TRANSPORT AND TELECOMMUNICATION INSTITUTE

Andrejs ROMANOVS

APPLICATION OF MULTI-CRITERIA ANALYSIS METHODS TO THE TOURIST INFORMATION SYSTEM DEVELOPMENT

SUMMARY OF THE PROMOTION WORK

to obtain the scientific degree
Doctor of Science in Engineering (Dr.sc.ing)

Scientific area "Transport and Communication"
Scientific subarea "Telematics and Logistics"

The Promotion Work has been Performed
at Riga Technical University

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RIGA – 2006

338.48:004
R 75

Transport and telecommunication institute

Romanovs A.
R 75 Application of Multi-Criteria Analysis Methods to the Tourist Information System Development. Summary of the Promotion Work. – Riga: Transport and telecommunication institute, 2006. – 43 pp.

ISBN 9984-9865-5-1

THE PROMOTION WORK PRESENTED TO THE TRANSPORT AND TELECOMMUNICATION INSTITUTE TO OBTAIN THE SCIENTIFIC DEGREE DOCTOR OF SCIENCE IN ENGINEERING (Dr.sc.ing.)

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The defense of the thesis will be delivered in 19 December 2006 at 16:00 o'clock at the special Promotion Council of Transport and Telecommunication Institute on award of a doctor's degree to the address: 1, Lomonosova street, room 4-II, Riga, Latvia, phone (371) 7100661, fax (371) 7100660.

CONFIRMATION

I confirm that I developed the promotion work that is presented to the Transport and Telecommunication Institute to obtain the scientific degree Doctor of Science in Engineering. The promotion work has not been presented to any other university or institute t obtain the scientific degree.

September 1, 2006 Andrejs Romanovs

The promotion work is written in Latvian, contains 6 chapters, 53 figures, 30 formulas and 25 tables, 145 pages in total. Bibliography contains 124 sources.

SUMMARY OF THE DISSERTATION

Relevance of the Research

Worldwide tourism and traveler transportation industry is one of the largest consumers of the information and communication technologies. The value of information technology for consumers lies in its ability to create new additional possibilities, to offer clients a wider choice of services according to the new tendencies of demand and to extend functional capabilities of information systems thereby increasing the competitiveness of tourist organizations.

Recently there has been a growing demand on the tourism market for creating the so-called flexible individual travels (FIT), when a tourist, thanks to the accumulated travel experience and computer knowledge, combines different elements of the travel him- or herself. The need to satisfy this demand has become an important problem for tourism development. Its relevance has been proven by research on the provision of consulting services to tourists done by H. Hruschka, J. Mazanec, A. Bodi, J. Zeleznikow, P. Bose, A. Padala.

In spite of the fact that the need for a system to choose flexible individual travels has been widely acknowledged in scientific research, a system, which could possibly be used in practice for making a choice decision in tourism, has not yet been created. The choice of a flexible individual, which is related to the demand for varied products, which itself is a subject to the influence of different factors, is a complicated decision making problem. Besides it is necessary to take into account the interdisciplinary nature of the task since the solution depends on a variety of considerations, which are related to the choice of adequate mathematical methods as well as information support for the process of choice.

The drawbacks of theoretical and methodical works devoted to the creation of information systems with a mechanism to choose flexible individual travels and the lack of a successful implementation of such a system as well as the significance of such a system in the conditions of competitive struggle has determined the choice of the topic for the promotion work as well as its relevance.

In this promotion work the analysis of different aspects of tourism business information systems has been done using both the works by foreign scholars: G. Archdale, D. Buhalis, H. Mowlana, W. Schertler, P. Sheldon, R. McLeod, Ch. Parker, M. Hammer, J. Champy,

V. Glushkov, E. Hotyashov, N. Plotnikova, A. Gvozdenko, G. Papirjan, and Latvian scholars as well: E. Vanags, Z. Ilmete, E. Vilums, L. Novicky, J. Merkuryev, N. Krumins. The author also uses the works by V. Praude and J. Belchikov on marketing, O. Larichev, B. Roy, H. Raifa, T. Saaty, A. Borisov and L. Frolova on mathematical modelling and the research by D. Bollinger on the practical application of multi-criteria methods in solving economic problems.

The Goal and Tasks of the Research

The goal of the promotion work is the development of the theoretical foundation and methodical support for the creation of tourist information system with the mechanism of choosing a flexible individual travel, based on the application of multi-criteria analysis methods.

In accordance with the goal specified above, the following tasks are solved in this promotion work:

- determining the role of information technology and information systems in increasing competitiveness of tourism business;
- establishing the need for solving the problem of choosing a flexible individual travel, analysis of the existing development and research on the possibility of applying multi-criteria analysis methods;
- developing the model for the problem of multi-criteria choice of the travel, solving the practical problem and sensitivity analysis of the solution;
- researching theoretical and methodological aspects of the development of modern information systems and their improvement;
- creating the technique of designing information support for the problem of the travel choice – regional tourist information system;
- researching the changes in the role of tourism specialists in the conditions of flexible individual travel choice.

The Objects of the Research

The objects of the research are the tourist information system and the choice of a flexible individual travel.

The Methods of the Research

This promotion work is founded on scientific research based on the analysis of general and specialized literature, laws and regulations of the Republic of Latvia, data of the Central Statistical Bureau, statistical data by the World Tourism Organization (WTO) and World Travel and Tourism Council.

In the promotion work the author uses general economic methods and methods of mathematical statistics – grouping, comparison, analogies, mathematical modelling methods, multi-criteria analysis methods, and methods of designing information systems of logistics, life cycle methodology, client-oriented technologies and Expert Choice package.

Scientific Innovation

In the promotion work the author offers a technique for the development of tourist information system, which differs from the already known ones in using the methods of multi-criteria analysis for the choice of a flexible individual travel. This allows solving a very relevant problem, related to the new tendency in modern tourism – the transition from the strictly packaged travel to the flexible individual travel, which, in turn, allows extending the functionality of the tourist information systems and improves the competitiveness of the tourism companies.

During the research the following scientific results were obtained:

1. Rationale for the application of multi-criteria analysis methods for the choice of an individual travel has been provided; the requirements to the choice process have been determined.
2. The model for the choice of the travel has been created and the use of the method of analytical hierarchy process for solving the problem has been rationalized. The technique for sensitivity analysis of the solution has been developed.
3. The technique for designing information support for the problem of choosing an individual travel – regional tourist information system has been developed.
4. Decomposition of information systems, which is based on the factors of implementation of information technology, has been rationalized. Classification of factors and development tasks has been designed.

5. A modular structure for the formation of a flexible individual travel has been offered, recommendations for tourism specialists in the new conditions of travel choice have been developed.

Theoretical Value

This promotion work offers a new approach to the creation of a tourist product using the mechanism of travel choice, which is founded on the methods of multi-criteria analysis and modular structure of travel package creation, which ensures the creation of a flexible individual travel.

Based on the implementation factors of information technologies, the author rationalizes the application of a new principle of decomposition of information systems with the aim to integrate information, communication and behavioural aspects in a single process, which is relevant for the public access information systems that are currently in development.

Practical Value

This promotion work develops the technique for designing tourist information systems, which use the methods of multi-criteria analysis for making decisions of choice of an individual travel, and the author gives recommendations for practical development of regional tourist information system in his work, which extends the functionality of a tourist information system according to the new tendencies of market demand.

The use of the developed classification of information technology's implementation factors and their corresponding aspects allows increasing the quality of design and the effectiveness of utilization of information systems, by taking into account the human factor throughout the life cycle of the system.

The offered technique for sensitivity analysis of the solution to the problem of travel choice using the package «Expert Choice» allows finding a solution, which is not sensitive, which makes arriving to the final decision easier.

The use of developed recommendations for the creation of flexible individual travel packages, which is done by the tourist itself, allows determining the functions of tourist specialists under the new work circumstances.

This work can also be used for the design of information systems as well as during the training of the specialists in using information technologies in tourism business.

Approbation of the Results of the Research

The results of the research have been reported and positively appreciated at the following international and regional scientific conferences:
the conference of the University of Latvia and JSC DATI "Informācijas tehnoloģija: zinības un prakse" (Riga, 1996), scientific conferences of the University of Latvia (Riga, 1999, 2000, 2001), conference of the University of Rostock "Tourismus und Verkehr" (Rostock, 1999), conference of the Warsaw Higher School of Economics "Perspektywy współpracy Polska – kraje bałtyckie w kontekście europejskich procesów integracyjnych" (Warsaw, 1999), international scientific conference 6th Nordic-Baltic Conference in Regional Science "Nordic-Baltic Sea Region on the Eve of the 21st Century" (Riga, 2000), international scientific conference "Tradicionālais un novatoriskais sabiedrības ilgtspējīgā attīstībā. Vide un sabiedrība. Informācijas tehnoloģijas." (Rezekne, University of Rezekne, 2002), international scientific conference "Uzņēmējdarbība un tās tiesiskā vide: procesi, tendences, rezultāti." (Riga, "Turība" School of Business Administration, 2002), international conferences in Riga Technical University (Riga, 2002, 2003, 2004).

Separate research results that are related to the application of new information technologies and designing information systems have been used to conduct applied work within the course «Automation of Accounting» for the Faculty of Economics and Management of the University of Latvia, for lecture courses «Design of Logistic Information Systems» and «Design of Managerial Information Systems», as well as for the supervision of laboratory and qualification theses of the students of the Faculty of Information Technology of Riga Technical University.

The author has used methodical principles and theses presented in the promotion work to design information systems for different purposes including systems to the Ministry of Finance, Ministry of Welfare and State revenue service as well as information systems for business management (author was awarded a copyright for one of the products), including tourist information system CRS PROVIT.

Publications

The author has summarized the basic results of the research in 12 scientific publications.

Personal Input

All of the results of the research contained in the promotion work have been obtained by the author during his independent research.

