

DIFFERENTIATION OF REGIONAL TOURIST-RECREATIONAL SYSTEMS USING SELF-ORGANIZING NEURAL NETWORKS

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Methods. The study uses general scientific and specialized methods, including: theoretical generalization – to synthesize theoretical principles and analyze international experience in the development of tourism systems; logical-analytical and static methods – to characterize the current state of development of Ukraine's tourism sector; clustering based on self-organizing neural networks and Kohonen maps – to identify the optimal structure of tourism activities by determining the key factors that constrain their development.

Results. The theoretical foundations and practical experience of differentiating socio-economic systems of different levels is analyzed in the research. Taking into account the availability and quality of statistical data characterizing the state of the regional tourism sector of Ukraine, the optimal tools for differentiating the relevant regions were identified. The analysis made it possible to divide the regions of Ukraine into 3 clusters and establish the key factors of their differentiation, which vary significantly from region to region. Natural and cultural-historical conditions, such as the presence of nature reserves, environmental threats and climatic features, and the presence of outstanding historical and cultural monuments, have a significant impact on the differentiation of regions.

Novelty. The authors proposed a scientific and methodological approach to assessing the level of development of the regional tourism sector, taking into account the structure of tourist flows (in terms of tourism goals), costs for the organization and support of tourist complexes and other factors and limitations. The factors of regional differentiation of tourist and recreational systems were determined based on the clustering method. The structure of indicators of consumer (tourist) attractiveness, based on financial performance characteristics, was used as a key indicator for such grouping.

Practical value consists in planning and optimizing the structure of tourism activities of regions on the basis of sustainable development, depending on tourist flows, gross regional product, entrepreneurial and investment activity, and tourism expenditure. This leads to strategic development priorities for such groups of regions of Ukraine that are related in terms of the organization of tourism business. In addition, the proposed methodology allows for the formulation of practical recommendations for business and authorities and local self-government and to ensure a balance between the needs of tourism and the preservation of the natural and cultural environment.

Keywords: tourist and recreational system, clustering, grouping, tourist spending, tourist infrastructure, region.

Problem statement. The development of the tourism and recreation system of Ukraine requires an individual approach to each region, taking into account its unique characteristics. Borrowing successful practices from other regions or expanding to new territories requires

a deep understanding of the specifics of the local tourism market. Different regions are characterized by their own natural, social and economic conditions that directly affect the development of tourism and recreation. Considering these systems through the prism of

Differentiating tourism and recreation systems by region allows us to solve a number of issues related to their assessment in a given context.

In the context of these issues, the problem of access to statistical data used by various researchers is significant. In conditions where statistical reporting on tourism and the use of recreational resources is not regular and standardized, the use of analytical methods based on a rigid list of indicators becomes impossible as soon as any form of reporting used ceases to be formed or its composition changes.

Thus, our task is to create a flexible approach to identifying the components of regional tourism and recreation systems and the determinants of their development, which would work in conditions of variability and take into account the possibility of changing priorities and determinants.

Analyses of recent papers. There are different approaches to solving the problem of regional differentiation. Thus, in work [1] for the analysis of tourist recreations, the clustering method based on the Moran diagram was used. In the study for the grouping of regions of Ukraine in the context of assessing tourism competitiveness, the segmentation method based on the threshold values of the integral indicator is used [2]. A similar approach is used by scientists in relation to EU countries in work [3]. For the differentiation of agro-industrial regions, B. Vandana and S. Kumar use clustering methods based on the modified k-mean algorithm [4]. In other studies that were analyzed, one of these approaches is also mainly found - either segmentation based on integral indicators or clustering.

The methodology for combining territories into a cluster was studied in the work of Smiesova et al. [5]. The authors proposed a new methodological approach to clustering countries of the world, which is based on Kohonen maps. However, this approach is based on a significant amount of macroeconomic indicators, and it is quite difficult to apply it at the level of one country when analyzing regional clusters.

In addition, the study [6] deepened the methodological foundations of the study of recreational areas and their impact on the sustainable development of urbanized territorial

communities. In the work [7] it was proven that the instability of enterprises in the field of art, entertainment and recreation led to a decrease in the level of community sustainability, and cluster processes in the tourism sector have a positive effect on the balanced development of territories.

Aim of the paper is to improve the methodology for grouping regions based on the level of development of tourism and recreation systems, which makes it possible to find among them the closest ones in terms of the peculiarities of organizing the tourism business.

