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IMPORTANCE OF LANDSCAPE DIVERSITY IN HYDROLOGY (ON THE EXAMPLE OF EAST KAZAKHSTAN REGION)

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KEY WORDS

landscape diversity
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flow size
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complexity indices

ABSTRACT

The article examines the diversity of landscapes in terms of the importance of studying nature and ecosystems. In general, landscape diversity encompasses components of bio and ecosystems, affecting their stability and change. The use of geographic information systems (GIS) to assess landscape diversity helps to determine the quantitative and qualitative results of spatial and temporal changes in the natural environment. In addition, the article shows the relationship between landscape diversity and water bodies. This is because water resources play a key role in shaping landscapes, their structure and functions. The landscape diversity of the study area was assessed using a number of indices: uniqueness, relative richness, landscape mosaic, landscape complexity, landscape fragmentation and entropic dimension of landscape complexity (Shannon index). These indicators help identify areas of low geographic and hydrological potential using quantitative data obtained from them, and plan various preventive measures.

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1. INTRODUCTION

At the beginning of the twentieth century, scientists studying nature and its components came to the need to consider objects of study as systems, that is, the totality of certain components that are naturally [1] interconnected and other components that resulting to new properties [2].

In recent years, due to the increased anthropogenic impact on the environment, the volume of bio- and ecodiversity in the natural environment has begun to decline. The impact of anthropogenic load was reflected not only on the state of the surrounding environment, but also on the pollution of water bodies [2].

In connection with the emergence of such complex problems in science, a new direction of landscape research was formed, studying the relationship between human activities and the natural environment [2].

Hydrological exploration of landscape diversity, that is, the study of landscapes as applied to the field of hydrology, began at an early time. In recent decades, landscape hydrology has infiltrated systemic ideas that should be seen as a frontier discipline between hydrology and landscape science.

In the course of geographical, landscape and hydrological studies, a large amount of information has been collected. However, the disadvantage of these studies is that during the study, scientific areas are considered separately. According to the recommendations of scientists working in these areas, it is necessary to consider the components that combine the qualitative and quantitative aspects of the natural-territorial complex (flow rate and volume, structure of the natural-territorial complex, their dynamics, etc.) together, and not separately, and develop new methodological approaches that combine these aspects. Thus, taking into account obstacles in interdisciplinary research and the introduction of new methodological approaches affects the development of new science, developing on the basis of the integration of geography and hydrology [1…3].

In general, the hydrological functions of the landscape are those that support the water-resource and water-ecological properties of the catchment. The hydrological functions of the landscape are understood as the processes of converting the humidity of precipitation entering the natural complex, and the processes of water loss from the territory, expressed by the amount and quality of water entering water bodies [1]. The evaluation of these functions is related to the qualitative and quantitative characteristics of the water drainage, taking into account all interactions, including local parameters of moisture circulation [1].

At the present stage, a landscape-ecological approach to the study of patterns of runoff formation is developing. The essence of this pattern is the direct connection between the landscape structure of the catchment and the hydrological processes occurring there. At the same time, the possibilities of quantitative and qualitative assessment of factors affecting the formation of runoff are directly related to hydrological processes, climatic and landscape-structural features of the territory. According to the prevailing hydrological process, flow-forming, transit and accumulating landscape hydrological complexes are distinguished [3].

2. MATERIALS AND METHODS

Geographical and hydrological research originates in the works of European and Russian research scientists [3].

Landscape hydrological studies combine two aspects: water and landscape features. Over the course of several years of research, hydrologists have studied and identified a number of landscape features. In landscape hydrological studies, assessment of the landscape, prediction of hydrological flow and determination of quantitative characteristics of the flow make it possible to indirectly determine the stability and equilibrium value of the flow [1, 4].

Recently, more and more attention has been paid to quantifying the biological and landscape diversity of the natural environment. However, in most cases, the landscape-hydrological complex is formed from a set of natural territorial complexes

Quantitative identification of landscape diversity was initially done through landscape map analysis. Later, in connection with the development of technology, new methods for studying landscape diversity began to be developed. Such research methods include the use of earth sensing observations and space imagery. In general, two types of landscape diversity studies can be distinguished. The first method is the use of landscape maps, the second is the use of space images during research [2...3, 5].