Basis Theses for Defense

1. The model of choice of an individual travel, which is based on applying the methods of multi-criteria analysis, provides tourists and tourism specialists with the mechanism for choosing individual travels.
2. The method of analytical hierarchy process is the most appropriate one for the problem of choosing an individual travel. The technique of sensitivity analysis allows finding a solution, which is not sensitive.
3. The technique of designing regional tourist information system using the methods of multi-criteria analysis serves as a foundation to create information support for the problem of multi-criteria choice.
4. The offered classification of information technology's implementation factors and their corresponding aspects improves the quality of designed tourist information systems.
5. The model of modular structure of creating a travel package with multi-criteria choice ensures the creation of flexible individual travel package and extends the functions of tourism specialists.

The Structure and Size of the Promotion Work

The promotion work consists of six chapters, bibliography and appendices. The structure of the work and logical relationships between the chapters are shown on the Diagram 1. The main body of the promotion work consists of 145 pages and contains 53 schemes, 30 formulas and 25 tables. The bibliography includes 124 items.

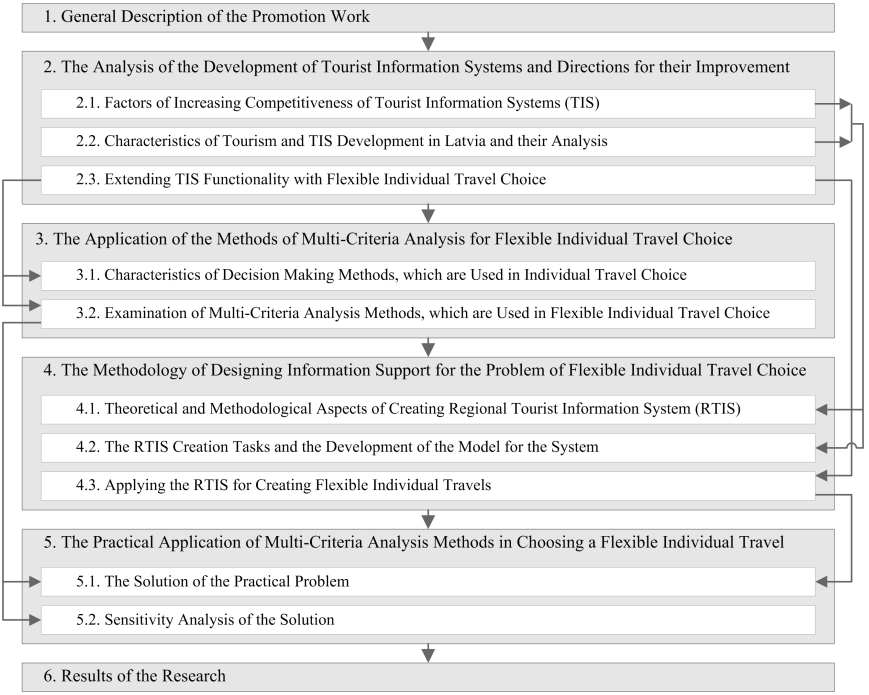


Diagram 1. The Logical Structure of the Promotion Work

BRIEF SUMMARY OF THE PROMOTION WORK

In the **first chapter** «General Description of the Promotion Work», the author provides a justification for the relevance of the chosen topic, formulates the goal and tasks of the promotion work as well as subjects and methods of the research, the author describes the scientific novelty, the theoretical and practical value of the work and lists the basic theses of the promotion work that are put up for the defense.

In the **second chapter «**The Analysis of the Development of Tourist Information Systems and Directions for their Improvement» the author rationalizes two important directions for the improvement of modern tourism business: using the achievements of information technology to increase the competitiveness of tourism business and extending the functionality of the tourist information systems in accordance with the new tendencies of demand for travel. Currently the

tendency of choosing flexible individual travels is relevant; its realization gives tourists and specialists in tourism wider possibilities for satisfying individual demand.

Tourism and traveller transportation industry has by now become one of the most rapidly developing industries in the world. Its boom, to a large extent, is ensured by the application of information and communication technologies. Information and communication technologies at this stage of the development of tourism should be viewed as a strategic resource for increasing competitiveness in the tourism business. Information technologies change the operational conditions of tourism organizations. In this promotion work the directions of these changes are summarized in six groups.

In this chapter the possibilities of modern information technologies are explored, which, together with the use of modern management theories, for instance, the reengineering of business processes, ensure increased effectiveness of business operations. The use of the basic tenets of the reengineering of business processes, that is introducing client-oriented technologies aiming to satisfy individual demands of every client, is one of the significant directions of improving competitiveness of the tourism business.

As a result of the research a pyramid of creating competitiveness has been developed (see Diagram 2), which shows the role of information technology in creating competitiveness of the organization.

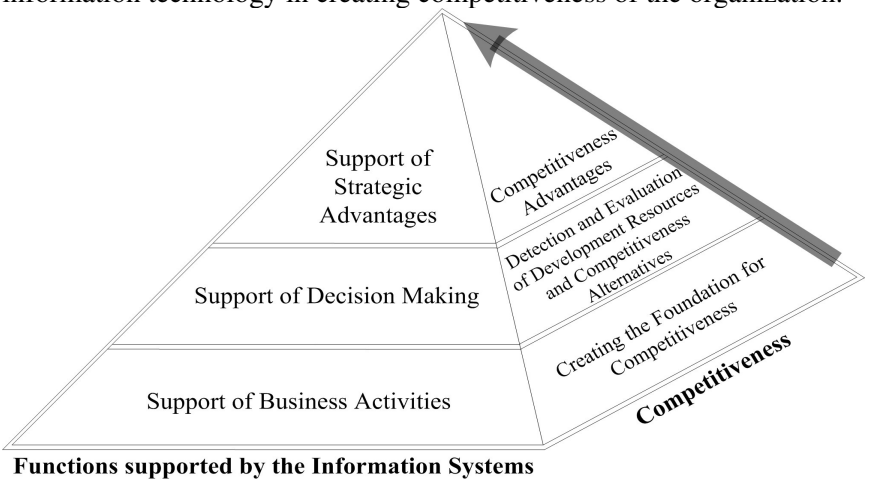


Diagram 2. Pyramid of Creating Competitiveness

Information systems for operations, ensuring automated processing of information, which has become traditional and simultaneously the standard of competitiveness, create the foundation of the pyramid on the lower level. The middle level is created by information systems, which provide support for making managerial decisions, which, in their turn, help to clarify and evaluate resources for development and evaluate alternatives of competitive possibilities. On the highest level information systems support strategic decisions, which are directed at creating competitive advantage, under the circumstances of a large number of alternatives and high risk.

In the promotion work, the author defines strategic and tactical objectives of information technologies in the tourism business. The strategic objective of information technologies is to increase the responsiveness of the management of organization to market dynamics, to create, sustain and increase competitive advantage. Tactical objectives are oriented towards increase in productivity, cutting down spending, more informed and effective decision making processes.

Latvia's accession into the European Union creates favourable circumstances for further development of the tourism business in the country. Latvia's entrance into the European Union was followed by a large interest from foreign tourists and provided the stimulus for further development of the tourism industry. For the first time during the last 15 years, more than 3.5 million tourists have been visiting Latvia (in 2005 due to statistical data). In recent years there has been observed a slowdown in the growth rate of the exports of tourism services throughout the world, including Europe, however in Latvia during the last two years a stable growth is ongoing – more than 7%. Still, in spite of the achievements of the recent years, data on the balance of payments of the country indicates that the proportion of exports of tourism services in the gross domestic product is significantly lower than in the countries of the European Union and the rest of the world. Among the main factors that are slowing down the development of local tourism the experts consider the lack of budget financing and support from the state and local governments, as well as the lack of information and advertising for tourists.

The existing tourist information systems do not ensure sufficient support for the consumers of tourism products. Critical analysis of the local tourist information systems, with the objective of using those as information support for making an individual tour choice decision,

highlights the drawbacks of the existing systems: different quality of system development, information is placed chaotically in many systems and information in foreign languages is insufficient. The main drawback is the lack of technique of system development that is unified in content and presentation of information, which makes accessing and using information more difficult. Research by the author allowed justifying the need for the development of technique for creating regional tourist information system, which would include a mechanism for making a choice of an individual travel and creating a package of flexible individual travels.

To solve the problem of choosing an individual travel a series of authors have already done research related to the provision of consulting services to tourists, where the basis of choice is taken to be a model founded on the rule of sequential selection. The available experience of creating consulting systems proves that for the solution of the problem one needs to consider together the mathematical, psychological and computerization questions as a single whole.

In the promotion work the author formulates the problem of choice of an individual travel, defines the requirements to the process of choosing an individual travel and offers a solution to the problem.

Formally, the problem of the choice of individual travel can be expressed as following:

$$C = < T , N , O , P >, \text{ where}$$

T — types of transportation,
N — accommodation,
O — tourism objects,
P — tourism events.

The choice of individual travel is a complicated process of finding a solution, due to the natural instability of a tourism product and a large number of alternatives. The author presents the requirements to the process of choice of an individual travel in the promotion work; these requirements the author separates into two groups (see Diagram 3):

- Requirements, which are related to the mathematical methods of choosing an individual travel;
- Requirements, which are related to the information support for the choice process.

