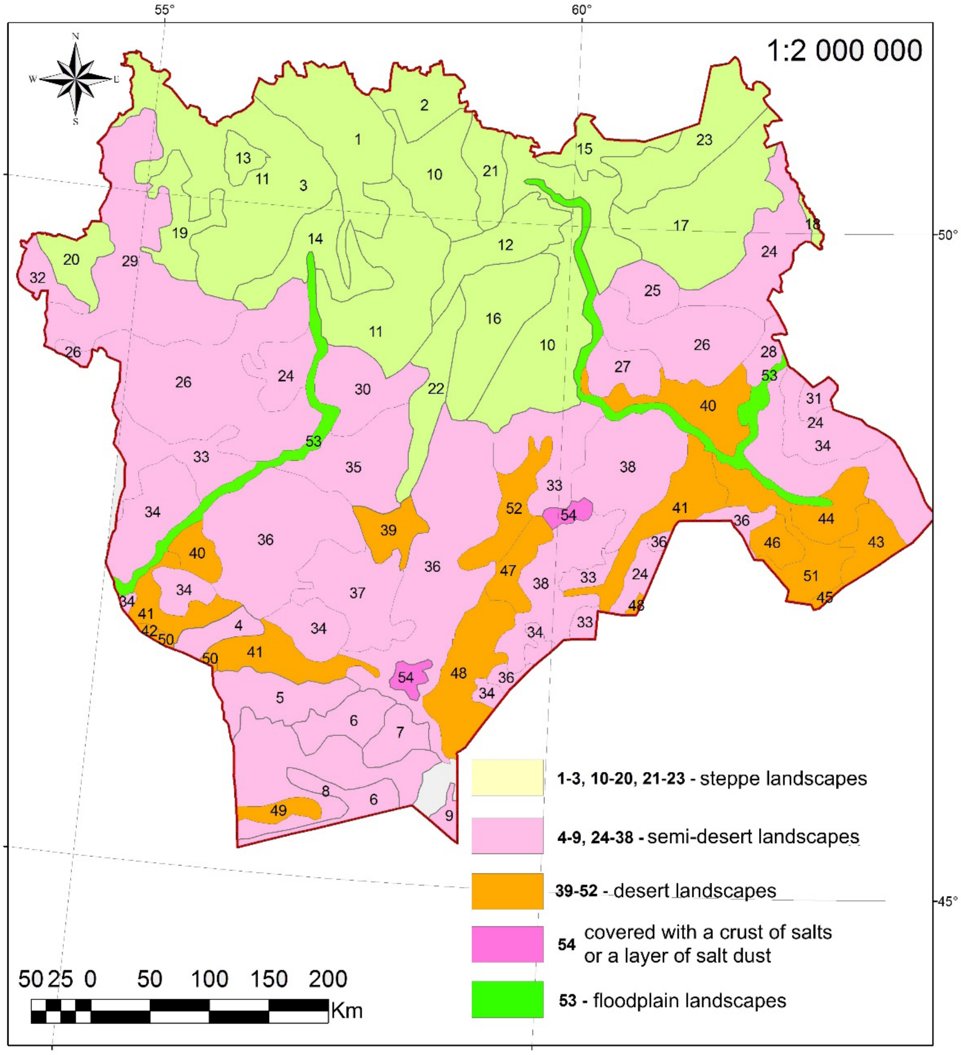

Figure 3 – Landscape zoning of Aktobe region

Some of the problematic issues are included in the register of environmental problems of Kazakhstan, and their solution is important not only for the Aktobe region, but also for the entire western region:

• pollution of the Ilek river by boron in the Aktobe region;

• pollution by ownerless waste of the industrial site of the former Alginsky chemical plant;

• contamination of the Ilek river by hexavalent chromium in the Aktobe region. Pollution of the Ilek river by untreated wastewater of Akbulak JSC of Aktobe;

• emergency condition of the complex of treatment facilities in Aktobe;

• movement of sand on the territory;

• pollution of the air basin;

• problem of solid household waste;

• contamination of land by overburden dumps by mining enterprises.