The use of these methodologies makes it possible to assess the diversity of landscapes in different areas. The diversity of the scale of the territories is associated with the degree of natural-territorial complexes, which are the subject of study of the morphological parts of landscape, typological or regional complexes [2].

Studies of landscape diversity identify areas requiring protection and conservation, determine the role of the modern formal forest protection system in landscape conservation and diversification, identify areas for economic use of landscapes in different territories, and organize the most important eco-audits and solve other environmental and applied problems [2].

On the territory of the East Kazakhstan region, which is the subject of the study, more than a thousand rivers flow. The main rivers and tributaries: Ertis, Bukhtyrma, Ulbi and other rivers.

3. RESULTS AND DISCUSSION

The aim of the work is to conduct an analysis using different approaches and indicators of landscape diversity, which will be implemented using common properties and patterns. The landscapes of the East Kazakhstan region were taken as the object of research.

The main material for the study is a landscape map of the East Kazakhstan region. Using information on the totality of landscape species within each administrative region and the ratio of their areas, a number of indicators were calculated that have proven themselves in studying the landscape diversity of different regions. The main indicators used in assessing landscape diversity include: landscape complexity, landscape mosaic, landscape fragmentation, uniqueness index, relative wealth index [6...8].

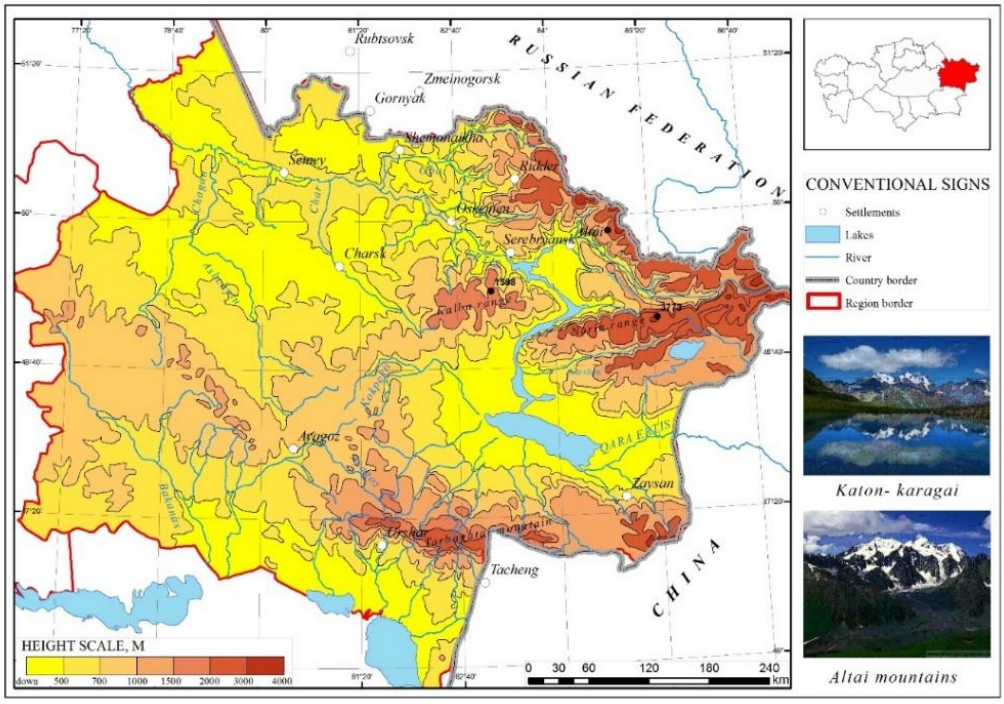

Figure 1. *Physical map of East Kazakhstan region*

Assessment of landscape diversity traditionally works with such characteristics as the number of landscape types, the number of contours, their size, shape, share in the landscape structure of the territory, etc. Theoretical and methodological approaches to the assessment of landscape diversity are presented in the works of M.D. Grodzinsky, K.N. Dyakonov, K.S. Ganzey, A.N. Ivanova, E.A. Pozachenyuk, Yu.G. Puzachenko, A.S. Sokolov, A.O. Domaransky, etc. Due to this, it has been sufficiently developed and studied [7, 9...10]. In our work, the main unit of research for assessing the landscape diversity of the territory of the East Kazakhstan region is the landscape. 80 separate landscapes are identified here (Fig. 2) [11].