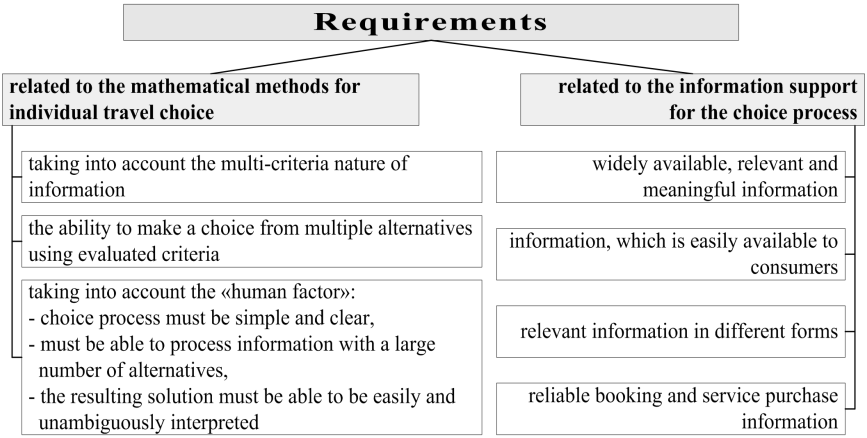


Diagram 3. Requirements to the Process of Individual Travel' Choosing

In the **third part** «The Application of the Methods of Multi-Criteria Analysis for Flexible Individual Travel Choice» the methods of multi-criteria analysis, which are applicable for solving this problem, are investigated. The correspondence of the chosen method to the specifics of the problem is the main requirement to the choice of the solution methods.

The choice problem of an individual travel is characterized by:

- type of the system — the problem of individual decision making;
- conditions of choice — under certainty;
- number of evaluation criteria — multi-criteria;
- a set of alternatives — discrete;
- type of the criterion scale — ratio scale;
- type of the information required — quantitative.

When choosing the methods used, one has to take into account the size and complexity of information, which is required from the decision maker – an important factor for the choice of the method. The problem of choosing an individual travel is usually solved by the tourist or tourism specialists, who as a rule are not professional mathematicians. Therefore, it is important to find out whether the decision maker will be willing and able to use subjective criteria with qualitative or quantitative measurement scales. It is also necessary to take into account the time limitations for the decision maker.

A variety of methods of multi-criteria analysis, which in scientific literature are separated by different classification criteria, is offered for solving the problem of decision making. A unique classification, which corresponds to the requirements of the conducted research, is considered in the given work. The analysis of the existing classifications allows coming forward with a classification of methods of multi-criteria decision making, which, in their turn, allows taking into account the particular details of the problem of choosing an individual travel (see Diagram 4).

Two classification criteria are chosen as the main ones: the type of information required from the decision maker and the features of information. One can distinguish three groups by the type of information criteria: information is not required, information on criteria, information on alternatives. By features of information, one can separate four groups: standard, ordinal, quantitative and marginal rate of substitution.

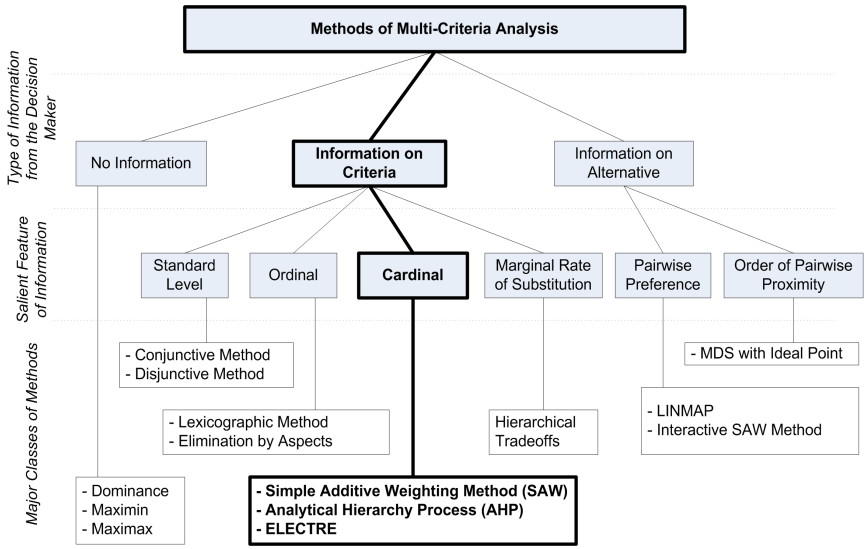


Diagram 4. Classification of Methods of Multi-criteria Analysis

Particular features of the problem of travel choice point to the need to apply methods from the quantitative method group: simple additive weighting method (SAW), analytic hierarchy process method (AHP) and ELECTRE methods.

The named methods allow taking into account the multi-criteria nature of information and making a choice out of many alternatives using the criteria for which an evaluation scale exists. Research on these methods and their comparative analysis are accomplished in the promotion work. The author determined positive features that characterize the methods and methodological differences that involve the process of creating priorities and evaluating criteria by the decision maker (see Table 1).

Table 1

Features of the Methods of Multi-criteria Analysis

Features	AHP	ELECTRE I	SAW
General Positive Features:			
⇒ certainty conditions, ⇒ take into account multi-criteria circumstances, ⇒ criteria with the evaluation scale, ⇒ support the problems of individual decision making, ⇒ the possibility to modify the original problem or the representation of the decision maker			
Methodological Differences:			
⇒ decomposition of the problem	hierarchical structure	none	none
⇒ creating priorities for the decision maker	during the analysis of the problem	before the application of the method	before the application of the method
⇒ criteria evaluation	contains an evaluation mechanism	requires evaluated criteria	requires evaluated criteria
User Interaction with the Solution:			
⇒ difficulties in processing expert information	none	exist	exist
⇒ correspondence to the intuitive understanding	yes	no	yes

The basic methodological differences are as follows:

- creation of preferences for the decision maker occurs during analyzing the problem (ELECTRE I and simple additive

weighting method) or before the application of the method (AHP);

- the method contains the mechanism for the evaluation of criteria (AHP) or the method requires the use of the previously evaluated criteria (ELECTRE I and simple additive weighting method).

There are differences both in the role of the user throughout the process of locating solutions to the problem as well as in the correspondence of the method to the intuitive understanding of the user. ELECTRE I method requires the aid of a qualified expert during the analysis of the problem, determination of the priorities and throughout the application of the method. The AHP method is distinguished by its simplicity; it is clearer to the user and gives a good correspondence to its intuitive representation.

A model of choice of the flexible individual travel is offered in the promotion work (see Diagram 5).

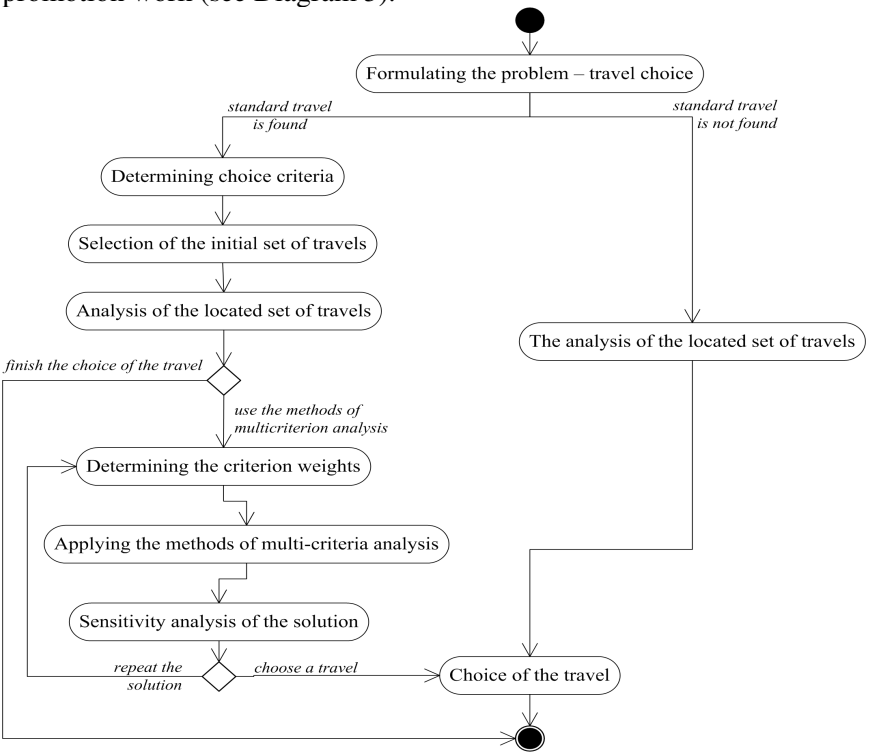


Diagram 5. The Model of Choosing Flexible Individual Travel

There are three stages in the process of the travel choice:

1. Formulating requirements to the travel and the search for the corresponding standard travel.
2. If the standard travel has not been found, then choice criteria are determined and the initial list of travels is formed.
3. If the initial list of travels is large, then the best travel is chosen from the list by applying the method of multi-criteria analysis.

In **chapter four** «The Technique of Designing Information Support for the Problem of Flexible Individual Travel Choice» the author researches theoretical and methodological aspects of designing information support for the problem of travel choice – regional tourist information system (RTIS).

As a result of the research, the methodical principles of designing information systems have been augmented with the principle related to the increasing significance of the «human» factor in current market conditions. For this purpose the author suggests using the new approach to system decomposition in designing information systems, which is based on information technology's implementation factors. Two main factors are distinguished – humanitarian and non-humanitarian, the significance of these factors and their place in the process of creating and using information systems is rationalized.

The author classifies the aspects of information technology implementation factors. For the humanitarian factor, subjective, motivational and organizational aspects are distinguished and for the non-humanitarian factor information, technical and business aspects are distinguished. The author develops design tasks for each aspect (see Table 2) as well as their implementation during the entirety of the system's life cycle (see Table 3)

Table 2

Design Tasks for Separate Aspects of the Humanitarian and Non-humanitarian Factors

Aspects	Content of Design Tasks
Subjective aspect	1. Determining computer literacy of the users (*S*1). 2. Determining the necessary level of competence for the users and choosing or designing a study program (*S*2). 3. Educating the users (*S*3).

