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Information System for Decision Support in the Field of Tourism Based on the Use of Spatio-Temporal Data Analysis

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ABSTRACT

Information plays an important role in decision-making processes. The methods of data processing and analysis are of particular importance. Such methods should provide additional information. This is critical in decision support information systems. We propose to use wavelet coherence for spatio-temporal data analysis. This approach is considered for data from the tourism sector to assess the effectiveness of the decisions made. Calculations are given for real data. Hidden shortcomings in tourism are shown.

Key words: Information System, Decision Support, Wavelet Analysis, Tourism, Space-Time Analysis.

1. INTRODUCTION

Information is a generalization of processes and phenomena that occur in the micro- and macrocosm. Information helps you make decisions. Moreover, information is a key element of a decision support system [1], [2]. This is because information can be converted into data. This data is the foundation of knowledge. We can also get additional information. This expands the scope of decision making. Such solutions are the most effective.

Decision support systems can be applied in any areas and spheres of human activity [3], [4]. Such systems are especially important at the junction of various spheres of human activity. This helps to make the necessary decisions that affect different areas of activity. Thus, a more efficient and balanced development of the field of activity under consideration is possible. One of the spheres of human activity, which is important for different areas of human life, is tourism [5]. It is the decision support system in the field of tourism that is considered in this article.

The effective use of the decision support information system is determined by its structure, data system. The structure of the decision support information system helps to take into account all the factors that influence decision making. At the same time, for data analysis it is necessary to use the most effective methods of information processing. Building an appropriate decision support information system also requires the use of a logical and integrated approach. These questions are basic and are discussed in this article.

2. REVIEW OF THE LITERATURE

The use of information systems to support decision-making in different spheres of human activity determines the presence of a large number of relevant studies.

For example, M. Bohanec, in his study, describes and clarifies the meaning of the term decision support [6]. This is important for understanding the general structure of the corresponding system, the interaction of its individual elements, and increasing the efficiency of such a system. According to M. Bohanec, such a system should include: research and analysis of possible solutions, decision support, data storage and analysis, complex analysis in the development of recommendations with decision support [6].

In [7], the issues of decision making in the context of several alternatives are considered. The article shows that the decisions made for different conditions of their implementation affect each other. This is important from the point of view of analyzing possible situations and their development after making decisions.

J. E. Aronson, T. P. Liang and R. V. MacCarthy consider an integrated assessment of the decision-making system [8]. The authors also disclose various technologies that can be used in the respective systems. Particular attention is paid to intelligent analysis in identifying possible decision-making alternatives.

The study [9] analyzes decision-making systems that are built on the basis of knowledge bases. It is shown that such systems are more flexible in the context of many alternatives. It is also concluded that such systems are more efficient.

W. Teniwut and S. Hasyim carry out a comprehensive analysis of various decision-making systems in tourism [10]. The authors pay special attention to methods and models for data analysis that summarizes various indicators from the tourism sector. The importance of using adequate models for decision making is shown.

A. Jahani, H. Goshtasb and M. Saffariha analyze the impact of tourism decisions on the environment [11]. This impact is assessed using data mining techniques. Among such methods, the authors distinguish neural networks and the theory of fuzzy sets. This study shows how the result of the decision-making system affects different spheres of life.

A. Mailangkay, E. Indrajit, R. Kosala and A. Hidayat in their research analyze the factors that influence the development of tourism [5]. The authors use online travel booking data as data sources. Thus, work [5] analyzes the relevant service and its impact on the development of tourism. This allows a comprehensive approach to assessing the effectiveness of decision-making, the reliability of the corresponding information system.

N. Stylos and Zwiegelaar pay attention to data that are used in decision support systems in tourism [12]. The authors draw attention to the amount of data, which needs to be processed to make decisions. The issues of the value of big data are discussed. Particular attention is focused on obtaining additional information from the data possessed by the decision support system. Also, attention is paid to the consistency of the data with which the decision-making system works. All of these aspects are important for assessing the effectiveness of decisions that have been made and implemented.

The factors that determine the degree of complexity for the decision-making system are discussed in the article [13]. Such factors are analyzed for the system of decision-making in the field of tourism. The authors have shown that the difficulty level is based on decision tree tests, which include four stages: data collection, data analysis, analysis rigor, data analysis methods [13].