As follows from the legend of a fragment of the landscape map of the East Kazakhstan region, the landscapes of the territory of the East Kazakhstan region are diverse. For example, mountain, low mountain, valley, forest-steppe, steppe and hilly flat landscapes are found here.

Quantitative data obtained using formulas for determining the landscape diversity of East Kazakhstan make it possible to identify connections between landscapes, quantify them and conduct a comparative analysis [2]. Quantitative assessment of landscape diversity was carried out by the GIS program based on the landscape map of the East Kazakhstan region. We divided and classified landscapes into classes and types using a GIS program.

Studying the map of the administrative districts of the East Kazakhstan region, differentiated by the value of the main Shannon index, which estimates landscape diversity, you can see that the maximum values are concentrated in the southwest, south and southeast of the region (Ayagoz, Urjar and Tarbagatai districts - index above 1,40). This is primarily due to the location of the Akshatau, Tarbagatai, Birliktau mountain ranges in these areas, as well as the good distribution of the hydrographic network in these areas and the complication of the landscape picture. One of the main components that make up the landscape are water bodies. In these areas there are large and small rivers and lakes, such as Sasykkol, Alakol and Ayagoz, Bakanas, Emel. In addition, high diversity contributes to the organization of recreation and specially protected natural areas. Accordingly, in these areas there are such specially protected natural areas as: Tarbagatai National Park, State Forest Natural Reserve "Semey Orman" Significantly lower values are in the Shemonaikhinsky and Glubokovsky districts with an index value below 0,35. Accordingly, this is due to the relatively small number of landscape areas and their large scale, the distribution of river systems with an irregular channel. The areas of greatest importance include Ayagoz (1,78), Tarbagatay (1,46), Urjar (1,47). The least significant areas are Glubokoe (0,29), Shemonaikha (0,32), Beskaragai and Borodulikha (0,47) (Fig. 3).