Table 2 (continued)

Aspects	Content of Design Tasks
Motivational aspect	1. Determining the personal interest of the user in using the means of information technologies (*M*1). 2. Developing measures to neutralize opposition (*M*2).
Organizational aspect	1. Organization of the cooperation procedures between separate users, their groups and structural divisions (*O*1). 2. Organization of cooperation procedures between automated and non-automated workplaces (*O*2).
Information aspect	1. Choosing the strategy of designing information aspects (*I*1). 2. Developing information models with different level of detail of management system (*I*2). 3. Determining the content and structure of the database (*I*3).
Technical aspect	1. Determining the necessary configuration of technical support (*T*1). 2. Determining the necessary configuration of system software (*T*2).
Business aspect	1. Determining the type of the automated information process (*L*1). 2. Determining the functional models of management systems with different level of detail on different stages of design (*L*2). 3. Developing the concept of user interface (*L*3). 4. Determining or developing professionally oriented, functional, commercial software (*L*4).

Decomposition of the system, based on the factors of implementation of information systems, allows viewing the information, technical, organizational, subject, motivational and business aspects of the implementation of information technologies in an integrated and related fashion, which increases the effectiveness of design and utilization of information systems.

Table 3

The Implementation of Separate Aspects of the Humanitarian and Non-humanitarian Factors in the Life Cycle of the Information System

Planning	Analysis	Design	Implementation	Usage
Researching the problem and the need for an automated solution	Determining information needs and developing system configuration	Developing a detailed project	Determining and preparing resources. Acquisition and installation of software. Educating the personnel.	Utilization of the system
*S*1	*I*1	*O*1	*S*2	*O*1
*M*1	*I*2	*O*2	*S*3	*M*1
	*L*1	*I*3	*L*4	*M*2
	*L*2	*L*4	*O*2	
	*L*3	*T*1	*M*1	
	*O*1	*T*2	*M*2	
	*O*2			

Currently a large variety of design methods for information systems has been developed. In this promotion work the author uses the existing classifications of design methods and, in addition to the classifications based on separate features, the author also generalizes classification methods, distinguished by the complex approach to the choice of classification features (see Table 4). The use of complex classification of design methods makes the choice of design methods easier and allows making more justified choice decisions.

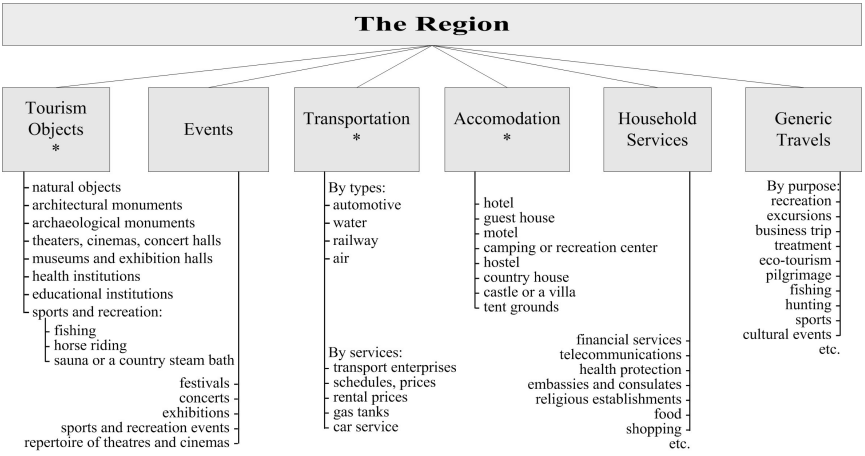
Based on the results of the research of the theoretical and methodical aspects of information system design and the principles offered by the author, a technique for creating regional tourist information system (RTIS) is developed together with the practical suggestions for the implementation of the system. The author suggests viewing the RTIS as a tourist reference information system containing actual and detailed information about tourist offerings and services in the region, which, in an interactive fashion, presents the maximum of useful information to the professionals of tourism market and tourists with the possibility of choosing an individual travel. The author develops in the

promotion work the main tasks for the regional tourist information system, a model for system architecture, the structure and contents of the database (see Diagram 6).

Table 4

Classification of Design Methods

Classification criterion / Design technology class	By the level of application of automation tools	By the level of use of generic design solutions	By the level of the decomposition of system	By the adaptability of design solutions	By the applied tools of design	By the applied design methodologies
Canonical design	Manual design	Original design	Element method	Reconstruction	Supports separate design operations and procedures for processing processes	Procedurally-oriented original design
Industrial design	Partially automated (generic) design	Generic (assembly) design	Element method Subsystem method Object method	Parametrization of the model and restructuring (EIS configuration)	Supports separate project components, related sets of components (project parts, projects). Uses parametric and model-oriented technologies	Functionally-(structurally-) oriented design. Typical is a modular approach with generic elements; use of generic projects, packages of applied programs, generic design solutions
	Automated design	Original design	Object method	Restructuring of the model (EIS generation)	Supports project design by CASE methods. Uses functionally and object-oriented technologies (CASE and RAD)	Object-oriented design. Repeated use of design components is typical



** - Contains Expert Evaluations*

Diagram 6. Information Content of the Regional Tourist Information System

Regional cooperation, directed to the joint development and utilization of an integrated information system, is intended to support measures on the introduction and sales of tourist products. The scheme or regional cooperation is developed taking into account the fact that promoting tourist products to consumers requires sizeable financial resources, which are frequently too large for the regions, where tourism just begins to develop.

The proposed RTIS is developed using modern methodologies and technologies of system creation. The author works out a scheme for the implementation of the regional tourist information system, which is based on the life cycle methodology and encompasses the entirety of the life cycle of tourist information system, starting from the planning phase and onwards to the usage phase.

The system implements humanitarian factors of information system design offered by the author, such as involving information suppliers and professional users of the RTIS in its development, starting from the creation of regional tourism association, when the idea of creating the association and information centre is discussed, and throughout the whole cycle of system design. Such an approach that takes into account the «human factor» allows creating qualitative and user-friendly system.

The RTIS is based on the client-oriented technology, which allowed implementing modern requirements to the system. Thus, satisfying the demands of the users for the relevant and detailed information about tourist products and services as well as for the simple access to the necessary information, providing the option of choosing an individual travel and creating a flexible individual travel were taken as a basis for developing the information and functional models of the system.

RTIS is based on the fundamental methodical assumptions of logistics: system approach, open system, the principle of continuous development, the principle of information integration as well as on the principles of centralization and decentralization.

The system is developed on the basis of system approach, taking into account a variety of relationships that exist in tourism between service suppliers and their consumers. On the organizational level, cooperation is envisaged between suppliers of tourist services, their consumers and the regional information centre. The RTIS is designed as an open system, whose implementation is based on taking into account

the principle of continuous development of the system. The core of the system is composed on the tourist information system basis, which can be complemented by reservation systems, electronic clearing systems and other functional modules.

In designing the RTIS the principles of centralization and decentralization are used. Creation and use of tourist information is done in a decentralized fashion: information is presented by the participants of the tourist association; it is also used by the participants themselves as well as the tourists from all over the world. The aggregation and storage of information, on the other hand, is done in a centralized fashion in a single database of the information center. Thus, the principle of information integration is implemented. The RTIS architectural model is composed of four logical blocks, the database, the application server, the Web server and the user interface (see Diagram 7).

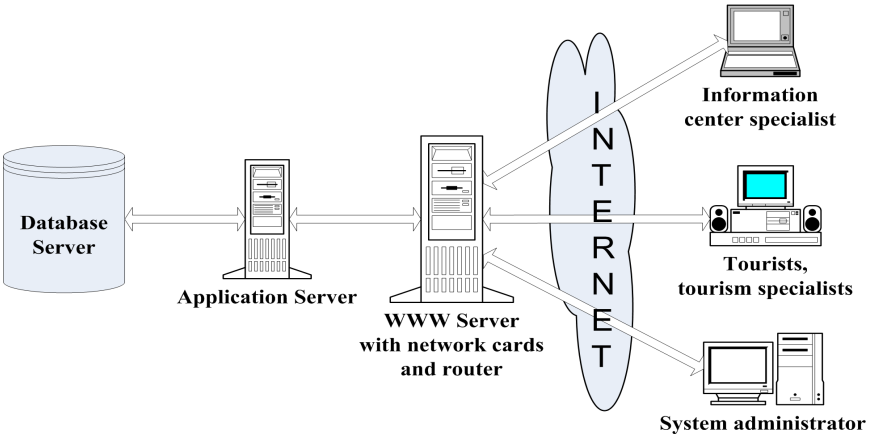


Diagram 7. The Architectural Model of the Regional Tourist Information System

The designed model allows the implementation of the requirements to the system and gives the tourist the detailed and relevant information on the topic of interest, allowing small tourist firms to promote their offering on the market in an inexpensive and effective manner, to augment their channels of information dissemination and finally to augment their traditional marketing systems with the additional, more complete information for the analysis. On the basis of

the developed model, one can create an open economic system for selling tourist services in an electronic form.

To create a flexible individual travel in practice, a modular structure of package creation is offered. The tourist can get some of the tourist services from the suppliers directly, another part – through the tourist information systems and a part – through the help of tourist agencies. Therefore, the tourist has a possibility to create a package for a flexible individual travel.

To respond to the question, which is currently actively debated, about the place and role of tourism specialists in the new conditions of product creation, when the tourist himself or herself individually combines different elements of the travel, the author develops recommendations for tourism specialists. The functions of the specialists in the new conditions are given in Table 5.

Table 5

The Functions of Tourism Agents and Tour Operators

Tourism Agencies	Tour Operators
⇒ will preserve control over market; ⇒ will fulfil the functions of the electronic agency; ⇒ will implement more qualitative customer service.	⇒ will preserve their main functions, thanks due to the better price offering, ensuring reservations and providing guarantees in conflict situations; ⇒ will extend the ways to fulfil marketing functions, in practice they will increasingly fulfil the functions of a marketing company.