D. Li, L., Deng and Z. Cai for tourism decisions are based on statistical findings [14]. The authors draw such conclusions based on the analysis of a large amount of data and using classical statistical methods. Nevertheless, there remains the question of reconciling the data and the results of their processing to make a final decision.

We see that individual authors consider various aspects of the functioning of decision support information systems in the field of tourism. This is due to the fact that it is necessary to take into account various factors influencing decision-making. This is what determines the complexity and importance of building such systems. At the same time, the analysis made it possible to determine the main elements of the structure of information systems for supporting decision-making in the field of tourism.

3. KEY ELEMENTS OF THE STRUCTURE OF INFORMATION DECISION SUPPORT SYSTEM

First of all, it should be noted that in a formalized form, decision-making in the corresponding information system consists in transforming the initial data into a decision made:

$$ND(x_1,...,x_m) \xrightarrow[F]{} RE(y_1,...,y_p), \quad (1)$$

ND – a set of initial data ($x_1,...,x_m$), which describes the situation in the subject area of research (in the field of tourism),

F – methods and algorithms for the analysis of initial data,

RE – the decision, depending on the influencing factors ($y_1,...,y_p$).

Then the general structure of the decision support information system (for example, in the field of tourism) has in accordance with Figure 1.

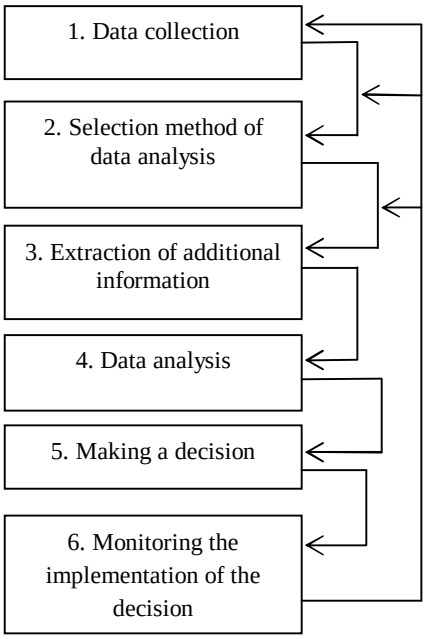

Figure 1: Key structural elements of the decision support information system

From Figure 1 and the analysis of literary sources, it can be concluded that the methods and algorithms for data analysis determine the effectiveness of the functioning of the decision support information system. These methods and algorithms allow you to process data, obtain additional information, and monitor the decisions made. Comprehensive data analysis takes a special place in such processes. Such analysis should cover the data timeline; take into account the relationships of these data within separate time intervals. To solve such problems, it is advisable to use space-time data analysis. This can be done using wavelet coherence.

4. WAVELET COHERENCE AS A TOOL FOR SPATIO-TEMPORAL DATA ANALYSIS

The ideology of wavelets is one of the directions for researching data, which are presented in the form of a time series. Indicators that characterize tourism can be presented as a time series. Therefore, the ideology of wavelets can be used in the decision support system in the field of tourism.

Among the methods of the ideology of wavelets for data analysis, the wavelet coherence method should be distinguished. Wavelet coherence also allows cross-analysis of data. This allows us to take into account the relationships between data within separate time intervals. If we have two series of data g(t) and q(t) then we can determine the wavelet coherence.

To determine the values of wavelet coherence, we consider the values of cross wavelet spectra $W_{xy}(g,q)$ (x is the variable that displays the data number in the series under investigation and y is the variable that displays the depth of cross-links for a time series) [15]. These values are presented as absolute values. We also normalize some variables. The general formula has the following form [16], [17]:

$$R^2(g,q)=\frac{\left|\Theta(q^{-1}W_{xy}(g,q))\right|}{\Theta(q^{-1}\left|W_x(g,q)\right|^2)\Theta(q^{-1}\left|W_y(g,q)\right|^2)}, \qquad (2)$$

where Θ is a smoothing operator,

$R^2(g,q)$ – The squared wavelet coherency coefficient. $0\le R^2(u,s)\le 1$. If these values tend to zero, then we have a weak correlation. Otherwise, we have a strong correlation.

We use the Morlet wavelet to find the values $R^2(g,q)$.

Formula (2) makes it possible to carry out space-time data analysis. This is important for the functioning of the decision support information system.