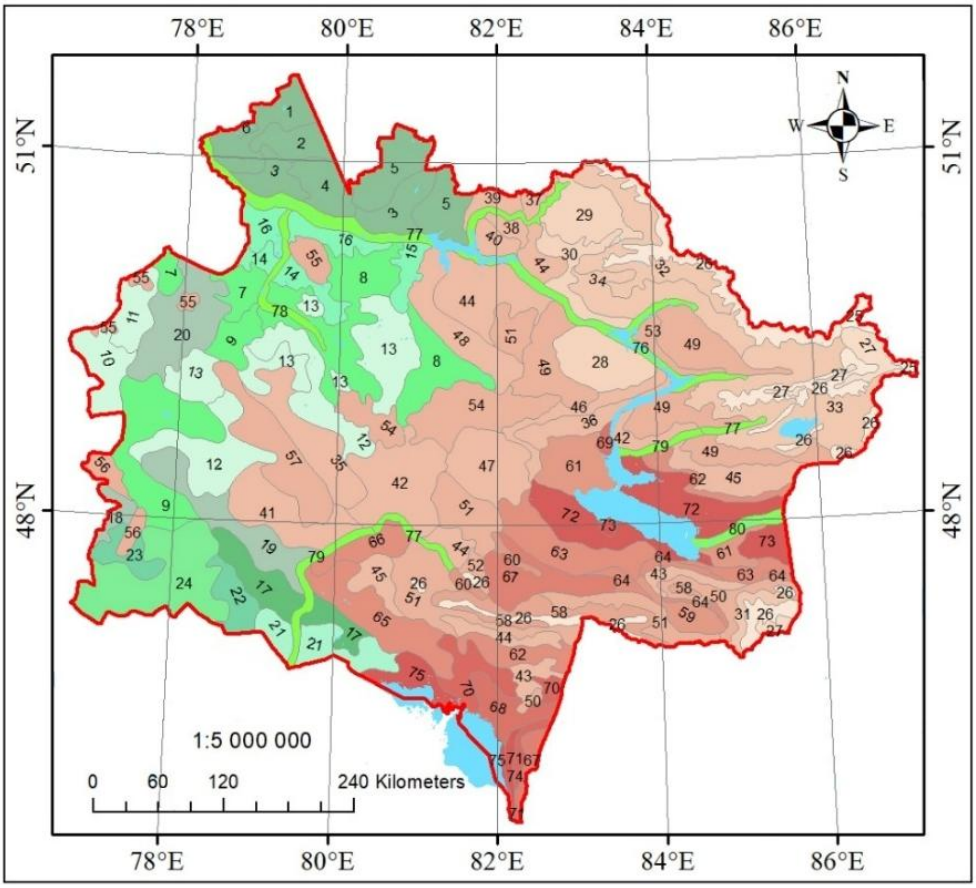

Figure 2. *Landscape map of East Kazakhstan region*

In terms of uniqueness, the area distribution corresponds to the Shannon index distribution. The areas with the highest values of the uniqueness index are Ayagoz (1,75), Urjar (1,42), Tarbagatai (1,40). All of them are located in the south, southwest, southeast of the East Kazakhstan region. In the central part of the region, two districts with the lowest indicators of uniqueness are distinguished - Kokpektinsky district (0,80) and Ulansky (0,40) district. As in the Shannon index, the map highlights lower values in areas in the north and northeast of the East Kazakhstan region.

In terms of relative wealth, areas of the south of the East Kazakhstan region are noted. Ayagoz District (1) is the most important, followed by Urjar District (0,75) and Tarbagatai District (0,73). Areas with minimum values are located in the northern part of the region. The smallest indicator on this index (0,20).

The landscape complexity index shows the ratio of the total number of landscape areas to the average area of landscapes. In the regions of the East Kazakhstan region, the index ranges from 0,29 to 0,05. The lowest indicator is in Ayagoz district (0,29), Borodulikhinsky (0,05), Beskaragai and Glubokovsky districts (both 0,08). This is due to the significant mosaic and high degree of anthropogenic impact.

Landscape mosaic is determined by the fragmentation of sections of one type of landscape in the district, that is, the more sections correspond to one type of landscape, the higher the index. The highest indicators for this index are in Ayagoz, Urjar, Tarbagatai districts (index above 0,85) (Fig. 4).