In spite of the fact that the tourist will acquire different tourism services directly from their suppliers, tour operators and tourism agencies will remain as an important part of this concept. In these circumstances the role of the specialists (agents and operators) on the tourism market will change: tourist agencies will mainly fulfil the functions of electronic agencies, but tour operators will to a large extent be fulfilling the functions of marketing companies.

In the **fifth chapter** «The Practical Application of Multi-criteria Analysis Methods in Choosing a Flexible Individual Travel» the author formulates the practical problem of choice of an individual travel and its

solution using the following methods: AHP, ELECTRE I, SAW. The author also performs comparative analysis of the obtained solutions and analyses the sensitivity of the solution.

The problem of choice of an individual travel is formulated as follows. The tourist, while planning a vacation, presents the following requirements to the travel:

- place of the vacation —Vidzeme region,
- accommodation — a farm or a country house,
- types of activities – fishing, horse riding, sauna or country steam bath,
- quality of the service (for the accommodation and activities) — as good as possible,
- price of the services — as cheap as possible.

To solve the problem, already evaluated alternatives are required, in our case, evaluated accommodation and activity types. The author suggests using the standard qualitative evaluations commonly accepted in the tourism industry for the RTIS database — from one star (low quality) to four (high quality) stars.

Using the method of analytical hierarchy, with the participation of the experts a numerical value can be attached to every standard evaluation of alternatives by comparing them in pairs using a nine point scale of relationships. The resulting matrix is given in Table 6. Inverse values in the matrix are calculated automatically.

Table 6

Expert Evaluations

	****	***	**	*	Own Vector Evaluation	Normalized Evaluation of the Priority Vector
****	1,000	3,000	5,000	9,000	3,409	0,565
***	0,333	1,000	3,000	7,000	1,627	0,270
**	0,200	0,333	1,000	5,000	0,760	0,126
*	0,111	0,143	0,200	1,000	0,237	0,039

The user may set the relative significance of the criteria by using the classifier or the significance degree that is offered in the promotion work (see Table 7), which is based on a nine point of relationships scale

and contains in a compact fashion, the interpretation of every point of the relationship scale.

Table 7

Classifier of the Degree of Significance

Weight	Interpretation
1	same significance
2	very slight significance
3	some prevalent significance
4	almost significant advantage
5	significant advantage

Weight	Interpretation
6	almost material significance
7	material significance
8	strong significance
9	absolute significance

The database of the RTIS serves as a source of information. The initial list of travels that might be of interest is selected from the database (see Table 8).

Table 8

Initial List of Travels (a fragment)

Code	Title	Accom modation	Type of Activity			Price per day (Ls)
			Horse riding	Fishing	Sauna or bath	
*A*1	Zaķi	****	***	****	****	160,00
*A*2	Mūrnieki	**	****	****	***	90,00
*A*3	Denderi	***	***	***	***	140,00
*A*4	Upeskrasti	****	****	*	**	120,00
*A*5	Saulgozes	*	****	****	**	80,00
...	...	...	...	...	...	...

15 options are obtained as a result of selection. However, it is difficult to select the best option from such large lists. According to psychologists, it is in general difficult to make a choice, if the number of objects exceeds 7±2. Multi-criteria analysis methods are applied to choose the best travel out of a large list.

The choice of the best travel from the above mentioned list has been done by applying three methods of multi-criteria analysis: analytical hierarchy process (AHP), ELECTRE I method and simple additive weighting method (SAW).

The algorithm for solving the problem using the method of analytical hierarchy is presented on the Diagram 8.

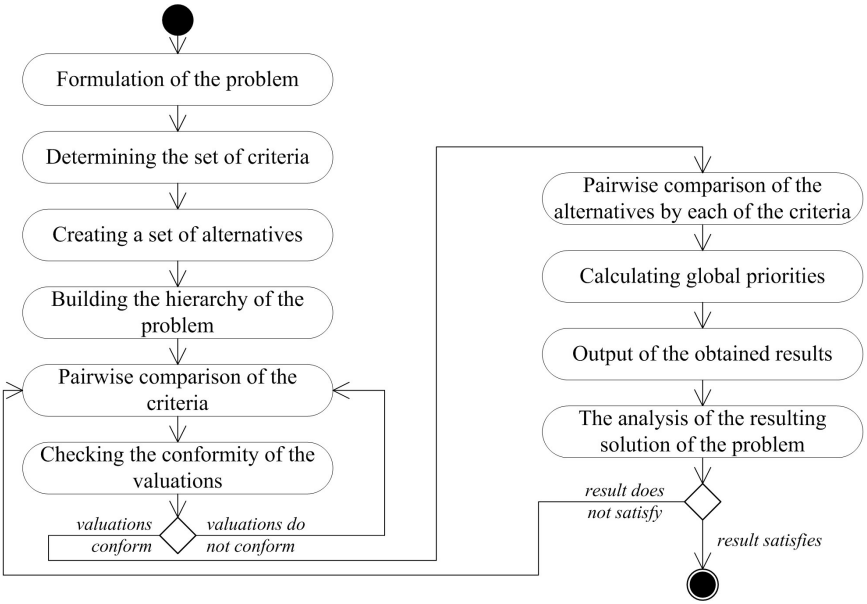


Diagram 8. The Solution Algorithm Using the AHP Method

In order to apply the AHP method, the problem is decomposed and represented in a hierarchical form (see Diagram 9). The choice of the region has been made on the level of primary selection and a three level hierarchy with three first level criteria, three second level criteria and 15 alternatives that correspond to the requirements of the problem.

When solving the problem, the user can see on screen the classifier of the degree of significance and the questions, which the user needs to respond to. In order to do pair wise comparison of the elements, the user needs to respond to two questions, which are created automatically. The program envisages forming questions, which are based on standard phrases, for example «which is more important for you — <name of the first criterion> or <name of the second criterion>?» and «to what extent?».

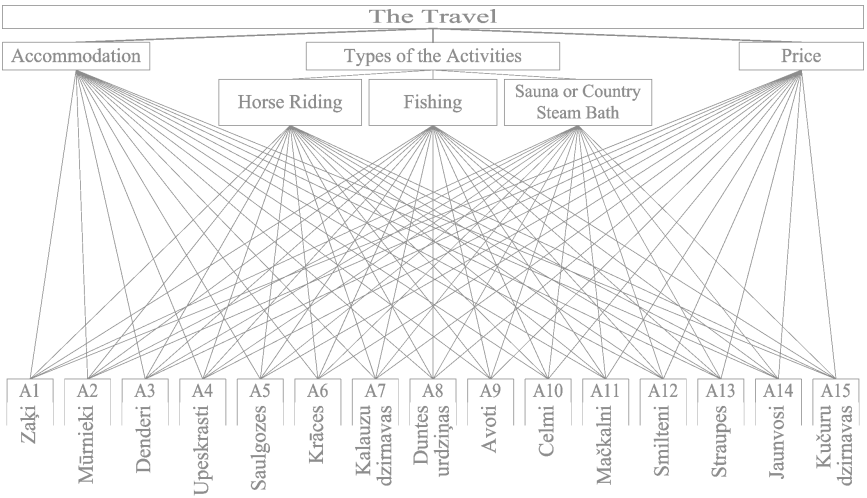


Diagram 9. Decomposition of the Problem in a Hierarchical Form

In the example considered, when comparing the criterion «accommodation» and «type of activity», the tourist had chosen the criterion «type of activity» as the more significant one and evaluated the criterion «type of activity» as having an almost material significance (evaluation — 6), when compared to the criterion «accommodation». Evaluations by the tourist, which are obtained as a result of the pair wise comparison, are placed in the matrix (see Table 9), which is subsequently solved.

Table 9

Pair wise comparison of the criteria «accommodation», «type of activity» and «price»

	Accom modation	Type of Activity	Price	Own vector evaluation	Normalized evaluation of the priority vector
Accommo-dation	1,000	0,167	0,200	0,322	0,081
Type of Activity	6,000	1,000	2,000	2,289	0,577
Price	5,000	0,500	1,000	1,357	0,342

Similarly, the tourist evaluates all of the criteria of the problem by pairwise comparison on all levels of the hierarchy. Afterwards, using the previously prepared evaluation of the alternatives, a pair wise comparison of all the alternatives occurs by each of the criteria.

Further, to obtain the end result – global priorities, there is a synthesis of intermediate results. A fragment of the solution to the problem is made in Table 10.

Table 10

Solving the Problem Using the AHP method (fragment)

Alternatives		Criteria					Global priori-ties
		Numerical value of the priority vector					
		Accom modati on	Fishing	Horse riding	Sauna or bath	Price	
		0,081	0,401	0,132	0,044	0,342	
*A*1	Zaķi	0,145	0,063	0,131	0,159	0,009	0,064
*A*2	Mūrnieki	0,030	0,142	0,131	0,073	0,108	0,117
*A*3	Denderi	0,067	0,063	0,058	0,073	0,015	0,047
*A*4	Upeskrasti	0,145	0,142	0,009	0,032	0,030	0,082
*A*5	Saulgozes	0,010	0,142	0,131	0,032	0,160	0,131
...	...	...	...	...	...	...	...

For the convenience of the user, the solution to the problem is presented as a list in a descending order by the values of the alternatives and a percentage as well (see Table 11) and in graphic form (see Diagram 10). The best solution is taken to be a 100%.

Table 11

The Resulting Solution to the Problem Using AHP method (fragment)

Code	Alternatives	Result	Value %
*A*5	Saulgozes	0,131	100,00%
*A*2	Mūrnieki	0,117	89,04%
*A*8	Duntes urdziņas	0,092	69,84%
*A*15	Kučuru dzirnavas	0,088	66,75%
*A*4	Upeskrasti	0,082	62,42%
...	...	...	...

