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FROM THE PERSPECTIVE OF
SUSTAINABLE DEVELOPMENT**

Summary of Doctoral Dissertation
Technological Sciences, Civil Engineering (02T)

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Vilnius "Technika" 2005

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Jurgita Antuchevičienė

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INTRODUCTION

Topicality of the research. High construction activity is observed both in Lithuania and in other countries of the World. Many new structures that embody modern construction quality were built recently. Unfortunately, a great bulk of old redundant buildings is still left. These buildings do not meet the contemporary requirements and demands. Consequently, they are disused and derelict at present. Industrial buildings that are situated in traditional industrialized European regions, also redundant rural buildings that emerged as a result of massive changes of agriculture production's character, constitute the largest proportion of derelict structures. In Lithuania one feels the most concerned about agriculture buildings, also objects of rural social infrastructures that were built during the socialist years under socialist economic conditions and are derelict and disused at present.

Considering the aspects of sustainable development, increasing construction activities provide not only positive outcomes that meet the new demands of a society, but also cause some negative influence on a natural and man-made environment. The above negative influence of construction processes and products could be reduced by exploiting more effectively the existing building stock and limiting the building of new structures.

The problem of disused buildings from the perspective of sustainable development has been recognized only in countries of strong economy and actions have been taken. However, such actions the most related to single and local efforts. Sustainable construction was treated rather constricted, a top priority was given to the technical aspects that were some times coupled with a natural environment, but hardly ever social and other human aspects were included. The complex, scientifically based strategy that includes multiform planning levels and overall components of sustainability was missing.

Derelict buildings visually contaminate the anthropogenic landscape, threaten people's safety, increase social tension and cause material waste. Much more than the economic profit ought to be appreciated when planning the rational use of buildings. Consequently, management of the above objects ought to be solved in a complex way that considers technical and non-technical conditions, i.e. in conformity with principles of sustainable construction and in a context of sustainable development of a locality and of a local community. A scientific research and engineering tools on the ground of the research are necessary to initiate effective derelict rural buildings' management and use decisions. A complex model is required that embraces various components of sustainable development. In the research the model

approaches the totality of logical and mathematical connections that describe the behavior of the process and possible subsequences under varying conditions and considering practical experience as well as theoretical presumptions. Modelling consists of determination of the objective, accumulation of the initial data, setting the limitations and regulative conditions, formation of structural and functional scheme, selection of the forecast methods and evaluation of the obtained results (according to Malinvaud, Aivazian and Mkhitarian, Martišius, Davis).

Research object – renewal of disused and derelict buildings as a complex process; searching the rational decisions of derelict buildings' management with an emphasis on sustainable development.

Objective of the research is developing a complex model that is designed for modelling and evaluating the rational use of derelict buildings. The model allows solving multi-attribute problems of buildings' management from the perspective of sustainable development and carrying rational decisions that meet technical capabilities, secure a social progress, assist when achieving objectives of interest groups and are environmentally sound, also helping to maintain a high level of economic growth and employment.

The following **goals** have been set to develop an effective model:

- To explore theory and practice of disused buildings' management in conformity with principles of sustainable development, to determine shortcomings as well as improvable fields and to formulate fundamental premises of planning and technical procedures for a proposed model.
- To analyze the conception of sustainable development and sustainable construction, sustainability indicators and a process of their development. To develop an indicator system on the ground of the analysis, intended to describe the alternatives of sustainable redevelopment of buildings.
- To carry out the analysis of methods and tools those are applied when solving sustainable development and sustainable construction problems. Considering the multi-attribute character and uncertainty of the analyzed problem, to propose the mathematical algorithm for evaluating the derelict buildings' redevelopment alternatives.
- To substantiate a different conception of derelict objects' management in the particular regions.
- To measure the accuracy and the credibility of the results of derelict buildings' use decisions.