Materials and methods. Let us consider the issue of determining the factors of regional differentiation of tourist and recreational systems based on clustering methods (grouping). The advantage of this approach is that clustering is a practically autonomous process, and therefore its result is practically free from the influence of the researcher's subjectivity. Clustering regions into regions according to common features that affect the conduct of the tourist business will reduce the influence of random factors on the final assessment and make it more qualitative.

As a basis for clustering, we will take indicators of financial activity in tourist and recreational activities. Their analysis allows us to assess how much regions are able to maintain and develop their respective infrastructure without harming the environment. Differentiation of regions according to these indicators will allow us to identify clusters of regions that invest with varying intensity in «green» technologies, conservation of natural resources and social responsibility.

As a key indicator for such grouping, we will use the structure of indicators of consumer (tourist) attractiveness, which is based on the financial characteristics of the effectiveness of tourist services. These data are available thanks to official statistics published by the State Statistics Committee of Ukraine.

Let us consider the procedure for clustering regions of Ukraine based on consumer attractiveness data for 2019 and 2020 [8–12], which is divided into several stages.

1. Data pre-processing

The use of mathematical statistics and machine learning methods imposes certain

requirements on the data set. Their implementation is important in order to ensure the integrity and reliability of the results of data evaluation and clustering. Among such requirements, the following can be distinguished [17]:

- absence of gaps in the data. To correctly conduct the analysis and ensure the accuracy of the results, the data set must be complete, that is, not contain gaps (missing values). Gaps in the data can lead to distortion of the results of clustering, regression models or other analysis methods, which will make it difficult to obtain objective conclusions;

- absence of anomalies in the data. To ensure the accuracy and reliability of the analysis results, it is important that the data set does not contain anomalies or unusual values that can distort the results of modeling or clustering.

Anomalies are values that differ significantly from other observations in the data set and may be the result of measurement errors, data entry, or reflect non-standard phenomena that are not typical for the system under study. This requirement is necessary to ensure the stability of the models and to avoid erroneous conclusions in the analysis results. To detect anomalies, statistical analysis methods (e.g., analysis of deviations from the mean values, calculation of the interquartile range) or other approaches to detect extreme values can be applied.

Thus, at the stage of data preparation, it is necessary to carry out their verification and processing. If missing values are found, it is necessary to decide whether to replace them with appropriate methods (e.g., interpolation, filling with mean values) or to exclude such records from the sample, if this does not distort the overall analysis. If anomalies are found, they also need to be corrected or excluded from the data set, depending on the nature and causes of their occurrence.

Analysis of statistical data [8-12] showed the presence of both omissions and anomalies, namely:

- some indicators presented in an insufficient number of regions (for example, «costs of accommodation and living in the private sector», «costs of visa services», etc.);
- it was found that in some regions,

statistics were not collected (Kirovohradska, Luhanska, Sumska, Chernihivska);

- data for the City of Kyiv differed significantly from data for other regions, which is due to the unique characteristics of this city, namely its status as the capital and largest city of Ukraine.

Since we do not have another source to verify missing data, it is impossible to correct them. Thus, missing and anomalous data should be excluded. It should be noted that the composition of indicators in the reporting is somewhat different, so it is necessary to use clustering algorithms that are resistant to such differences.

2. Choosing a clustering method

Clustering involves processing data using certain methods, or mathematical algorithms. Currently, there is a fairly large number of clustering algorithms, which are analyzed, for example, in the study [13]. However, among them, several basic approaches and corresponding algorithms can be distinguished, which are more common than others.

K-means is one of the most popular clustering algorithms, which groups data into a fixed number of clusters (k), trying to minimize the difference between the points within each cluster and the centroid (middle point) of this cluster. The disadvantage of the method is its strict requirement for a predetermined number of clusters. This can be a problem in this study, since it is impossible to accurately predict the number of regional clusters. In addition, this method is very sensitive to initial conditions.

Kohonen maps (Self-organizing maps, SOM) are a neural network that clusters data and reduces dimensionality by organizing similar objects next to each other on a two-dimensional map. Kohonen maps are a powerful clustering tool that also provides the best visual interpretation of the results among the methods reviewed. Because the process of training the map requires adjusting a number of parameters (map size, training, generalization), the analysis process can take longer than with other tools. Kohonen maps also do not always provide a clear interpretation of the results. Regions that cluster together on a map may have similar characteristics, but it is not always obvious which characteristics were key to their clustering.

