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Improvement of Tools for Government Regulation of Tourist Activity Based on Analysis of Simplicial Complexes

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Abstract:

The main aim of this research is conditioned by the need to improve efficiency of tourism in the context of economic modernization, which can lay the groundwork for sustainable development of both regions and the country.

This is to be achieved using government regulation and support tools for sustainable development of tourist activity. The purpose of the article is to improve the existing tools for government regulation of tourist activity in the Russian Federation.

The proposed method to investigate the problem is to analyze simplicial complexes of q-connectivity, which has allowed the authors to consider the structure of tools for government regulation of tourist activity and to identify their features and limitations.

Because of the research, control elements of the structure of tools for government regulation of tourist activity have been identified, including: regulations to ensure safety of tourists and holidaymakers at resorts, advertising tourism opportunities, transportation of tourist flows, coordination with environmental institutions, and recreational nature management.

The research has proved inconsistency of the existing structure of tools for government regulation of tourist activity, and, consequently, the need for its improvement based on sustainable development principles.

Keywords: *Analysis of simplicial complexes, analysis of system q-connectivity, government regulation, structural analysis, sustainable development, tourist activity*.

JEL code: *Z32, Z38.*

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1. Introduction

At present, arrangement of conditions for growth of human well-being determined by economic, ecological and social environment is one of the main objectives of government policy, which reflects in a concept of sustainable development. Sustainable development is increasingly becoming a priority issue in tourism development in today's context. The main objective of sustainable development of tourist activity is its balanced development, whereby all tasks will be equally important and compatible, including economic development, local society's well-being, thriving culture, intact nature, and satisfaction of tourist needs (Dudetskiy, 2014; Vasiljeva and Dudetskiy, 2014).

However, it is important not to just create conditions for tourism development, but also to think through its ramifications. It is necessary to reduce both negative implications of its development and make the best use of positive effects. Hence, it is social, economic and environmental goals in the government policy that will become a key to success in tourist activity.

Therefore, it is necessary to study the structure of tools for government regulation of tourist activity as an integrated system. This allows one to consider implementing the idea to improve tools for government regulation of tourist activity based on structural analysis, the method for analyzing simplicial complexes and system q-connectivity analysis to identify its features and limitations, the laws of existence and development that require particular attention both from the researcher and the decision-maker.

2. Literature review

At present, structural analysis is one of the main stages of complex system studies, including socioeconomic and political ones representing a complex of different subsystems in a hierarchical view and uniting a large number of interrelated and interacting objects of different nature. At the same time, one of the most important characteristics of a complex system is its sensitivity to detrimental environmental effects. This problem has been insufficiently studied so far and, therefore, is an up-to-date line of research.

The peculiarities and laws of complex systems were initially studied purposefully by Gigch (1981), Golubkov (1982), Casti (1982), Klir (1990), Volkova and Denisov (1998), Knyazeva and Kurdyumov (1999), Terekhov and Tyukin (1999). Their research has formed the basis for many studies and works.

In modern scientific literature, most of the studies devoted to semi-structured systems, including tourism, are based on a series of composite works on systems theory and system analysis that facilitate specialist training for solving applied problems using ideas and methods of systems theory and system analysis. The paper of Gorelova *et al.* (2006) lays the groundwork for analyzing the structure of a system under study whereby it is necessary to identify its functionally significant elements to determine conditions for structural stability.

Approaches to understanding how to build a system model to predict its sustainable development potential appear in recent research of Bozhenyuk and Ginis (2013; 2014) and Epifanova *et al.* (2017). The studies of Slesarev and Yanovskiy (2014), Tretyakova (2013) contain elaboration of sustainable development pathways in managerial decision-making.

The paper of Bereza (2011) proposes analysis of system q-connectivity in order to analyze the connectivity of system of tourist activity and the external environment interaction. The analysis findings show controllability of tourist activity whereby the federal authorities have been selected as managers both for the whole system under investigation and for each element separately. Also, they confirm that ecological situation and the standard of human well-being are the most important as target factors. This allows the authors to continue the study where it is necessary to consider tools for government regulation of tourist activity and to propose ways to improve them based on analysis of simplicial complexes.

Problems, trends, and prospects of research into sustainable tourism development have been considered by such authors as Lane (2018), Angelevska-Najdeska and Rakicevik (2012) and Mihalic (2016). Issues of tourist activity management prospects have been considered in the works of Ryan (2018), Jamal and Camargo (2018), Saito and Ruhanen (2017) and Joppe (2018).

3. Materials and methods

Structure analysis is designed to identify significant and functionally significant connections in a system, to determine conditions for its structural stability. For these purposes, one can apply the apparatus of algebraic topology, group theory, systems theory, and binary relations that allow for analysis of the structure of a complex as a multidimensional geometric formation. This complex is called simplicial; it was put forward by Atkin (1997), Casti (1982), Barcelo *et al.* (1998).

The method of q-connectivity analysis makes it possible to consider connectivity of the system under study more thoroughly than in traditional studies of graph connectivity, whereby it is established that there is a mutual influence of simplicial system blocks through a chain of communications between them. Based on these possibilities, formalized rules for justifying the choice of target and control vertices, determination of the stability of systems characterized by particular simplicial complexes, and conditions for structural stability of systems have been proposed (Ginis, 2015; Ginis *et al.*, 2016).

Determination of the number of simplexes and their structure, analysis of system q-connectivity makes it possible to advance reasons for solving the problems of decomposing and composing the system of tools for government regulation of tourist activity, to identify simplexes that most markedly affect processes in the system and form the vertices that are more rational to choose as control ones.

A simplicial complex $K_x(Y;\lambda)$ shall be understood to be a geometric figure whereby the elements of Y set are considered as vertices and the elements of X set are simplexes reflecting the interrelation between the vertices through a corresponding element $x_i \in X$ (Gorelova 2011; 2013).