- To adjust the developed model to carry decisions regarding derelict rural buildings' rational management in Lithuania.
- To explore the possibilities of integrating multi-attribute decision making methods and geographical information systems (GIS) technologies dealing with the problem of derelict buildings' use.

Methods of research. Methodological principals of systematic standpoint and systematic analysis are applied in the research. Evaluation of derelict buildings' rational use is based on the multiple-criteria decision making methods (Technique for Order Preference by Similarity to Ideal Solution, the method of Complex Proportional Assessment, the Compromise Ranking Method) and on the elements of fuzzy set theory. Mathematical statistics, Borda, Copeland, the Average Weight and Multicriteria Iterative Decision methods are applied to evaluate the results of a multiple-criteria analysis. General findings on derelict rural buildings in Lithuania are assessed by the means of factual and statistic data analysis. Mathematical statistics methods (Correlation, Multiple Regression Analysis of Forward and Backward Selection and the Method of Principal Components) are applied to evaluate territorial distribution of derelict buildings.

Scientific novelty of the research work:

- Derelict buildings' redevelopment is examined from the perspective of sustainable development that combines technical, economic, social and environmental components.
- A theoretical model of sustainability indicator system for evaluating the rational use of derelict buildings is suggested.
- Multi-attribute methods are applied for modelling and evaluating the use of buildings.
- A multi-attribute analysis of derelict buildings' rational use under uncertainty is supplemented by elements of fuzzy set. In the present research the first attempt has been made to introduce the fuzzy set theory into the method of Complex Proportion Assessment and the Compromise Ranking Method.
- A methodology for measuring the accuracy of determining the relative significance of alternatives as a function of the criteria values is developed.
- Objective congruence (incongruence) of the results obtained in a multiple-criteria analysis of derelict buildings' rational use is measured by applying mathematical statistics methods.

- Multi-attribute decision making methods and geographical information systems' technologies are integrated to increase the effectiveness of decisions regarding the use of derelict buildings.

Theoretical and practical results of the work:

- A universal hierarchic sustainability indicator system is created, intended to evaluate derelict buildings' rational use and that involves the idea of sustainable construction and sustainability of a locality as well as of a local community.
- An algorithm for the process of evaluating the rational use of derelict buildings in a fuzzy environment is suggested.
- A new methodology for measuring the accuracy as well as congruence (incongruence) of the relative significance of buildings' management alternatives is developed. The above methodology is applicable for analyzing the results of different multi-attribute tasks.
- A theoretical complex model for modelling and evaluating the rational use of derelict buildings is proposed, that intends to solve multi-attribute buildings' management tasks in the context of sustainable development.
- The model was adjusted to analyze the redevelopment of derelict buildings in Lithuanian rural areas. Different priorities of rural buildings' management were estimated in regions of a particular development activity.
- A tentative model is presented, that integrates GIS and multi-attribute decision making methods and is intended to evaluate derelict rural buildings' rational use in Lithuania.

Approval of the research work and practical application of the results.

The results of the research were published in 19 editions of scientific articles and proceedings. The main aspects and propositions that presented in the dissertation were reported in 4 international and 8 national conferences.

Some material that accumulated in the dissertation was applied in educational process (Sustainable Development of Territories STSM02305) and was used when preparing graduate works of students (BSc and MSc).

Volume and structure of the research. The dissertation is comprised of introduction, four chapters, conclusions and suggestions, a list of literature sources (401 sources), a list of scientific publications of the author (19 publications) and a brief summary in English. Volume of the dissertation is 165 pages.

THE CONTENT OF THE DISSERTATION

Chapter 1. Importance and possibilities of disused buildings' revival from the perspective of sustainable development. The chapter discusses a problem of derelict buildings and their renewal with the emphasis on sustainable construction. A survey of related scientific literature was carried out and the relevance of the research was based.