Hierarchical clustering is an algorithm that creates a cluster tree (dendrogram) by gradually merging or splitting points. It can be agglomerative (combining clusters) or divisive (dividing into smaller clusters). This is the method used for clustering horticultural areas in the study [14]. Therefore, a critical drawback of the method is that it does not allow adjusting clusters after their creation. Once objects are grouped into a certain hierarchy, it cannot be changed, even if new information or a more detailed analysis reveals that objects may belong to other clusters. This can be problematic when studying such complex systems as tourist and recreational systems, where certain regions may have special characteristics that are difficult to reflect at the first stages of clustering.

Analysis of the advantages and disadvantages of these methods shows that Kohonen maps have the best potential for solving the problem of regional differentiation of tourist and recreational systems. In addition, this tool has already been used by Ukrainian scientists for similar tasks, such as clustering regions of Ukraine by production potential [15], or grouping regions of Ukraine by demographic indicators [16].

3. Data preparation

For the correct operation of self-organizing network training methods, it is desirable to ensure the same scale of input data (normalization). If this is not done, then clustering will occur according to quantitative characteristics, while for our study, it is first necessary to take into account qualitative characteristics, that is, to understand how priority these or other components of costs are for visitors.

4. Data clustering

The Kohonen map is a two-dimensional grid of neurons, where each neuron contains a weight vector equivalent in size to the number of input variables. The clustering results are shown in Fig. 1, 2.

Specialized software was used in this study to construct Kohonen maps – Deductor Studio. The main parameters that need to be set when training the network are the grid size and the method of initializing the neuron weights.

The grid size determines the number of neurons on the map and sets the aspect ratio in

two-dimensional space. This parameter depends on the number of data points and the desired granularity of clustering.

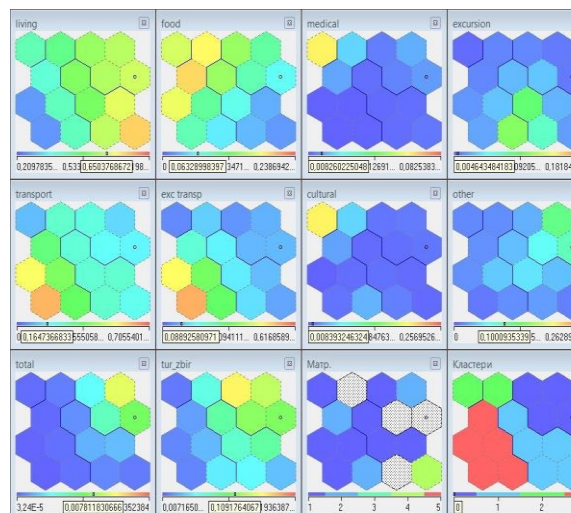


Fig. 1. Results of clustering data for 2019 using Kohonen maps

Source: compiled by the authors

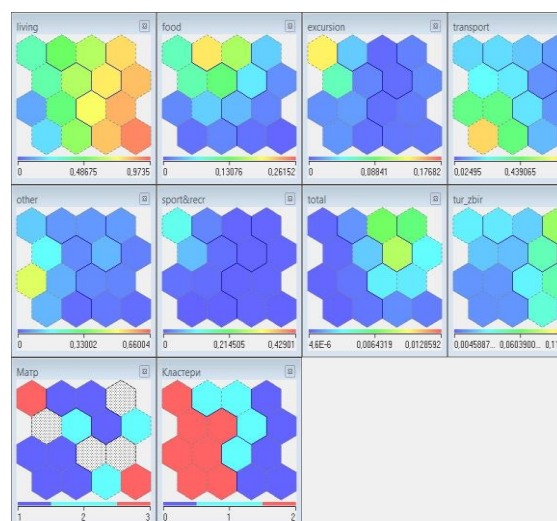


Fig. 2. Results of clustering 2020 data using Kohonen maps

Source: compiled by the authors

Initializing neuron weights involves choosing from two options – neuron weights can be initialized with random values or might be based on sample averages.

The training of a self-organizing network occurs in several stages. Each stage consists of feeding an input data vector, after which the map is adapted to better reflect the input data. When using specialized software, the training process is transparent to the researcher.

5. *Analysis of data clustering results* is carried out both on the basis of a visual study of the constructed maps and on the basis of calculating the statistical characteristics of the clusters.