Let us denote the simplex by $\delta^{(i)}_q$, where i is the number of a vertex and q is the geometric dimension of a simplex. Q number is determined by the number of arcs joining vertices y_j in the simplex through a variable x_i. Q number (the number of arcs incident with y_j) is one less than the number of ones (“1”) in the respective i-row of matrix Λ. If there is no 1 in a row of matrix Λ, the “empty” simplex dimension is denoted by q = 0-1= -1.

Let us pass on to one more relation generated by Λ, that is, a conjugate relation Λ*. The latter is obtained by interchanging positions of sets X and Y, that is, Λ*=Y*X, $\Lambda^*=[\lambda^*_{ij}]$, and transposing matrix Λ, that is, $\Lambda^*=\Lambda^T$. The relation Λ* exists between y_j and x_i if and only if there exists a relation Λ between x_i and y_j. Hence, we obtain a simplicial complex $K_y(X,\lambda^*)$ whereby X is a set of vertices and Y is a set of simplexes. Sometimes, the complex $K_y(X,\lambda^*)$ can be more meaningful than $K_x(Y,\lambda)$.

A simplicial complex is a mathematical generalization of a planar graph that reflects multidimensional nature of the binary relation under consideration. Since a simplicial complex is a family of face-shared simplexes (including a common vertex, that is a point), the dimension of a face shared by two simplexes can serve as a connectivity characteristic. However, since there is a complex as a whole, a “communication chain” concept is used for connectivity analysis (Gorelova and Pankratova, 2015).

A communication chain reflects the possibility that two simplexes not sharing a face can be connected by a sequence of intermediate simplexes.

The concept of a communication chain – q-connectivity – is formulated as follows: two simplexes σ_r and σ_p (r and p are geometric dimensions q of the respective simplexes) of complex K are connected by a q-connection chain if there is sequence of simplexes $\sigma_{\alpha\, q}$, q = 1, 2,…,n in K is such that:

$\sigma_{\alpha q}$ is a face of σ_r,
$\sigma_{\alpha n}$ is a face of σ_p,
$\sigma_{\alpha\, q}$ and $\sigma_{\alpha\, q+1}$share a face of dimension β for q=1, 2,…,n-1;

$q = \min\{r, \beta_1, \beta_2, \ldots \beta_n, p\}$.

The simplex subscript corresponds to its geometric dimension, that is, dim σ_i=i. It is shown that q-connectivity generates an equivalence relation on the simplexes of complex K; therefore, the problem of studying the global connectivity structure of complex K resolves itself into studying q-equivalence classes. For each value of dimension q=0, 1, 2,…,dimK, one can find the number of different equivalence classes Q_q.

Q analysis of simplicial complex K is an operation of finding the number of its various equivalence classes, and vector $Q = \{Q_{dimK}, \ldots, Q_1, Q_0\}$ is the first structure vector of the complex.

The q-analysis algorithm developed by Gorelova, Zakharova, Ginis includes several steps (Gorelova *et al.*, 2015; Zakharova *et al.*, 2015; Ginis, 2015). It is represented by a diagram in Figure 1.

4. Results

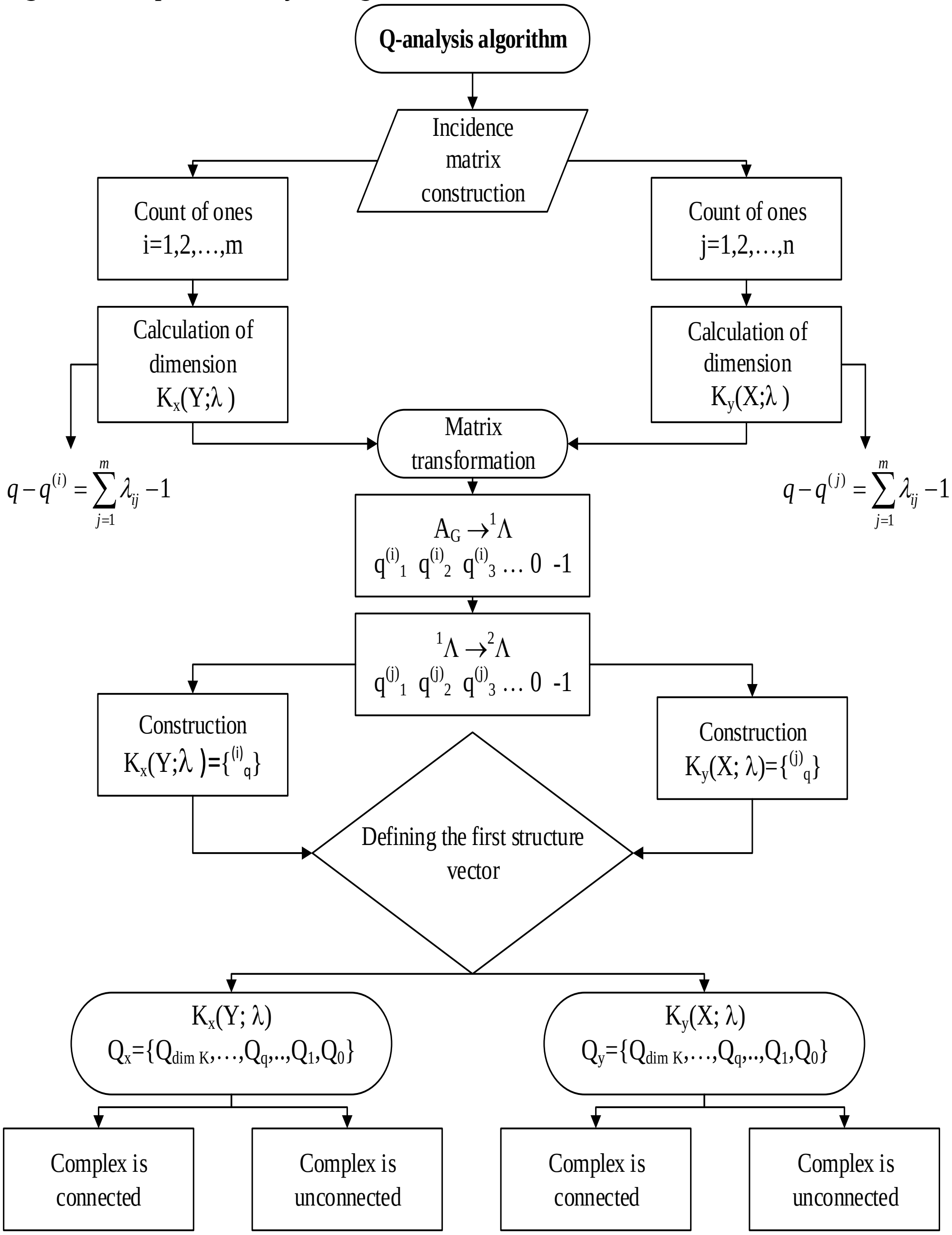
Activities in tourism sector are regulated by the norms of various branches of law – civil, administrative, environmental, insurance, customs, taxation, and constitutional. Legal support in tourism sector is based on international law, legislation and regulations adopted at the federal and regional levels.