It was found that the problem of the decline and deterioration of structures is relevant to many countries of the world. In the analyzed literature much attention has been paid to environmental problems at abandoned sites. An analysis of the redevelopment of the brownfield land and structures from an economic perspective can also be found in severe scientific publications. But there are a very few implemented initiatives on the revival of brownfields. Only a few countries have made surveys to specify the extent of the brownfield problem. Scientifically based initiatives that are related to sustainable development of derelict structures are missing.

Since 1987, when the World Commission on Environment and Development defined a concept of sustainable development, sustainability has received significant attention. To accomplish these tasks, human and natural environmental considerations need to be regarded in the engineering – technical and economic decision-making. Consequently, it was motivated that the various activities of the construction sector have to be analyzed by emphasizing sustainable development.

Planning and technical procedures of disused buildings' management or dismantling in conformity with principles of sustainable development were explored and shortcomings as well as improvable fields were determined. It was stated, that buildings that are less depreciated should be renovated and used for appropriate purposes, especially in view of the fact that in the European Union and other foreign countries more attention is paid to urban renovation than to the development of new sites. Buildings with great depreciation and those not fit for renovation should be dismantled rather than falling into decay or being simply demolished.

The dissertation analyzes a problem of formalization of sustainable development. For this purpose, a common understanding of an indicator, distinguishes between data and indicators as well as their interaction was described. The main purposes of using sustainability indicators and their role in the construction and real estate management processes were showed. Models, concepts and typology of sustainability indicators were analyzed in the chapter. The sustainable development indicator systems as developed by

science and government institutions in Europe and other countries of the world as well as some theoretical recommendations were surveyed for the purpose of formulating the indicator set to carry effective and sustainable buildings' revitalization decisions. It has been found that there was no universal indicator system that could be used in every situation. A survey enabled to maintain that a unique indicator set should be developed for the best achievement of the desired goals in any given situation.

To achieve rational development decisions there is a need for scientific methods and tools. The methods and tools that applied to sustainability decisions were surveyed in the chapter. It was found that decision problems of the sustainable development type are conflicting by nature. A set of multiple goals and objectives needs to be considered simultaneously. Therefore multi-criteria techniques seemed to be an appropriate tool and able to assure sustainability of the total system and objectivity of the solution.

A survey of multiple criteria decision making (MCDM) basic theory and a classification of methods were carried out in the chapter. According to different classification theories as presented by top researchers Chen and Hwang, Triantaphyllou, Hwang and Yoon, Larichev, Zavadskas, etc., a generalized classification of the methods depending on the main features of initial information was developed and selecting the appropriate methods for derelict buildings' management was motivated.

It was stated that buildings' redevelopment decisions are characterized by conflicting multivariate factors as well as concerned with spatial preferences. Consequently, coupling of multiple factors in a spatial context could be a way to effective decision-making. A survey was made and it was found that multi-attribute evaluation methods linked with geographic information systems could be used to make the above decisions.

Chapter 2. Analysis of disused buildings in Lithuanian rural areas.

The chapter analyzes the problem and the peculiarities of derelict rural buildings in Lithuania. In order to manage derelict buildings, firstly the existing situation was explored. Based on the data obtained from the Lithuanian State Territorial Planning and Construction Inspectorate, it was found that there are nearly 7,400 disused and derelict buildings in the Lithuanian countryside. General findings on these investigative objects on the basis of the above data were carried out in the chapter. It was established, that these objects occupy about 4.8 percent of the total building area in Lithuania. The average density of disused rural buildings was estimated to be 1.88 objects per 1000 ha. It was established that derelict farming buildings make up to 3 percent of the total stock of Lithuanian industrial buildings. It was

found out how many rural buildings subject to depreciation are fit for reconstruction. The number and the area of building sites of the objects that have been designated for demolition was measured. For the reuse and recycling of building materials, which is an important requirement for sustainable construction, the quantity of building materials and their decomposition were determined. The measured extent of a problem substantiated the importance of redevelopment of rural buildings.