Visual analysis and comparison of clustering results in 2019 and 2020 shows that the landscape of Ukraine's tourism sector has changed significantly. However, some structural features remain relatively stable, which indicates their permanent nature. Thus, maps of accommodation costs and transport costs have a similar appearance. Clear clusters in 2019 are formed around general, medical, excursion costs, as well as costs for cultural, educational and leisure services. Interestingly, the location of the clusters of the largest general costs, as well as costs for accommodation, food and excursion transport do not coincide, which indicates a difference in the needs of the main tourist flows in different regions. Thus, the regions with the highest unit costs for accommodation include Dnipropetrovska, Donetska, Zakarpatska, Ivano-Frankivska, Kyivska, Lvivska, Kharkivska, Cherkaska, Chernivetska oblast. The highest unit costs for food are characteristic of Volynska, Zhytomyrska, Khersonska, Rivnenska, Odeska oblast. The highest unit costs for excursion transport are observed in Ternopilska, Khmelnytska, Poltavska, Vinnytska ta Zaporizka oblast. It can be assumed that these factors are among the most important for the regional differentiation of tourism and recreation systems.

The highest total expenses of tourism entities on the services of third-party organizations in both 2019 and 2020 are characteristic of Ivano-Frankivska and Lvivska oblast, which in both years were part of the same cluster. It is also clear that on the 2020 maps, regions with high total expenses of tourism entities form a very clear group, which also includes Dnipropetrovska, Zhytomyrska, Kyivska and Odeska oblast.

It should also be noted that Rivnenska oblast, which has the highest specific level of expenses for cultural, educational and recreational services, as well as medical expenses. However, there is no relevant information for many other regions, which does not allow for solid conclusions.

If we analyze the results of automatic clustering by all indicators, the composition of clusters (with correction for numbering) remained quite stable. In total, 12 out of 19 studied regions in 2020 fell into the same cluster as in 2019. Taking into account all the dissimilarity of the conditions of 2019 and 2020 for tourism and recreation services, this result indicates the effectiveness of the chosen approach for grouping regions into regions. The third region in cluster 2, which is characterized by the largest total expenses of tourism entities, changed from Odeska to Khersonska oblast. Moreover, it is obvious that Odeska oblast in 2019 was in 3rd place in terms of total expenses, while Khersonska oblast in 2020 took only 10th place in terms of this indicator. However, it can be seen that Khersonska oblast is quite similar to Odeska oblast in terms of tourism and recreation features (Table 1).

Let us consider the data in Table 1 in more detail. Cluster 0 unites the regions with the lowest indicators of total costs of tourism entities. This cluster is characterized by the lowest specific costs for accommodation (36%-39% of the total) and the highest specific costs for transport, excursion services, food, etc. However, in absolute terms, the size of these indicators remains quite low compared to the leaders. Together with the analysis of data on the significance of the indicators, we can conclude that the key factor differentiating this cluster from others is the low level of activity of external tourists (those traveling from other regions). This is also indicated by the fact that the average value of the tourist fee in the cluster remained almost unchanged in 2020. The dominance of domestic tourism explains the low level of specific costs for accommodation together with high costs for transport services.

Cluster 1 is characterized by the highest costs for accommodation and the lowest costs for food. These two indicators are the most significant for separating this cluster from others. It is also characterized by low transport costs. In 2020, the highest values of tourist fees were observed in this cluster. It can be concluded that the main factors in the development of tourism and recreation systems in these regions are business tourism. In addition, Ukrainians can consider them as an alternative to traditional tourist destinations.

Comparison of the results of regions clustering according to data from 2019 and 2020

Cluster No. by author numbering	Composition of regions by clusters (in brackets – cluster number according to Fig. 1 and Fig. 2)		Data matching
	2019	2020	
0	(3) <u>Vinnyska</u> Volynska <u>Zhytomyrska</u> <u>Zaporizka</u> Poltavska <u>Ternopilska</u> <u>Khmelnyska</u>	(2) <u>Vinnyska</u> <u>Zhytomyrska</u> <u>Zaporizka</u> <u>Ternopilska</u> <u>Khmelnyska</u> Dnipropetrovska Mykolayivska (new) Rivnenska Cherkaska	71%
1	(1) Dnipropetrovska <u>Donetska</u> <u>Zakarpatska</u> <u>Kyivska</u> <u>Kharkivska</u> Khersonska Cherkaska <u>Chernivetska</u>	(0) <u>Donetska</u> <u>Zakarpatska</u> <u>Kyivska</u> <u>Kharkivska</u> <u>Chernivetska</u> Volynska Odeska	63%
2	(0) <u>Ivano-Frankivska</u> <u>L'vivs'ka</u> Odeska	(1) <u>Ivano-Frankivska</u> <u>Lvivska</u> Khersonska	66%
3	(2) Rivnenska		0%