A list of federal executive bodies of the Russian Federation that regulate tourist activity is shown in Figure 2.

The government regulators in regional tourism are various government institutions that operate in a broad range, including economic development, youth policy, entrepreneurship, external affairs, culture, investment, tourism, consumer market and services, and health resort complex (Yakimenko, 2008). These include ministries, committees, directorates, departments, agencies for tourism. (Krivoruchko, 2011; Kuklina and Desyatnichenko, 2017).

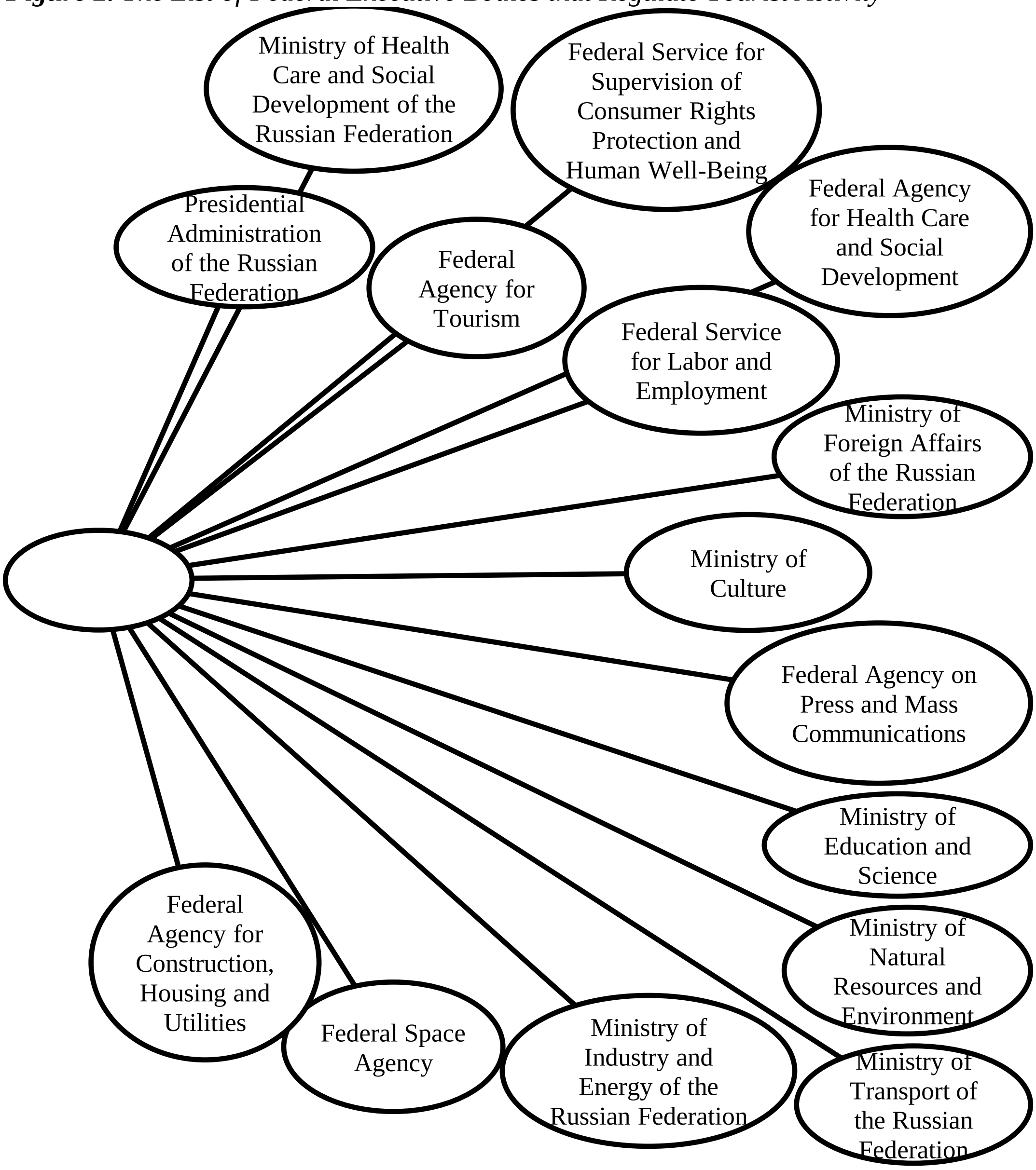
Let us present the current structure of tools for government regulation of tourist activity as a model in Figure 3.