Within Aktobe region, 53 landscapes were identified on the map and organized into a hierarchical systematics as a result of their typological grouping with subsequent structural and genetic classification (Figure 3).

Steppe landscapes (1-3, 10-23) occupy more than half of the study area, covering the Torgai and Podural plateau, as well as the Mugalzhar massif.

In the northern part of the chernozem belt, the thickness of the chernozem layer reaches 70-80 cm, humus content up to 9%. Southward the layer of chernozem decreases, the amount of humus also decreases (up to 6%).

To the south of the chernozems, between 52° and 48°N, there are chestnut soils subdivided into dark chestnut soils of moderately dry steppe, typical chestnut soils of dry steppe and light chestnut soils of semidesert (Table 1).

Semidesert zone landscapes (4-9, 24-38). The climate of the semideserts is dry, much drier than in the northern zones.

The main soils of the semidesert zone are light chestnut soils. They differ from dark chestnut soils by lower humus content. In the upper layers of soil humus is only 2-3%. On plains and low areas with clay soil, solonetz occupy a significant place. Landscapes of the semidesert zone occur at relatively optimal moisture content and are used as pastures.

Desert zone landscapes (39-52). The desert zone covers the Ustyurt Plateau, the southern part of the Torgai Tableland – Turan Lowland (Priaralie) and is subdivided into two subzones – northern and southern desert. Desert landscapes are denudation plains and undulating accumulative plains with weak slope. Landscapes develop under insufficient moistening, under soil horizon moisture deficit. In this connection, saline soils, solonetz and solonchaks are widespread in the desert zone.

Conclusion

As a result of the research, there were 53 landscapes within the Aktobe region, which, as a result of their typological grouping, and then structural and genetic classification, were ordered into a hierarchical systematics. The results of component studies of geosystems, a three-dimensional relief model, satellite images, data from the Google Earth geo portal and topographic maps were used as the initial information for mapping geosystems of the Aktobe region. A landscape map is a complex cartographic model that characterizes a feature of the natural environment. The overlay method of various cartographic layers using a coordinate reference is used, thereby it allows to simplify the process of overlay. To begin with, a topographic map of the studied territory is needed, and then maps of natural components, which provide information about geomorphological features, rocks, soils and vegetation of the studied territory (such maps can be found in the funds of research institutes). After that, it is necessary to create a database in GIS, which is the basis for the formation of thematic layers. And the final step is to combine all the data in ArcGIS 10.1. This allows us to systematize cartographic data, where we can visually assess the landscape structure of the studied territory.

The completed landscape map of Aktobe region was built according to the structural and dynamic principle of community typification and reflects the genetic origin, classification hierarchy.

To obtain landscape differentiation, a matrix table is filled in, where a characteristic is indicated for each polygon. As a result of typological grouping, a landscape map is created. The resulting landscape map serves as a basis for studying the ecological situation of the territory.

All types and subtypes of landscapes of the Aktobe region are represented by the class of plains and the subclass of lowland, elevation and hill-lowland landscapes, since hypsometrically the studied area is represented by a steppe plain. The relief has the features of an elevated plain with deposited sedimentary rocks, in places of exceeding a height of 300 meters.

Steppe landscapes occupy more than half of the studied territory, while covering the Torgai and Poduralsky plateaus, the Mugalzhara massif. The climate of the steppe zone is more continental. Summers are hot and dry. Winter is harsh and snowless. The average temperature in January is -16°-18 °C, in July – from +18 ° C in the north to +23 ° C in the south. Precipitation falls up to 300 mm per year, and their amount decreases from north to south. The climatic conditions of most of this zone allow farming.

All types and subtypes of landscapes of Aktobe region are represented by the class of plain and subclass of lowland, upland and shallow-soil-levelled landscapes, as in hypsometric relation the studied region is represented by steppe plain.

Acknowledgements

This research is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19575017).

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