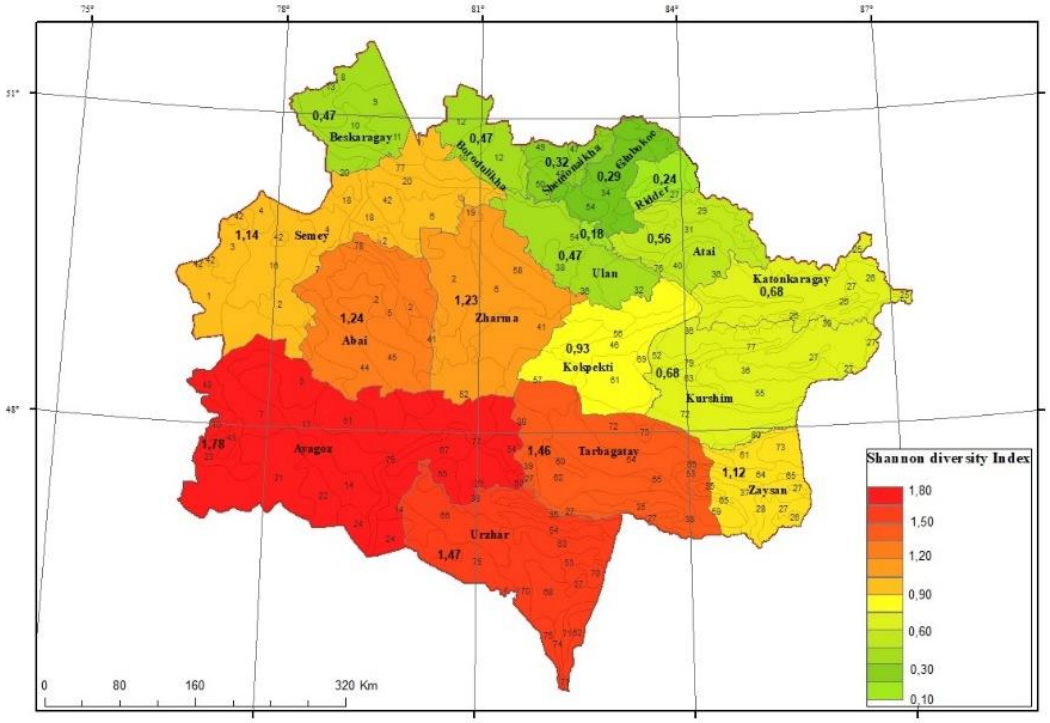

Figure 3. *Landscape diversity on the districts of the East Kazakhstan region (Shannon index).*

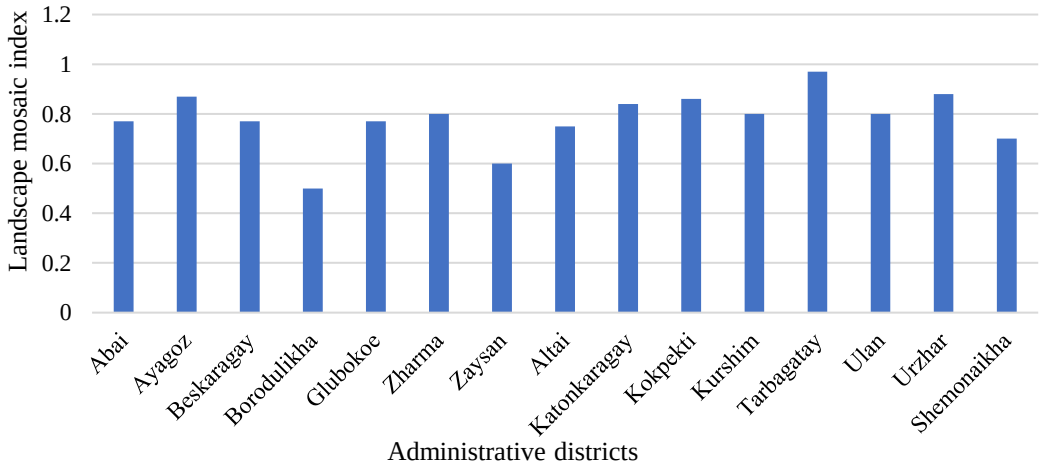

Figure 4. *Landscape Mosaic Index Gypsogram*

Landscape fractionality shows the ratio of the area of landscape plots to the area. This indicator characterizes such an aspect of the landscape structure as the density of landscape areas. The deviation of the maximum values from the minimum is 0,11 (from 0.12 in the Tarbagatai and Urjar regions to 0,06 in the Zharminsky region).

The fragmentation of the landscape shows the ratio of the average area of landscape contours to their area. The highest values for this indicator in Ayagoz, Urjar, Tarbagatai districts (index above 0,95) are explained by the increase in the area of these districts. That is, the higher the area value, the higher the granularity.