Figure 1. *Simplicial Analysis Algorithm*



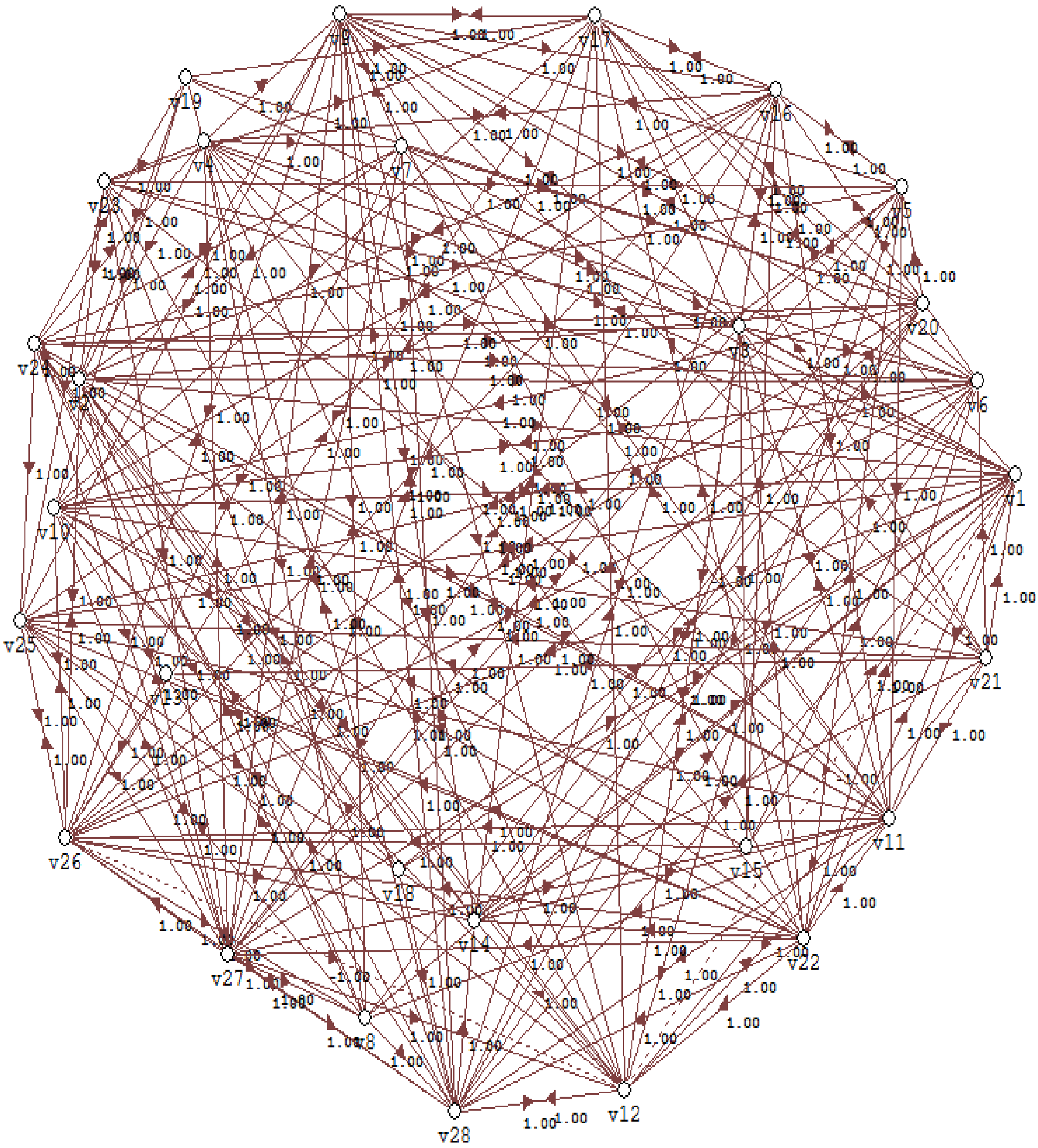
Source: *Compiled by the authors.*

Figure 2. *The List of Federal Executive Bodies that Regulate Tourist Activity*



Source: *Compiled by the authors.*

Figure 3. *Interaction Structure of Tools for Government Regulation of Tourist Activity*



Source: *Compiled by the authors.*

In this structure, the vertices have the following meaning:

V1. Transportation of tourist flows;
V2. Reconstruction of listed buildings aiming to locate hotel facilities at their premises;
V3. Control of tourist service quality conformance with the current standards;
V4. Environmental standardization and certification, auditing;
V5. Licensing and certification of health resort treatment;
V6. Participation in international tourist programs;
V7. State procurement;
V8. Subsidies, subventions, reimbursement, grants;
V9. Personnel training and professional development in tourism sector;
V10. Establishment of tourist representative offices outside the Russian Federation;
V11. Cooperation with environmental institutions;
V12. Recreational nature management;
V13. Health resort treatment financing at the expense of social and voluntary health insurance;
V14. Direct budgetary allocations for development and implementation of target tourism development Programs;
V15. Visa service regulations for tourists in Russian consulates abroad and foreign consulates in Russia;
V16. Outreach of national tourist product;
V17. Excursion service ;
V18. Tax concessions ;
V19. Credit facilities;
V20. Employment in tourism;
V21. Legislation to protect the rights of tourists as consumers;
V22. Regulations to ensure safety of tourists and holidaymakers at resorts;
V23. Health legislation;
V24. Economic legislation;
V25. Research in the tourism industry;
V26. Advertising tourism opportunities in Russia;
V27. Technical regulation in tourism and tourism development;
V28. Construction of tourist infrastructure and health resort complex facilities.

An incidence matrix of the interaction structure of tools for government regulation of tourist activity with included weighing coefficients of expert estimates of the tourism industry is presented in Figure 4.