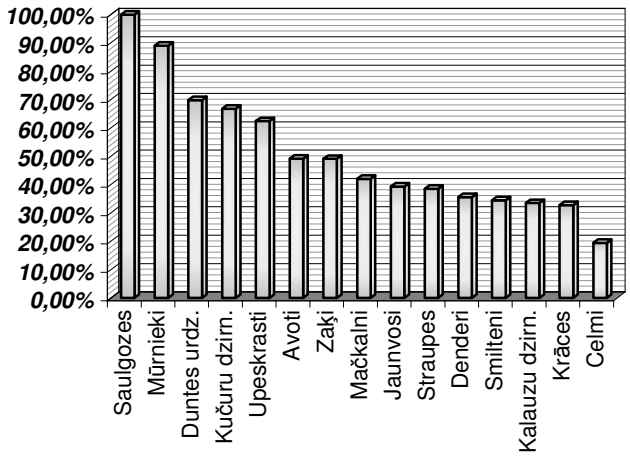


Diagram 10. The Resulting Solution to the Problem Using the AHP Method in a Graphic Form

In order to apply the ELECTRE I for the solution, already evaluated criteria are required. Because the method does not offer a mechanism for evaluating criteria, criteria weights that were obtained using the AHP method are used in practical application (see Table 12).

Table 12

Criterion Evaluation for the ELECTRE I Method

Code	Criterion	Weight	Min. or max
*K*1	accommodation	0,081	max.
*K*2	fishing	0,401	max.
*K*3	horse riding	0,132	max.
*K*4	sauna or country steam bath	0,044	max.
*K*5	price	0,342	min.

Criteria evaluation is used as input information. Taking into account the evaluation of the initial list of travels (see Table 8), the matrix of the evaluation of alternatives is created on its basis and the problem is solved. The algorithm for solving the problem using the ELECTRE I method is shown on the Diagram 11.

The solution to the problem is given in Table 13.

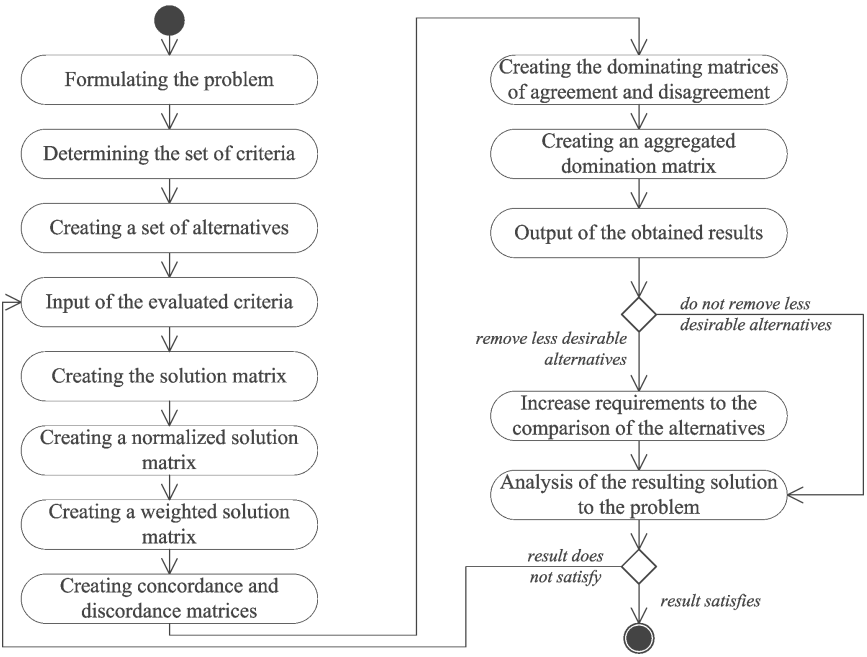


Diagram 11. The Solution Algorithm Using the ELECTRE I

Table 13

The Solution of the Problem Using ELECTRE I Method (fragment)

	*A*1	*A*2	*A*3	*A*4	*A*5	*A*6	*A*7	*A*8	*A*9	*A*10	…
*A*1	-	1	0	0	0	0	0	0	0	0	
*A*2	0	-	1	1	0	0	0	1	0	0	…
*A*3	0	0	-	1	0	0	0	1	0	0	
*A*4	0	0	0	-	0	0	0	0	0	0	…
...		...		...		...		...		...	

The solution of the problem is given in a graphic form on a Diagram 12a). The relationships between the alternatives are shown as a graph, where arrows lead from the best alternatives to the worst alternatives in such a manner, that two cases are confirmed:

- the first alternative is better than the second one (a level of concordance is achieved),

- the second alternative is worse than the first one (a level of discordance is achieved).

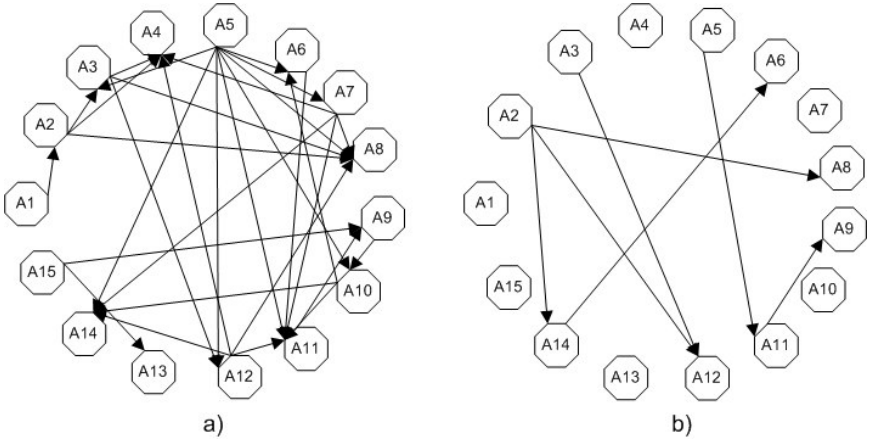


Diagram 12. The Resulting Solution for the Problem Using the ELECTRE I Method

In the given solution, a level of concordance of 0,5 is obtained, whereas the level of discordance is equal to 0,67. As can be seen from the graph, the amount of relationships and the number of possible solutions is large enough. To determine the best solution, formal methods of discarding less valuable alternatives are used. In the case of this problem it will be worthwhile to raise the requirements to the comparison of the alternatives, raising the threshold of concordance and lowering the threshold of discordance. The result is shown on the Diagram 12b) for the level of concordance of 0,6 and the level of discordance of 0,5. Under those conditions, the amount of connections between the alternatives has decreased, making it easier for the tourist to choose the best alternative.

Using the simple additive weighting method (SAW) can be assumed that the definition and the evaluation of the criteria are done before solving the problem. That method also does not feature a mechanism of criteria evaluation; therefore criteria weights that are obtained using the AHP method are used. The algorithm of the solution of the problem using the SAW method is shown on the Diagram 13.

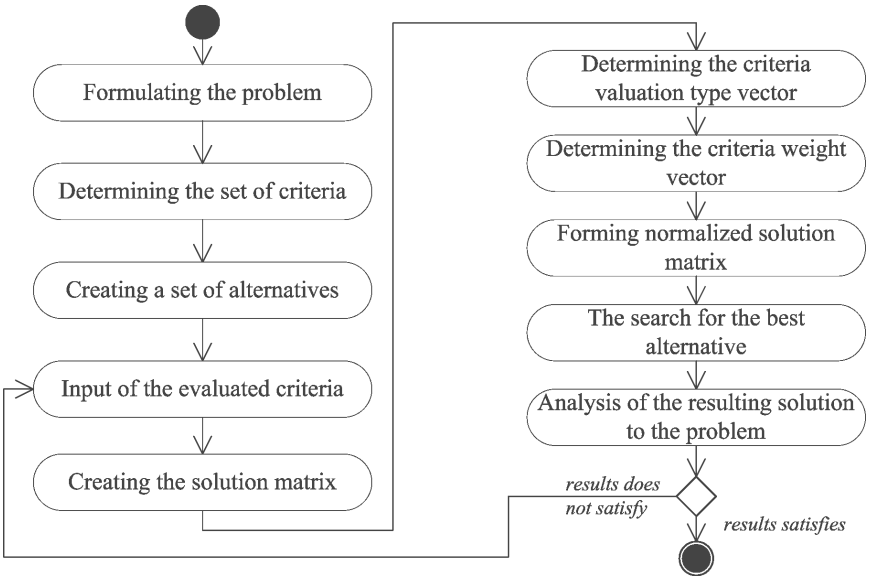


Diagram 13. The Solution Algorithm Using the SAW Method

Using the criteria weights evaluations for input, the criterion weight vectors are created together with the criteria valuations. On the basis of this information, the solution matrix for the problem can be created (see Table 14) and the problem is solved.

Table 14

The Solution Matrix Using the SAW Method (fragment)

$$D=\begin{array}{c} \begin{array}{ccccc} k1 & k2 & k3 & k4 & k5 \end{array} \\ \begin{bmatrix} 0{,}145 & 0{,}063 & 0{,}131 & 0{,}159 & 0{,}009 \\ 0{,}030 & 0{,}142 & 0{,}131 & 0{,}073 & 0{,}108 \\ 0{,}067 & 0{,}063 & 0{,}058 & 0{,}073 & 0{,}015 \\ 0{,}145 & 0{,}142 & 0{,}009 & 0{,}032 & 0{,}030 \\ 0{,}010 & 0{,}142 & 0{,}131 & 0{,}032 & 0{,}160 \\ \ldots & & \ldots & & \ldots \end{bmatrix} \end{array} \begin{array}{c} \\ A1 \\ A2 \\ A3 \\ A4 \\ A5 \end{array}$$

The resulting solution is presented to the user both in table form (see Table 15), and in graphic form (see Diagram 14). In the list of

travels, separate travels are arranged in a descending order according to the percentage value of the best alternative.