According to the objective of the research, the strategy of the revival of derelict objects ought to be based not only on physical characteristics of an object, but also on its regional peculiarities, the environmental performance that should meet the requirements of the local community, as well as compliance with the main principles of sustainable development. Therefore, observations of Lithuanian rural buildings' territorial distribution and their peculiarities were made in the context of the concept of the country's sustainable development. Economic, social and agricultural factors that determine the distribution peculiarities of disused buildings and their environment were established by using mathematical statistics methods. As a dependant variable in the analysis, a density of derelict and mismanaged buildings was used for this research. As independent variables the author used: farming land productivity, farming land percent rented by farming communities, parameters of life quality, population's activity indices, territorial concentration indices of farming and corn agriculture.

The initial data was grouped into several sets taking into account location and the use of buildings. The grouping into three regions according to the concept of the country's spatial development, i.e. areas of active development, areas of regressing development and 'buffer' areas, was proved to be the most significant. The main cities are situated in the areas of active development. The largest amount of facilities, the greatest variety of activities and the maximum internal as well as foreign investment was found to be characteristic of areas with active development. The economic basis of areas with regressing development includes agricultural, forestry and recreational activities. Such areas cover the northern-eastern and southern parts of Lithuania. 'Buffer' areas take a middle place according to the characteristic of activity, geographical and environmental situation and the peculiarities of the local population.

Several correlation matrices have been calculated that took into account regional peculiarities and the use of buildings and a statistical relationship was determined. Multiple Regression Analysis of Forward and Backward Selection was applied to determine a causative relationship between the

dependent variable and independent factors. The Method of Principal Components was applied to the above variables. It was found that a statistical relationship between derelict and mismanaged rural buildings and the regional concentration of economic, social and agricultural indices differs in zones of active and regressing development and in ‘buffer’ areas. The most statistically significant relations between mismanaged buildings and socio-economic factors with the probability of 95 percent in regions of active development are shown in Figure 1.

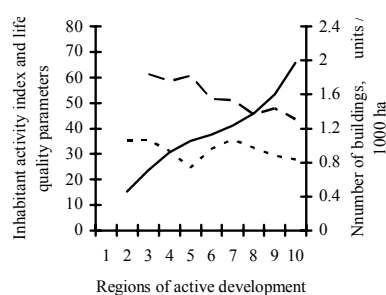


Fig 1. Connection between mismanaged buildings, the inhabitant activity index and parameters of life quality in areas of active development:

1 ... 10 – Šiauliai, Klaipėda, Panevėžys, Mažeikiai, Kėdainiai, Vilnius, Akmenė, Trakai, Kretinga and Jonava regions,

- is the trendline of density of buildings,
- - - is the trendline of inhabitant activity index,
- · · is the trendline of life quality parameters.

It was found that in areas of active development the distribution peculiarities were most of all influenced by population’s activity indices and life quality parameters. These connections were reversed.

Graphs of other analyzed sets were presented in a similar way in the dissertation. In areas of regressing development, indices of farming territorial concentration were statistically the most significant. “Buffer” areas took a middle place according to their concept as well as to the results of the analysis. Hereby the demand of a different conception of derelict objects’ management in the particular regions was substantiated.

Chapter 3. Complex model for finding derelict buildings’ rational use.

In the chapter a decision making model was developed that allows solving multi-attribute problems of buildings management from the perspective of sustainable development and under uncertainty. The model deals with the problem of developing the derelict buildings’ redevelopment variants and choosing the most rational one with an emphasis on sustainable construction.

Planning and technical components of an effective model in conformity with the main principles of sustainable development were proposed. The totality of components and their relations are shown in Figure 2.