Figure 4. *Incidence Matrix*

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25	V26	V27	V28
V1	0	0	0	1	0	0	0	0	0	1	1	–1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
V2	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0
V3	1	0	0	0	0	1	0	0	1	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
V4	1	1	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1
V5	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1
V6	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	1	0	0
V7	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
V8	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1
V9	0	0	1	0	0	1	1	1	0	1	1	1	0	1	0	1	1	0	0	1	0	0	0	0	1	1	0	0
V10	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	1	0	0
V11	0	1	1	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
V12	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
V13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
A_G = V14	1	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1
V15	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
V16	1	1	1	1	1	1	0	0	0	1	1	–1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1
V17	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
V18	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
V19	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
V20	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0
V21	1	0	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0
V22	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	1	1	1
V23	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1
V24	0	1	1	1	1	1	1	1	0	0	1	1	0	1	0	0	0	1	1	1	0	0	0	0	1	0	1	1
V25	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0
V26	0	1	0	0	0	1	1	1	1	1	0	–1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	1
V27	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	1
V28	1	0	0	0	0	1	0	0	1	1	1	1	0	1	0	1	0	0	1	1	0	0	0	0	0	1	0	0

To identify substantial, functionally significant connections in the functioning of the structure of tools for government regulation of tourist activity, let us analyze its q-connectivity.

At step 1, we find:
$\mathbf{X}_1$: $\sigma^{(1)}_{6}$; $\mathbf{X}_2$: $\sigma^{(2)}_{7}$; $\mathbf{X}_3$: $\sigma^{(3)}_{7}$; $\mathbf{X}_4$: $\sigma^{(4)}_{8}$; $\mathbf{X}_5$: $\sigma^{(5)}_{7}$; $\mathbf{X}_6$: $\sigma^{(6)}_{7}$; $\mathbf{X}_7$: $\sigma^{(7)}_{6}$; $\mathbf{X}_8$: $\sigma^{(8)}_{6}$; $\mathbf{X}_9$: $\sigma^{(9)}_{12}$; $\mathbf{X}_{10}$: $\sigma^{(10)}_{7}$; $\mathbf{X}_{11}$: $\sigma^{(11)}_{8}$; $\mathbf{X}_{12}$: $\sigma^{(12)}_{4}$; $\mathbf{X}_{13}$: $\sigma^{(13)}_{0}$; $\mathbf{X}_{14}$: $\sigma^{(14)}_{8}$; $\mathbf{X}_{15}$: $\sigma^{(15)}_{3}$; $\mathbf{X}_{16}$: $\sigma^{(16)}_{12}$; $\mathbf{X}_{17}$: $\sigma^{(17)}_{4}$; $\mathbf{X}_{18}$: $\sigma^{(18)}_{4}$; $\mathbf{X}_{19}$: $\sigma^{(19)}_{5}$; $\mathbf{X}_{20}$: $\sigma^{(20)}_{4}$; $\mathbf{X}_{21}$: $\sigma^{(21)}_{13}$; $\mathbf{X}_{22}$: $\sigma^{(22)}_{16}$; $\mathbf{X}_{23}$: $\sigma^{(23)}_{10}$; $\mathbf{X}_{24}$: $\sigma^{(24)}_{15}$; $\mathbf{X}_{25}$: $\sigma^{(25)}_{7}$; $\mathbf{X}_{26}$: $\sigma^{(26)}_{11}$; $\mathbf{X}_{27}$: $\sigma^{(27)}_{15}$; $\mathbf{X}_{28}$: $\sigma^{(28)}_{10}$.

Results of the dimension of simplexes of the complex of structure of tools for government regulation of tourist activity at step 2:
$\mathbf{Y}_1$: $\sigma^{(1)}_{16}$; $\mathbf{Y}_2$: $\sigma^{(2)}_{13}$; $\mathbf{Y}_3$: $\sigma^{(3)}_{9}$; $\mathbf{Y}_4$: $\sigma^{(4)}_{8}$; $\mathbf{Y}_5$: $\sigma^{(5)}_{5}$; $\mathbf{Y}_6$: $\sigma^{(6)}_{12}$; $\mathbf{Y}_7$: $\sigma^{(7)}_{4}$; $\mathbf{Y}_8$: $\sigma^{(8)}_{5}$; $\mathbf{Y}_9$: $\sigma^{(9)}_{15}$; $\mathbf{Y}_{10}$: $\sigma^{(10)}_{13}$; $\mathbf{Y}_{11}$: $\sigma^{(11)}_{16}$; $\mathbf{Y}_{12}$: $\sigma^{(12)}_{16}$; $\mathbf{Y}_{13}$: $\sigma^{(13)}_{1}$; $\mathbf{Y}_{14}$: $\sigma^{(14)}_{7}$; $\mathbf{Y}_{15}$: $\sigma^{(15)}_{0}$; $\mathbf{Y}_{16}$: $\sigma^{(16)}_{13}$; $\mathbf{Y}_{17}$: $\sigma^{(17)}_{14}$; $\mathbf{Y}_{18}$: $\sigma^{(18)}_{0}$; $\mathbf{Y}_{19}$: $\sigma^{(19)}_{1}$; $\mathbf{Y}_{20}$: $\sigma^{(20)}_{9}$; $\mathbf{Y}_{21}$: $\sigma^{(21)}_{-1}$; $\mathbf{Y}_{22}$: $\sigma^{(22)}_{0}$; $\mathbf{Y}_{23}$: $\sigma^{(23)}_{-1}$; $\mathbf{Y}_{24}$: $\sigma^{(24)}_{-1}$; $\mathbf{Y}_{25}$: $\sigma^{(25)}_{10}$; $\mathbf{Y}_{26}$: $\sigma^{(26)}_{19}$; $\mathbf{Y}_{27}$: $\sigma^{(27)}_{6}$; $\mathbf{Y}_{28}$: $\sigma^{(28)}_{14}$.