Table 15

The Solution of the Problem Using the SAW Method (fragment)

Code	The Alternative	Result	Value %
*A*5	Saulgozes	0,8896	100,00%
*A*2	Mūrnieki	0,8007	90,01%
*A*8	Duntes urdziņas	0,6298	70,79%
*A*15	Kučuru dzirnavas	0,5735	64,46%
*A*4	Upeskrasti	0,5659	63,61%
...	...	...	...

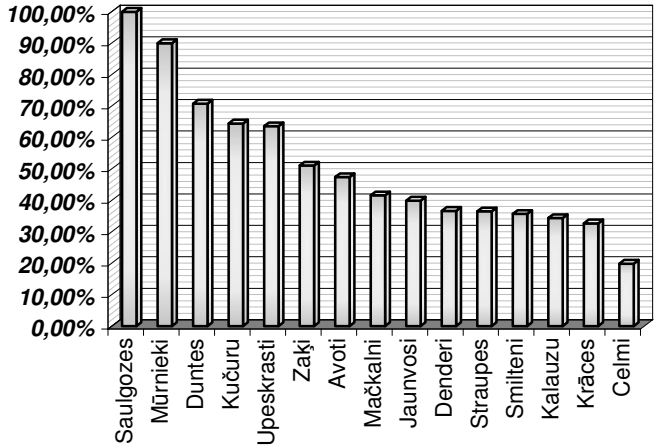


Diagram 14. The Result of Solving the Problem Using the SAW Method in a Graphic Form

The obtained solutions to the problem allow making the following conclusions:

1. All three methods – the simple additive weighting, the ELECTRE I method and the analytical hierarchy process method can be used for the choice of the travel.

2. The analytical hierarchy process method has advantages in application, because, being different from the rest of the methods, it has a mechanism for criteria evaluation.
3. The method of analytical hierarchy process gives a good correspondence to the intuitive understanding of the user, and thanks to the simplicity of the solution, it can be used successfully by people who are not professional mathematicians.
4. The involvement of the tourist into decision making, in the opinion of psychologists, will increase the sense of responsibility and provide a larger sense of satisfaction with the decision made.

Experimental Research of the Sensitivity of the Solution

Sensitivity of the solution is analyzed in the promotion work, in order to show how well are the alternatives chosen in relation to the changes in each criterion and how sensitive are the alternatives to the changes in the weights of every criterion. Only a sufficiently insensitive solution can be recommended for implementation.

The sensitivity analysis is done using the package "Expert Choice" for 5 best alternatives, which have been obtained from a solution by the method of analytic hierarchy process. To analyze sensitivity, the author creates the model of alternatives (see Diagram 15), which shows initial evaluation of alternatives by all of the criteria of the first level taken together as well as by each criterion separately. From the diagram one can see that the A5 alternative (colour blue) is the best out of all of the criteria, although with respect to some of the alternatives it is only better regarding the price criterion.

In depth the research of the sensitivity of solution is done by evaluating separate alternatives with respect to every criterion. By changing the weights of each criterion, the limits of the sensitivity of solution for the problem are determined. The weights of the criteria are increased and decreased within those limits until the best alternative is no longer the best. The results are provided in the following gradient diagrams.

Experimental research is done for the criteria of the first and second level: «accommodation», «type of the activity», «the price of the services», «fishing», «horse riding», «sauna or country steam bath». For example, Diagrams 16 and 17 show the results of the first sensitivity

experiment – the analysis of the sensitivity by the criterion «accommodation».

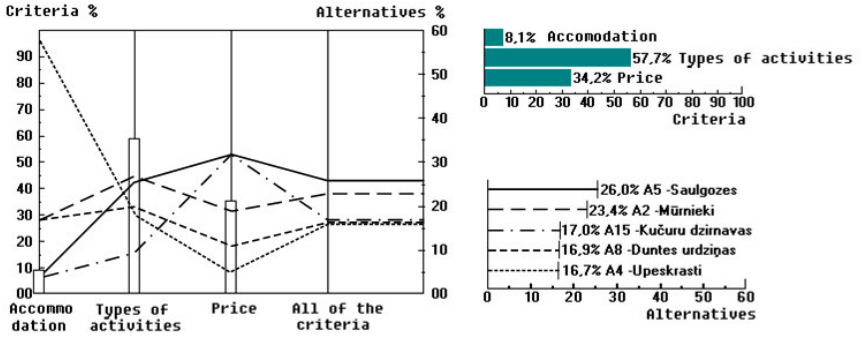


Diagram 15. The Model of Alternatives

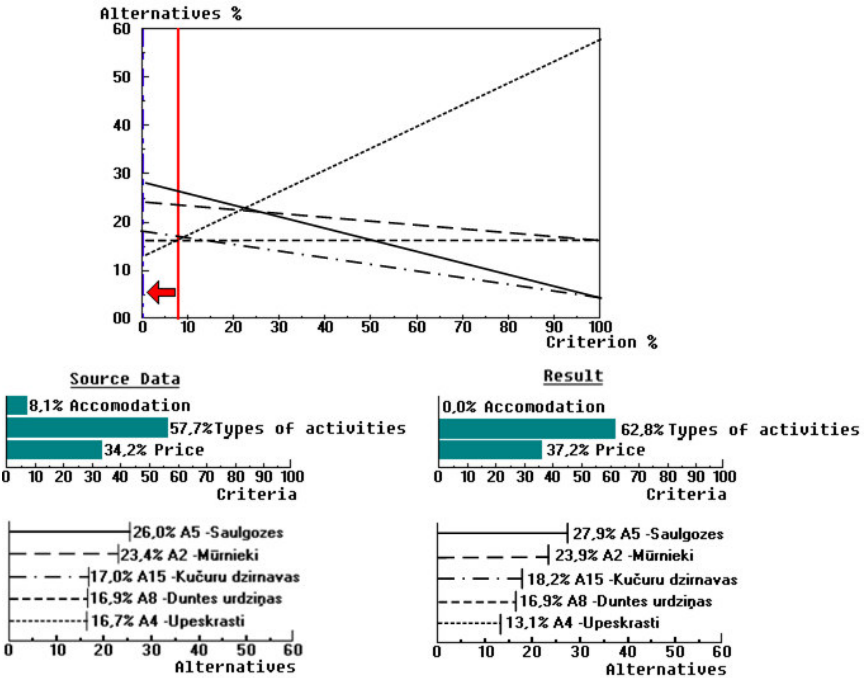


Diagram 16. Sensitivity Analysis by the Criterion «Accommodation»

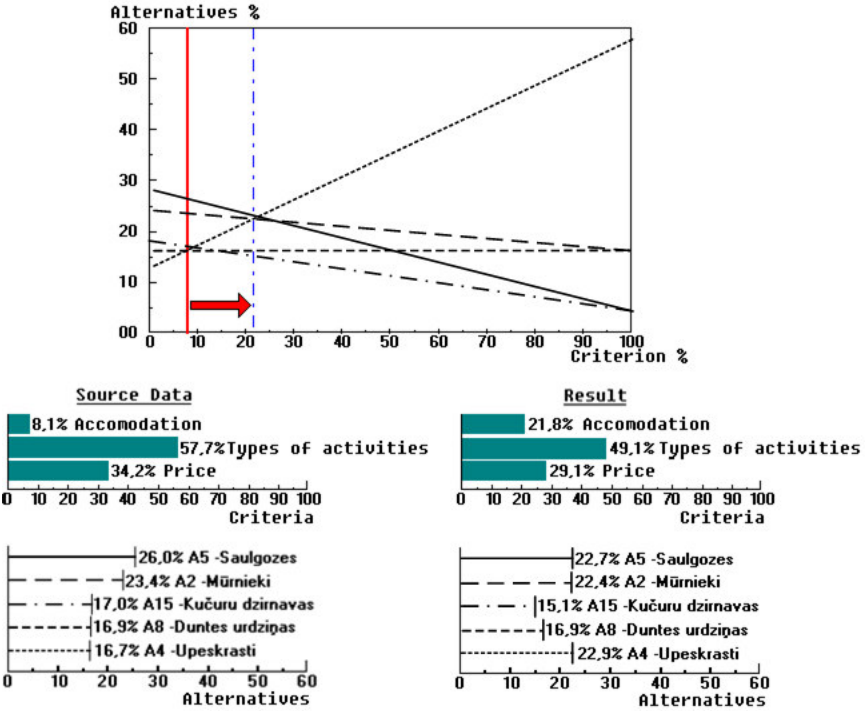


Diagram 17. Sensitivity Analysis by the Criterion «Accommodation» (continued)

In the problem considered, the criterion «type of activity» has the highest weight and, since that is the only criterion, which has the lower level criteria underneath, the author conducted sensitivity analysis for the second level criteria as well. The model of the alternatives is shown on the Diagram 18.

The model of alternatives for the second level criteria has been researched similarly to the first level criteria by evaluating alternatives on the overall totality of the criteria as well as by each of the criteria separately. As an example, the result of the research on the second level criterion «fishing» is shown below (see Diagram 19 and Diagram 20).