5. DATA FOR ANALYSIS

Considering the functioning of the decision support information system, we can analyze various data. At the same time, it is important to have tools to control the decisions that have been made. Therefore, any combination of data can be used for analysis. Wavelet coherence allows us to assess the dynamics of development of a certain field of activity according to the data that we have:

if the values of the wavelet coherence are consistent and stable - the dynamics of the studied field of activity is positive (↑),

if the values of the wavelet coherence are inconsistent and unstable - the dynamics of the investigated field of activity is not effective (↓).

In a formalized form (in terms that are disclosed above) this means the following:

$$x_1,\dots,x_m \xrightarrow[(y_1,\dots,y_p)]{} RE\begin{vmatrix} R^2(g,q)\to 1 \Rightarrow RE\uparrow \\ R^2(g,q)\to 0 \Rightarrow RE\downarrow \end{vmatrix}. \qquad (3)$$

Among the data that are characteristic of tourism activities are [5], [11]:

international tourism, expenditures, international tourism, expenditures for passenger transport items, international tourism, expenditures for travel items, international tourism, number of arrivals, international tourism, number of departures, international tourism, receipts, international tourism, receipts for passenger transport items, international tourism, receipts for travel items.

These data reflect the dynamics of development in general. Moreover, these data are interconnected. For our research, we will look at some of the data in more detail. These data refer to international tourism in general. Figure 2 shows the dynamics of expenditures on international tourism and receipts from international tourism. We consider the data for the period 1995-2018 (data.worldbank.org).

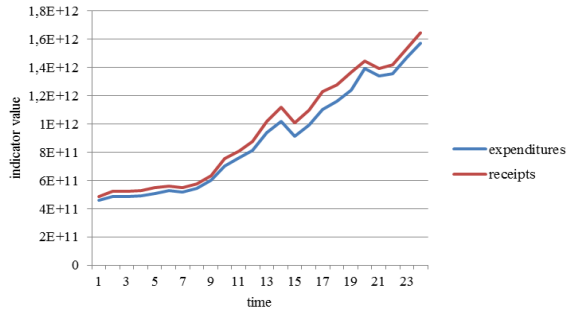

Figure 2: Dynamics of expenditures on international tourism and receipts from international tourism.

Figure 3 shows the dynamics of number of arrivals and number of departures as a result of international tourism activities.

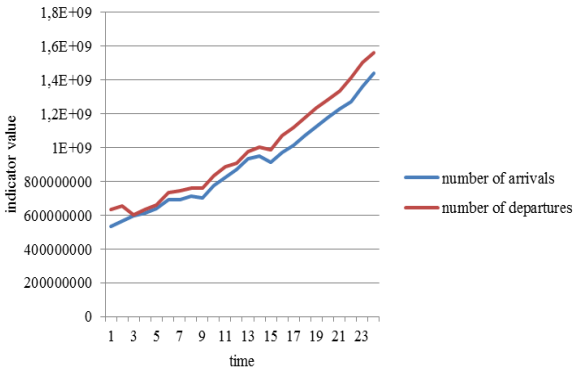

Figure 3: Dynamics of number of arrivals and number of departures as a result of international tourism activities.

Figure 4 shows the dynamics of expenditures for passenger transport items and receipts for passenger transport items in terms of international tourism.

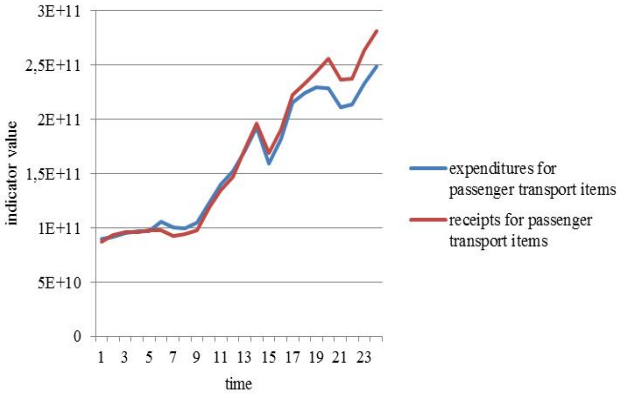

Figure 4: Dynamics of expenditures for passenger transport items and receipts for passenger transport items in terms of international tourism.