Source: compiled by the authors

Cluster 2 contains the regions with the highest total expenses of tourism entities. However, with the exception of the indicator of food expenses in 2020 and «other expenses», this cluster no longer takes first place in any of the other specific weight indicators, although in absolute terms it is often the leader. Moreover, in terms of the specific weight of transport costs, as well as expenses for sports and recreation, this cluster is even an outsider. In 2019, the cluster led in tourist fees, but in 2020 its size decreased by more than three times. Therefore, we can conclude that these regions are oriented towards external tourism. They have conditions for the uniform development of tourism and recreation systems of various orientations and that this is the best development strategy.

Conclusions. The analysis allowed dividing the regions of Ukraine into 3 clusters and establishing key factors of their differentiation, which vary significantly from region to region. The assessment of these aspects will allow further identification of key areas of regional development, ensuring inclusiveness and participation of the local population in the management of tourism

resources. Natural and cultural and historical conditions, such as the presence of protected areas, environmental threats and climatic features, the presence of outstanding historical and cultural monuments, have a significant impact on the differentiation of regions. However, the analysis performed showed that all regions have the potential for development, which only needs to be properly implemented.

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ДИФЕРЕНЦІАЦІЯ РЕГІОНАЛЬНИХ ТУРИСТИЧНО-РЕКРЕАЦІЙНИХ СИСТЕМ ЗА ВИКОРИСТАННЯ САМООРГАНІЗАЦІЙНИХ НЕЙРОННИХ МЕРЕЖ

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Методологія дослідження. В роботі використані такі загальнонаукові та спеціальні методи: теоретичного узагальнення – для узагальнення теоретичних положень та міжнародного досвіду розвитку туристичних систем; логіко-аналітичний та методи статистики – для характеристики поточного стану розвитку туристичної сфери України; кластеризація на основі самоорганізаційних нейронних мереж та карт Кохонена – для пошуку оптимальної структури туристичної діяльності на основі визначення ключових факторів, що обмежують її розвиток.

Результати. Проаналізовано теоретичні засади та практичний досвід диференціації соціально-економічних систем різного рівня. Враховуючи наявність та якість статистичних даних, які характеризують стан регіональної туристичної сфери України, визначено оптимальні інструменти для диференціації відповідних регіонів. Проведений аналіз дозволив розділити регіони України на три кластери і встановити ключові фактори їхньої диференціації, які істотно варіюються від регіону до регіону. Значний вплив на диференціацію регіонів мають природні та культурно-історичні умови, а саме: існування природоохоронних територій, екологічні загрози та кліматичні особливості, наявність видатних пам'яток історії та культури.

Новизна. Авторами запропоновано науково-методичний підхід до оцінювання рівня розвитку регіональної туристичної сфери із врахуванням структури туристичних потоків (в розрізі цілей туризму), витрат на організацію і підтримку туристичних комплексів та інших факторів і обмежень. Визначено фактори регіональної диференціації туристично-рекреаційних систем на основі методу кластеризації. Як ключовий індикатор для такого групування використано структуру показників споживчої (туристичної) привабливості, в основі якої лежать фінансові характеристики результативності.

Практична значущість полягає у плануванні та оптимізації структури туристичної діяльності регіонів на засадах сталого розвитку залежно від туристичних потоків, валового регіонального продукту, підприємницької та інвестиційної активності, витрат на туристичну діяльність. Звідси випливають стратегічні пріоритети розвитку для таких груп регіонів України, які є спорідненими за особливостями організації туристичного бізнесу. Окрім того, запропонована методологія дозволяє сформулювати практичні рекомендації для бізнесу та органів влади і місцевого самоврядування та забезпечити баланс між потребами туризму та збереженням природного та культурного середовища.

Ключові слова: туристично-рекреаційна система, кластеризація, групування, туристичні витрати, туристична інфраструктура, регіон.

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