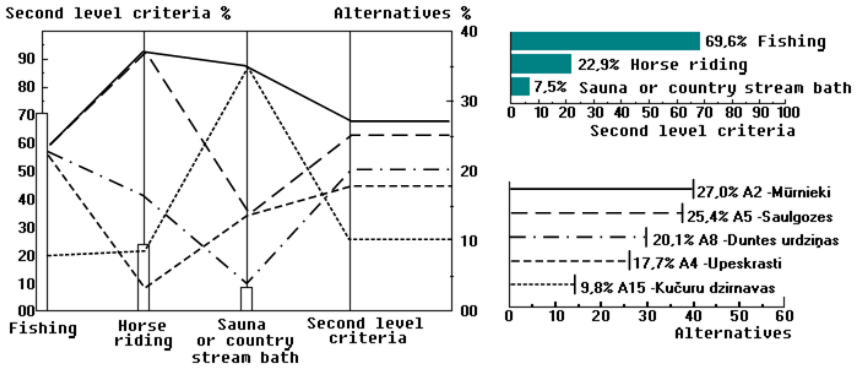


Diagram 18. The Model of Alternatives for the Second Level Criteria

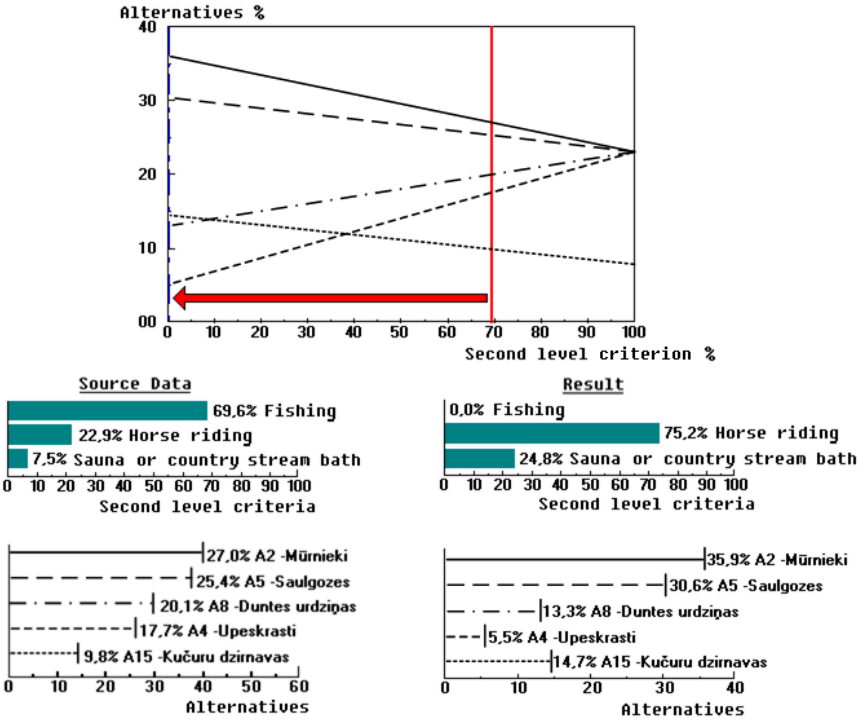


Diagram 19. Sensitivity Analysis by the Criterion «Fishing»

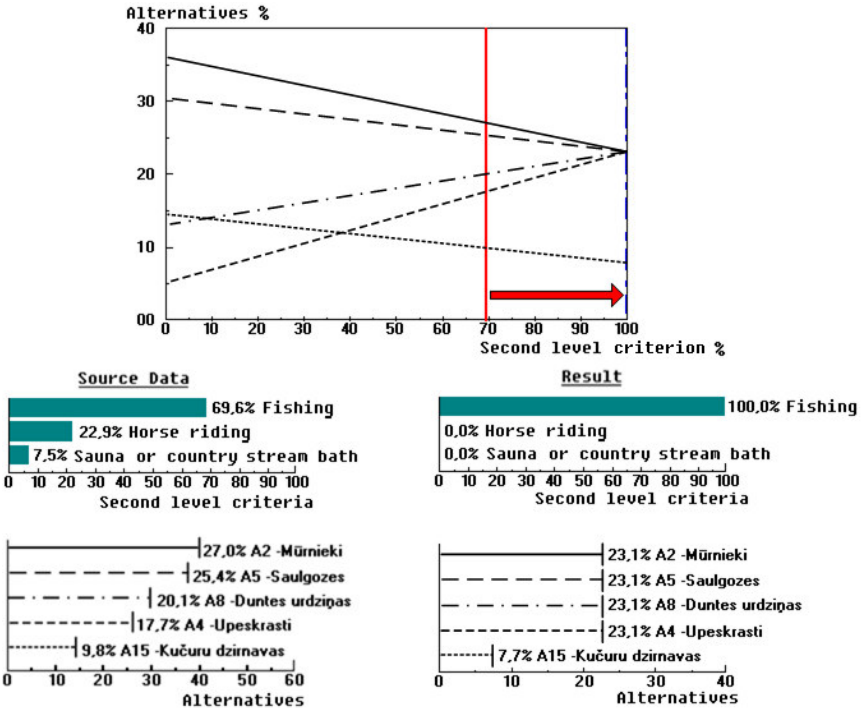


Diagram 20. Sensitivity Analysis by the Criterion «Fishing» (continued)

When analyzing the sensitivity of the solution to the problem, a situation can arise when the interval between the evaluations of the two best alternatives will be very small. Therefore the chosen travels are almost the same and it will be difficult for the user to make a decision. For example, in the solution considered, the difference between the alternatives A15 and A8 is equal to one tenth of the percent — 0,1 %. In this case it's worthwhile to conduct the so-called «head-to-head» analysis of the two close alternatives by all of the criteria, in order to clearly see the differences between the two alternative valuations (see Diagram 21).

The results of the sensitivity analysis for the obtained solution are as follows:

- by the criterion «accommodation» the best alternative does not lose its advantage after increasing the weight of the criterion from 8,1 % to 21,8 %, and after decreasing to 0 %;

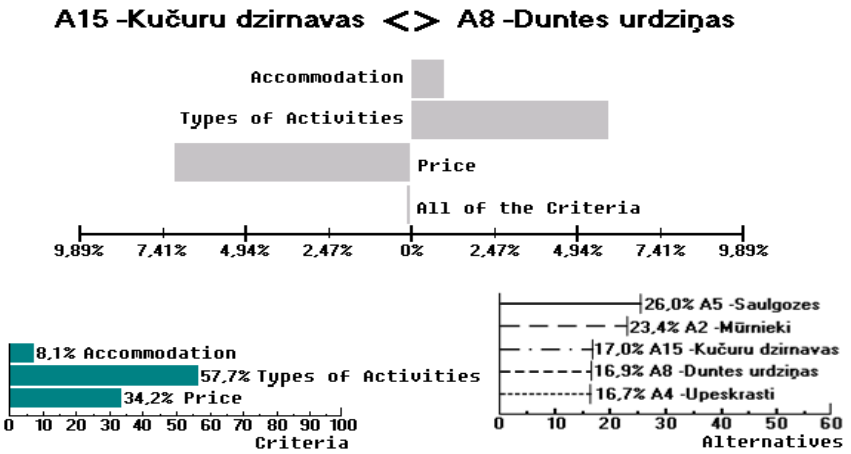


Diagram 21. Comparative Analysis of the Two Close Alternatives

- by the criterion «type of activity» the best alternative does not lose its advantage after increasing the weight of the criterion from 57,7 % to 84,5 %, and after decreasing it to 0%;
- by the «price» criterion the best alternative does not lose its advantage after decreasing the weight of the criterion from 34,2% till 17,8%, and after increasing it to 100%;
- by the second level criterion «fishing» the best alternative does not lose its advantage after decreasing the weight of the criterion from 69,6% to 0%, and after increasing it to 100%;
- by the second level criterion «horse riding» the best alternative does not lose its advantage after decreasing the weight of the criterion from 22,9 % to 0%, and after increasing it to 100%;
- by the second level criterion «sauna or country steam bath» the best alternative does not lose its advantage after decreasing the weight of the criterion from 7,5% to 0%, and after increasing it to 100%;
- overall, the solution of the problem is rather insensitive to the changes in criterion weights.

The obtained solution can therefore be recommended for the implementation.

The results of the conducted experiments allow offering the following technique for analyzing the sensitivity of the solution to the problem:

1. Create the model of alternatives and perform initial valuation of the alternatives by each criteria separately and by the overall set of the criteria.
2. Evaluate different alternatives by each criterion, changing the criteria weights within limits, until the best alternative loses its priority. In this way the sensitivity limits of the solution are defined.
3. In case of obtaining alternatives with similar weights, a comparative analysis of the two close alternatives is conducted using all of the criteria. In this way the differences between the two alternatives are clarified.

The offered technique for the sensitivity analysis of the solution to the problem extends the possibilities of the user in choosing the best travel.

In this promotion work the possibility of using the AHP method for making decision is proven experimentally with a condition that the database of the regional tourist information system contains evaluations of the alternatives.

In **the sixth chapter** the results of the research are formulated.

THE MAIN RESULTS OF THE RESEARCH

1. The need to apply the methods of multi-criteria analysis for the problem of choosing an individual travel is rationalized. The author develops requirements to the choice process.
2. The author performs theoretical and experimental research on applying the methods of multi-criteria analysis for solving the problem of choosing an individual travel. The advantages of applying the analytical hierarchy process method are rationalized.
3. Experimental research of the sensitivity of the solution is conducted, on the basis of which a technique for sensitivity analysis is developed, which allows analyzing an individual and overall influence of the choice criteria on the result and allows formulating an insensitive solution.

4. The information support for the travel choice problem – regional tourist information system is theoretically rationalized and methodically developed. The definition of the regional tourist information system is provided; the tasks for the system are developed together with the model of the architecture and the contents of the database.
5. The principles of system design are augmented by the principle of decomposition, which is based on the implementation factors of information technologies. The author develops the classification of factors and their separate aspects as well as their design tasks. A complex classification of the design methods is offered.
6. A model of a modular structure of the travel package creation with multi-criteria choice is developed, which allows creating the flexible individual travel package. The author develops recommendations for tourism specialists for the new circumstances of travel choice.
7. The offered technique for the RTIS design with the new approach towards creating a tourist product with the use of the travel choice mechanism, which is based on the application of methods of multi-criteria analysis and the modular structure of an individual flexible individual travel package creation, extends the functionality of the tourist information system and therefore creates conditions for increasing the competitiveness of entrepreneurial activity in the tourism industry

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