Results of transformed matrix A_G in $^{(1)}\Lambda$ and then $^{(1)}\Lambda$ in $^{(2)}\Lambda$ at step 3 are shown in the Table 1 below:

Table 1. *Results of Transformed matrices at Step 3*

	V26	V1	V11	V12	V9	V17	V28	V2	V10	V16	V6	V25	V3	V20	V4	V14	V27	V5	V8	V7	V13	V19	V15	V18	V22	V21. V23. V24	$q^{(i)}$
V22	1	1	1	1	1	1	1	1	1		1	1	1		1	1	1	1			1						**16**
V24			1	1			1	1			1	1	1	1	1	1	1	1	1	1		1		1			**15**
V27	1	1	1	1	1	1	1	1	1	1			1	1	1			1	1	1							**15**
V21	1	1	1	1	1	1			1		1	1	1		1	1		1			1						**13**
V9	1		1	1		1			1	1	1	1	1	1		1			1	1							**12**
V16	1	1	1	1		1	1	1	1		1	1	1		1			1									**12**
V26				1	1	1	1	1	1	1	1	1				1			1	1							**11**
V23		1	1	1		1	1	1				1	1		1		1	1									**10**
V28	1	1	1	1	1				1	1	1			1		1						1					**10**
V4	1	1	1	1	1		1	1		1							1										**8**
V11	1			1	1		1	1					1		1				1	1							**8**
V14		1	1	1	1	1	1	1				1		1													**8**
V2	1	1	1	1						1	1			1			1										**7**
V3		1	1	1	1	1				1	1												1				**7**
V5	1		1	1	1		1			1			1				1										**7**
V6	1				1	1			1	1		1	1			1											**7**
V10	1	1			1	1				1	1			1											1		**7**
V25	1	1	1	1						1						1	1		1								**7**
V1	1		1	1		1			1			1			1												**6**
V7	1	1	1		1		1	1						1													**6**
V8	1	1			1		1	1				1		1													**6**
V19		1				1	1	1	1					1													**5**
V12			1			1	1	1	1																		**4**
V17	1	1			1					1	1																**4**
V18		1					1	1	1		1																**4**
V20	1				1	1			1	1																	**4**
V15	1								1	1	1																**3**
V13	1																										**0**
$q^{(j)}$	**19**	**16**	**16**	**16**	**15**	**14**	**14**	**13**	**13**	**13**	**12**	**10**	**9**	**9**	**8**	**7**	**6**	**5**	**5**	**4**	**1**	**1**	**0**	**0**	**0**	**-1**	

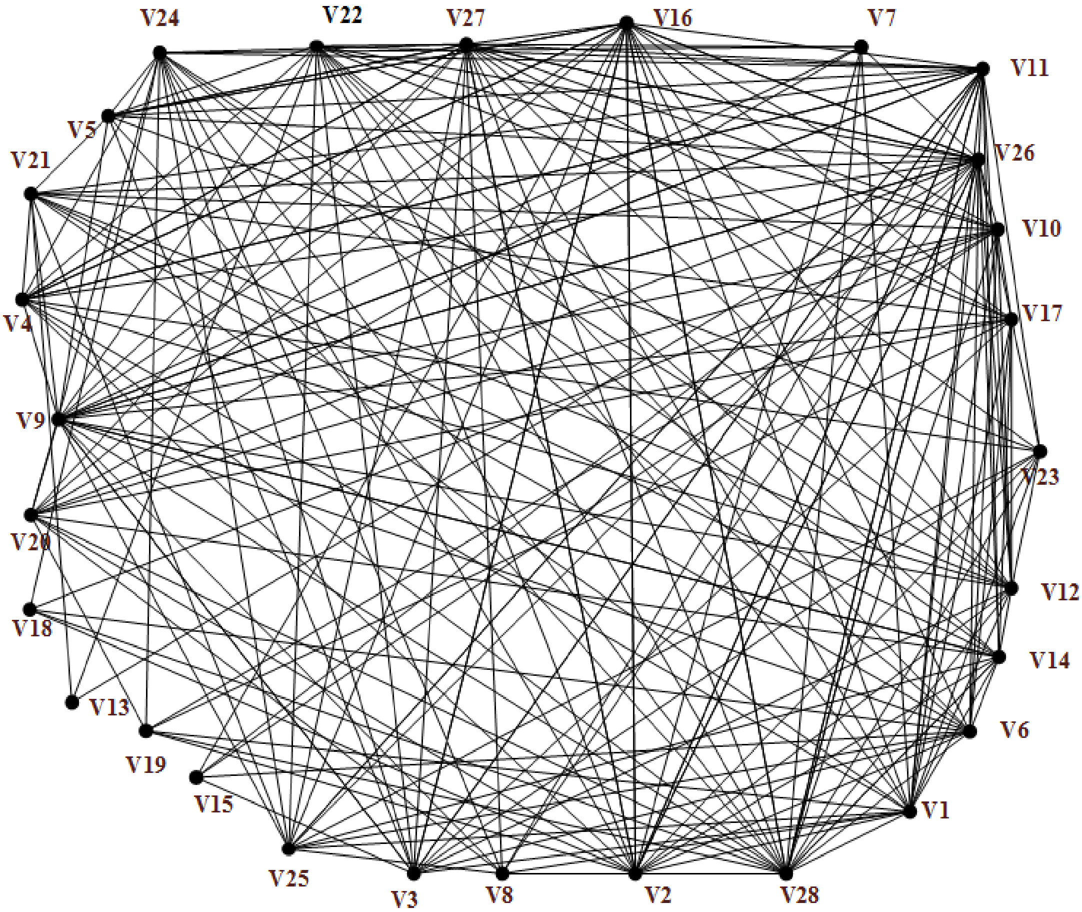
The simplicial complex $K_x(Y;\lambda)=\{\ \sigma^{(22)}_{16};\ \sigma^{(24)}_{15};\ \sigma^{(27)}_{15};\ \sigma^{(21)}_{13};\ \sigma^{(9)}_{12};\ \sigma^{(16)}_{12};\ \sigma^{(26)}_{11};\ \sigma^{(23)}_{10};\ \sigma^{(28)}_{10};\ \sigma^{(4)}_{8};\ \sigma^{(11)}_{8};\ \sigma^{(14)}_{8};\ \sigma^{(2)}_{7};\ \sigma^{(3)}_{7};\ \sigma^{(5)}_{7};\ \sigma^{(6)}_{7};\ \sigma^{(10)}_{7};\ \sigma^{(25)}_{7};\ \sigma^{(1)}_{6};\ \sigma^{(7)}_{6};\ \sigma^{(8)}_{6};\ \sigma^{(19)}_{5};\ \sigma^{(12)}_{4};\ \sigma^{(17)}_{4};\ \sigma^{(18)}_{4};\ \sigma^{(20)}_{4};\ \sigma^{(15)}_{3};\ \sigma^{(13)}_{0}\ \}$ contains 28 connected components. In the simplicial complex $K_x(Y;\lambda)$, simplex $\delta^{(22)}_6$ (regulations to ensure safety of tourists and holidaymakers at resorts) is meaningful. This simplex connects 17 vertices. In total, there are 222 communication chains in the complex $K_x(Y;\lambda)$.