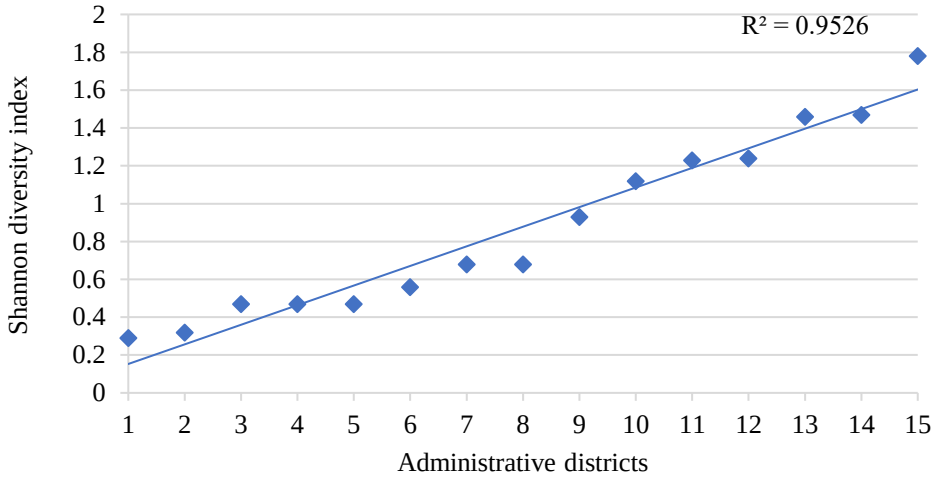

Figure 5. *Relationship between Shannon Diversity Index and neighborhoods*

Legend: Administrative districts (1 - Glubokoe, 2 - Shemonaikha, 3 - Borodulikha, 4 - Ulan, 5 - Beskaragay, 6 - Altai, 7 - Kurshim, 8 - Katonkaragay, 9 - Kokpekti, 10 - Zaysan, 11 - Zharma, 12 - Abai, 13 - Tarbagatay, 14 - Urzhar, 15 - Ayagoz).

It can be seen that the relationship between landscape diversity indicators and areas, as we can see in this figure, has a high level of interdependence, while the correlation indicator has a value of R^2 = 0,910 (Fig. 5). That means the connection between neighborhoods and landscape diversity is good. Low-connected areas include Glubokovsky, Shemonaikhinsky, and good connections are Urdzharsky, Ayagozsky districts.

4. CONCLUSION

Currently, the natural biogeocenotic balance is disturbed due to the high anthropogenic load of mankind. As a result of such changes, the natural balance of water bodies was disturbed, and many of them underwent changes. However, despite these changes, many ecosystems continue to recover. Such connections indicate the sustainability of biogeocenoses and the close interdependence of ecosystem and landscape diversity. To maintain this link in the future, the principles of sustainable development and natural resource management must be implemented and implemented now to maintain harmony and integrity between human activities and natural ecosystems. Such measures include the creation of generally and specially protected natural areas and water bodies, the restoration of degraded ecosystems, etc. Such actions, resulting from the integration of society, science and the state, ensure the preservation and development of the diversity of ecosystems and landscapes. Such activities require not only the restoration of ecosystems, but also the introduction of new technologies and the drawing up of international treaties based on the restoration and effective management of water bodies. Notably, water quality monitoring and management is the foundation of pollution prevention. The main conditions for restoration are the preservation of biodiversity and diversity of landscapes, the formation of sustainable ecosystems along water complexes.

In addition, it is necessary to take into account the issues arising from the interaction of agriculture and water bodies. In such situations, agroforestry and permaculture should be widely used to reduce soil erosion and fertilizer pollution of water bodies. Public awareness, environmental and economic services and activities contribute to the efficient use and conservation of water bodies. Currently, as world experience shows, one of the most important problems is pollution and a shortage of water bodies. To solve these problems, it is necessary to take into account the relationship of bio- and ecosystems as a whole.

The data obtained as a result of assessing the landscape diversity of the East Kazakhstan region can be used in practice to restore landscapes as follows.

Areas with high diversity in key indicators include Ayagoz, Urjar, Tarbagatai districts. This is suitable for creating specially protected natural areas and recreational facilities for these areas with high diversity. This requires effective management of surface water resources in these areas to

prevent soil erosion and flooding. The main water bodies in these areas are Ayagoz, Alakol, Sasykkol, Bakanas, Emel, etc.

A single powerful tourist medical and health tourism is also developing with its own "brand" of this region, using the healing properties (radon treatment) of lakes Alakol and Alabuga.

For areas of low diversity, these areas are suited to an efficient monofunctional economy. According to the region, these territories in Riddersky, Borodulikhinsky, Shemonaikhinsky districts are adapted to the main industrial centers in the field of mining and metallurgical, polymetallic ores and their processing. Meanwhile, in order to preserve the modern diversity of landscapes in these areas, it is necessary to strictly regulate economic activity and the use of natural resources in accordance with specially developed environmental rules and regulations. In addition, it is necessary to carry out measures to restore water supply on the site of old quarries. This is one of the cheapest ways to restore disturbed land, which allows you to create water reserves for industry and agriculture. Also, in place of the disturbed landscape, new cultural landscapes appear, most adapted to the changed conditions, performing sanitary, hygienic, aesthetic and recreational functions. For example, the pristine nature in the vicinity of Ridder (mountains and mountain rivers, pine forests) has great potential for the development of the tourism industry (including sports and environmental), but today this area of activity is not fully implemented.