The data presented above have the same dynamics. At the same time, you can see some differences. Therefore, consider the wavelet coherence for this data.

6. RESULTS AND DISCUSSION

Figure 5 – Figure 9 show the estimates of wavelet coherence between the individual data discussed above. These assessments reveal the relationship between various indicators of international tourism performance. The data presented in Figure 5 – Figure 9 correspond to classical descriptions of wavelet coherence estimates [15]-[18].

Figure 5 shows estimates of the wavelet coherence between expenditures on international tourism and receipts from international tourism. We see that such estimates reflect complete consistency between the data that is being investigated.

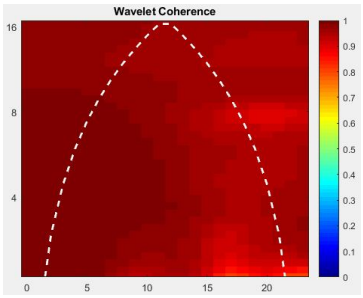

Figure 5: Wavelet coherence between expenditures on international tourism and receipts from international tourism.

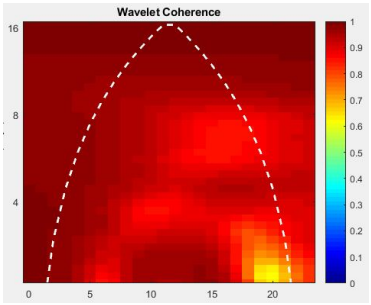

Figure 6: Wavelet coherence between of number of arrivals and number of departures as a result of international tourism activities.

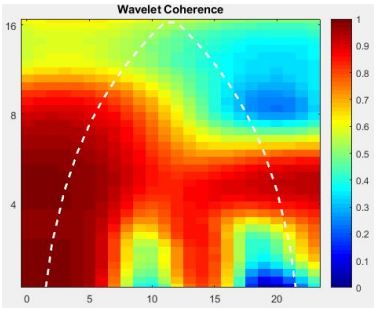

Figure 7: Wavelet coherence between of number of arrivals and of expenditures for passenger transport items in terms of international tourism.

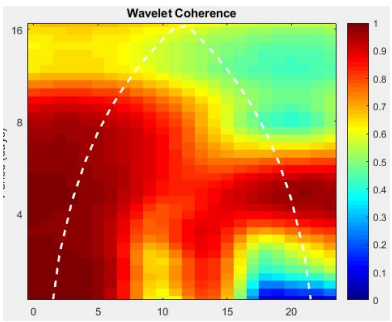

Figure 8: Wavelet coherence between of number of arrivals and receipts for passenger transport items in terms of international tourism.

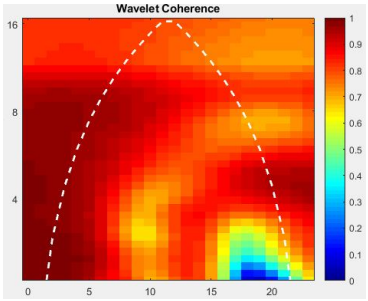

Figure 9: Wavelet coherence between of number of arrivals and receipts from international tourism.

At the same time, the wavelet coherence between of number of arrivals and number of departures as a result of international tourism activities is less consistent (Figure 6). This is observed for the last time period that is being investigated. However, all the data in question must be consistent in the same way.

An even greater imbalance is observed for the data in Figure 7 and Figure 8. Thus, it can be assumed that this is the result of a lack of consistency between expenditures for passenger transport items and receipts for passenger transport items in terms of international tourism. Therefore, from the point of view of the dynamics of the development of the tourism industry, it is necessary to adjust expenditures and receipts for passenger transport items. This conclusion is confirmed by the data in Figure 9. Then, in accordance with the formula (3), we can talk about some negative effects in the dynamics of the development of international tourism. At the same time, these negative effects are typical for the last periods of time that are being studied.

In general, we see that wavelet coherence can be used as a data analysis tool in a decision support system.

7. CONCLUSION

The article discusses various issues that relate to the functioning of the decision support information system in the field of tourism. Particular attention is paid to data analysis methods. For these purposes, it is proposed to use the wavelet coherence. Using specific examples, the expediency of using wavelet coherence in decision support systems in the field of tourism is shown.

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