A graphic representation of the complex $K_x(Y;\lambda)$ projection is shown on a plane in one of its projections in Figure 5.

The simplicial complex $K_y(X,\lambda^*)$ = { $\sigma^{(26)}_{19}$; $\sigma^{(1)}_{16}$; $\sigma^{(11)}_{16}$; $\sigma^{(12)}_{16}$; $\sigma^{(9)}_{15}$; $\sigma^{(17)}_{14}$; $\sigma^{(28)}_{14}$; $\sigma^{(2)}_{13}$; $\sigma^{(10)}_{13}$; $\sigma^{(16)}_{13}$; $\sigma^{(6)}_{12}$; $\sigma^{(25)}_{10}$; $\sigma^{(3)}_{9}$; $\sigma^{(20)}_{9}$; $\sigma^{(4)}_{8}$; $\sigma^{(14)}_{7}$; $\sigma^{(27)}_{6}$; $\sigma^{(5)}_{5}$; $\sigma^{(8)}_{5}$; $\sigma^{(7)}_{4}$; $\sigma^{(13)}_{1}$; $\sigma^{(19)}_{1}$; $\sigma^{(15)}_{0}$; $\sigma^{(18)}_{0}$; $\sigma^{(22)}_{0}$ } contains 25 connected components. In the simplicial complex $K_y(X;\lambda)$, simplex $\delta^{(26)}_{19}$ (advertising tourism opportunities in Russia) is meaningful. This simplex connects 20 vertices. In total, there are 226 chains of communication in the complex $K_y(X,\lambda^*)$ and, therefore, it is more meaningful than $K_y(X,\lambda^*)$.

Empty simplexes $\sigma^{(21)}_{-1}$; $\sigma^{(23)}_{-1}$; $\sigma^{(24)}_{-1}$ do not belong to the complex, which means that such vertices as health legislation, economic legislation and legislation to protect the rights of tourists as consumers play no part in the complex $K_y(X;\lambda)$.

Figure 5. *Graphic Representation of the Simplicial Complex $K_x(Y;\lambda)$ Projection*



At step 5, we obtain the following connectivity values for $K_x(Y;\lambda)$:

q=16	$Q_{16}=1$	$\{X_{22}\}$
q=15	$Q_{15}=3$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}$
q=14	$Q_{14}=3$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}$
q=13	$Q_{13}=4$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}$
q=12	$Q_{12}=6$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}$
q=11	$Q_{11}=7$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}$
q=10	$Q_{10}=9$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}$
q=9	$Q_9=9$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}$
q=8	$Q_8=12$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}$
q=7	$Q_7=18$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}\{X_2\}$ $\{X_3\}\{X_5\}\{X_6\}\{X_{10}\}\{X_{25}\}$
q=6	$Q_6=21$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}\{X_2\}$ $\{X_3\}\{X_5\}\{X_6\}\{X_{10}\}\{X_{25}\}\{X_1\}\{X_7\}\{X_8\}$
q=5	$Q_5=22$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}\{X_2\}$ $\{X_3\}\{X_5\}\{X_6\}\{X_{10}\}\{X_{25}\}\{X_1\}\{X_7\}\{X_8\}\{X_{19}\}$
q=4	$Q_4=26$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}\{X_2\}$

		$\{X_3\}\{X_5\}\{X_6\}\{X_{10}\}\{X_{25}\}\{X_1\}\{X_7\}\{X_8\}\{X_{19}\}\{X_{12}\}\{X_{17}\}\{X_{18}\}\{X_{20}$
q=3	$Q_3=27$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}\{X_2\}$ $\{X_3\}\{X_5\}\{X_6\}\{X_{10}\}\{X_{25}\}\{X_1\}\{X_7\}\{X_8\}\{X_{19}\}\{X_{12}\}\{X_{17}\}\{X_{18}\}\{X_{20}\}\{X_{15}\}$
q=2	$Q_2=27$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}\{X_2\}$ $\{X_3\}\{X_5\}\{X_6\}\{X_{10}\}\{X_{25}\}\{X_1\}\{X_7\}\{X_8\}\{X_{19}\}\{X_{12}\}\{X_{17}\}\{X_{18}\}\{X_{20}\}\{X_{15}\}$
q=1	$Q_1=27$	$\{X_{22}\}\{X_{24}\}\{X_{27}\}\{X_{21}\}\{X_9\}\{X_{16}\}\{X_{26}\}\{X_{23}\}\{X_{28}\}\{X_4\}\{X_{11}\}\{X_{14}\}\{X_2\}$ $\{X_3\}\{X_5\}\{X_6\}\{X_{10}\}\{X_{25}\}\{X_1\}\{X_7\}\{X_8\}\{X_{19}\}\{X_{12}\}\{X_{17}\}\{X_{18}\}\{X_{20}\}\{X_{15}\}$
q=0	$Q_0=1$	{all}