DATA AVAILABILITY

Geographical and hydrological materials, image processing methods, analysis of cartographic material using GIS, as well as information from the Google Earth geoportal.

AUTHORS' CONTRIBUTION

Conceptualization – ASh, SS; resources - TT; formal analysis – ASh; methodology – JW, ASh; software - YeM; supervision - SS; visualization - YeM; writing – original draft preparation – ASh, SS; writing - review and editing - SS, ASh.

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ЛАНДШАФТТЫҚ АЛУАНТҮРЛІЛІКТІҢ ГИДРОЛОГИЯДАҒЫ МАҢЫЗДЫЛЫҒЫ (ШЫҒЫС ҚАЗАҚСТАН ОБЛЫСЫ МЫСАЛЫНДА)

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ТҮЙІН СӨЗДЕР

ландшафттық алуантүрлілік
су объектілері
су режимі
ағын мөлшері
сулылық
ағынның өзгергіштігі
ландшафттық-гидрологиялық жүйе
бірегейлік
салыстырмалы байлық
күрделілік индекстері

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АБСТРАКТ

Мақалада ландшафттық алуантүрлілік зерттеудің өзектілігі, түсіндірілуі, қолданылуы және әдістері қарастырылады. Геоақпараттық жүйелерді пайдалана отырып орындалған Шығыс Қазақстан облысы аумағының ландшафттық алуантүрлілігін бағалаудың негізгі нәтижелері келтірілген. Сонымен қатар ландшафттық алуантүрліліктің су нысандарымен байланысы көрсетіліген. Бірқатар индекстерді қолдана отырып зерттеу аймағының ландшафттық алуантүрлілігін бағалау жүргізілді: бірегейлік,салыстырмалы байлық, ландшафт мозайкасы, ландшафт күрделілігі, ландшафттық бөлшектену және ландшафт күрделілігінің энтропиялық өлшемі (Шенон индексі). Сонымен қоса ландшафттық алуантүрліліктің гидрологиямен байланысы және де анықталған көрсеткіштердің сандық мәліметтері арқылы географиялық және гидрологиялық әлеуеті төмен нысандарды анықтауға және де алдын алуға әсер етеді. Ландшафттық алуантүрлілік көрсеткіштері негізінде бірқатар ұсыныстар берілген. Бұл ұсыныстар географиялық және гидрологиялық нысандарды жақсартып, оңтайландыруға арналған.

ЗНАЧИМОСТЬ ЛАНДШАФТНОГО РАЗНООБРАЗИЯ В ГИДРОЛОГИИ (НА ПРИМЕРЕ ВОСТОЧНО-КАЗАХСТАНСКОЙ ОБЛАСТИ)

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КЛЮЧЕВЫЕ СЛОВА

ландшафтное разнообразие
водный режим
размер потока
водность
изменчивость потока
ландшафтно-гидрологическая система
уникальность
относительное богатство
индексы сложности

АБСТРАКТ

В статье рассматривается актуальность, интерпретация, применение и методы исследования ландшафтного разнообразия. Приведены основные результаты оценки ландшафтного разнообразия территории Восточно-Казахстанской области, выполненные с использованием геоинформационная система. Также представлена связь между ландшафтным разнообразием и водными объектами. Была проведена оценка ландшафтного разнообразия исследуемой области с использованием ряда индексов: уникальность, относительное богатство, ландшафтная мозаика, сложность ландшафта, раздробленность ландшафта и энтропийная мера сложности ландшафта (индекс Шенона). Кроме того, связь ландшафтного разнообразия с гидрологией и количественные данные выявленных показателей также влияют на обнаружение и предотвращение

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объектов с низким географическим и гидрологическим потенциалом. На основе показателей ландшафтного разнообразия дается ряд рекомендаций. Эти рекомендации предназначены для улучшения и оптимизации географических и гидрологических объектов.