The structure vector of complex $K_x(Y;\lambda)$ is: $Q_x = \{1\ 3\ 3\ 4\ 6\ 7\ 9\ 9\ 12\ 18\ 21\ 22\ 26\ 27\ 27\ 27\ 1\}$. At step 6, we obtain the following connectivity values for $K_y(X,\lambda)$:

q=19	$Q_{19}=1$	$\{Y_{26}\}$
q=18	$Q_{18}=1$	$\{Y_{26}\}$
q=17	$Q_{17}=1$	$\{Y_{26}\}$
q=16	$Q_{16}=4$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}$
q=15	$Q_{15}=5$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}$
q=14	$Q_{14}=7$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28}\}$
q=13	$Q_{13}=9$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}$
q=12	$Q_{12}=10$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}$
q=11	$Q_{11}=10$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}$
q=10	$Q_{10}=11$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}$
q=9	$Q_9=13$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$
q=8	$Q_8=14$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}$
q=7	$Q_7=15$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}\{Y_{14}\}$
q=6	$Q_6=16$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}\{Y_{14}\}\{Y_{27}\}$
q=5	$Q_5=18$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}\{Y_{14}\}\{Y_{27}\}\{Y_5\}\{Y_8\}$
q=4	$Q_4=18$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}\{Y_{14}\}\{Y_{27}\}\{Y_5\}\{Y_8;Y_7\}$
q=3	$Q_3=18$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}\{Y_{14}\}\{Y_{27}\}\{Y_5\}\{Y_8;Y_7\}$
q=2	$Q_2=18$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}\{Y_{14}\}\{Y_{27}\}\{Y_5\}\{Y_8;Y_7\}$
q=1	$Q_1=20$	$\{Y_{26}\}\{Y_1\}\{Y_{11}\}\{Y_{12}\}\{Y_9\}\{Y_{17}\}\{Y_{28};Y_2\}\{Y_{10}\}\{Y_{16}\}\{Y_6\}\{Y_{25}\}\{Y_3\}\{Y_{20}\}$ $\{Y_4\}\{Y_{14}\}\{Y_{27}\}\{Y_5\}\{Y_8;Y_7\}\{Y_{13}\}\{Y_{19}\}$
q=0	$Q_0=1$	{all}

The structure vector of complex $K_y(X,\lambda)$ is: $Q_x = \{1\ 1\ 1\ 4\ 5\ 7\ 9\ 10\ 10\ 11\ 13\ 14\ 15\ 16\ 18\ 18\ 18\ 18\ 20\ 1\}$.

5. Discussion

Thus, the study of $K_x(Y;\lambda)$ has shown that with respect to vertices V or X of the system "inputs" (control factors), the complex is connected only for small values of q, whereas for large and intermediate values it falls into 27 unconnected components. For example, at the level q=7, 18 simplexes are distinguished, each of them influencing the system components, but there is an obstruction for effective interaction among them. Therefore, one may talk of a geometric obstruction to a free flow of information aimed at changing a particular situation at each level of dimension. $K_x(Y;\lambda)$ is connected for q=16 and q=0 and unconnected for q=15…1. Thus, vertex V_{22} (regulations to ensure safety of tourists and holidaymakers in resorts) can be chosen as a control one for the entire system.

Similarly, one can draw a conclusion about the structure vector of the complex $K_y(X,\lambda)$. The complex consists of 20 unconnected components. The most important components for the system under study are Y_{26} (advertising tourism opportunities in Russia), Y_1 (transportation of tourist flows), Y_{11} (cooperation with environmental institutions) and Y_{12} (recreational nature management). In addition, one can see that there are connected components $\{Y_{28}; Y_2\}$ and $\{Y_8; Y_7\}$ at the levels q=13 and q=4. This means that once control action is applied to Y_{28}, Y_2 will respond. It is similar for Y_8; Y_7 will respond.

Since the complex falls into unconnected components, which makes it difficult to transfer control actions, it is necessary to introduce additional vertices that would serve as a link between these components.

6. Conclusion

Currently, the main problem in the concept of sustainable tourism development is the lack of tools for implementing sustainability principles in practice. The existing tools do not allow for sustainable tourism development nationwide; the use of many tools is fraught with a lot of problems and pitfalls; therefore, only competent, elaborately planned governance can yield favorable results.

The paper has considered implementation of the idea to improve tools for government regulation of tourist activity based on the method of analysis of simplicial complexes. An analysis has been made of the q-connectivity of the interaction structure between tools for government regulation of tourist activity, including definition of the dimension of complex simplexes, matrix transformation, construction of simplicial complexes, and calculation of structure vectors. It has been identified that key tools for government regulation of tourist activity are regulations to ensure safety of tourists and holidaymakers in resorts, advertising tourism opportunities, transportation of tourist flows, cooperation with environmental institutions, and recreational nature management.

Since the analysis of connectivity of the structure under study has shown that the system is unconnected, there are obstructions to effective interaction of its components and, therefore, decomposition is possible, the authors recommend the following as additional tools for government regulation of tourist activity, some of which are based on the principles of sustainable development:

1. Cooperation with stakeholders (based on the principle of sustainable development, whereby the target community members pursue common objectives);
2. Holding activities to encourage local populations to participate more actively in tourism development planning;
3. Arrangement of conditions to ensure prompt implementation of tourism development projects;
4. Regulation of certification and appraisal of management and personnel at all levels and areas of tourism;
5. Reinforced government support and regulation of tourist activity through international system of service certification.

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