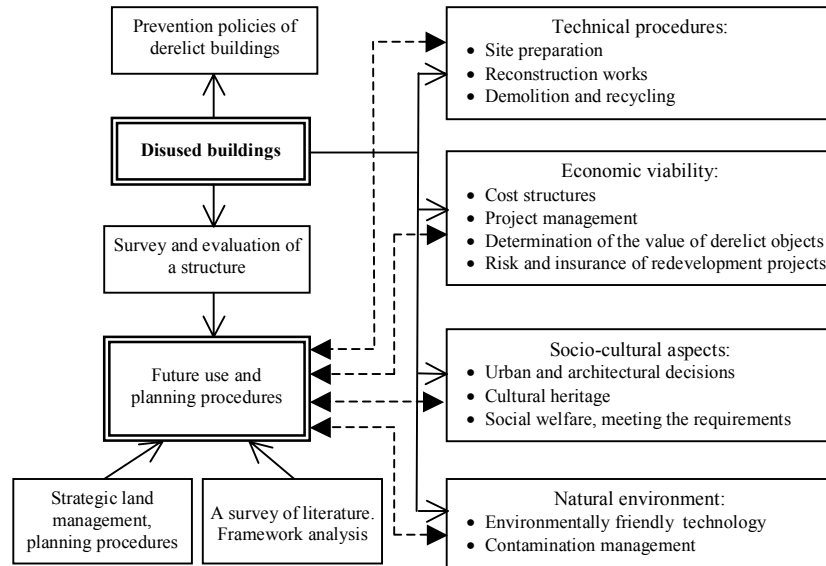


Fig 2. Planning and technical components in an initial stage of derelict buildings' use model

The author formulated the main statements to guide selecting the potential redevelopment variants of derelict rural buildings for the following analysis. It was proposed that the particular conversion variants of buildings should be selected agreeably to formulated statements and by meeting the peculiarities of objects and their location.

It was proposed to describe redevelopment variants of buildings by using a set of criteria, i.e. sustainability indicators. The model of the indicator system for management of derelict rural buildings was designed on the basis of *Pressure – State – Response* and *Driving-forces – Pressure – State – Impact – Response* indicator models. When considering the specific features of an analyzed problem, three typological groups were proposed, i.e. *Current State*, *Development Possibilities* and the *Impact*.

The total system was made up of a large number of component systems. Each of the proposed typological group consists of several subsystems. These subsystems describe various components of sustainability that have been chosen according to the singularity of the problem. It is possible to change some of the component systems, depending on the aim and circumstances of the research. Some of the main subsystems are shown in Figure 3.

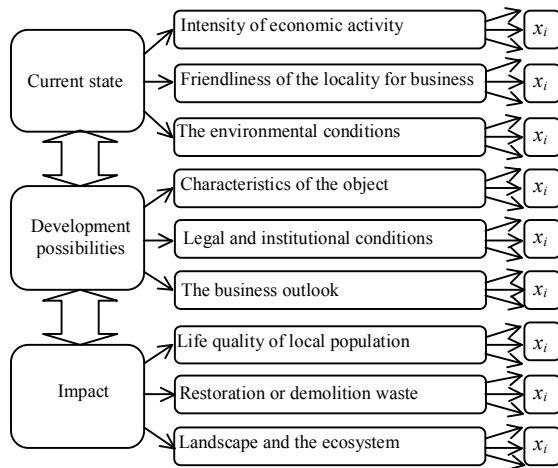


Fig 3. Model of indicator system for derelict buildings' sustainable revitalization:
 $x_i, i = 1, 2, \dots, m$ is the indicator, m is the number of used indicators

Suggested subsystems consist of a number of indicators $x_i, i = 1, \dots, m$, selected from the available and approved indicator systems and then adapted to local singularities and to the peculiarities of the problem. The developed criteria system was applied to multi-attribute decision-making.

A process of multi-attribute analysis of buildings regeneration by using the fuzzy set approach was performed in several stages and is presented in Figure 4.

According to the MCDM methodology, the variants of buildings' redevelopment and the list of criteria should be determined. For this reason, the initial information concerning derelict buildings should be analyzed.

When describing and ranking the available regeneration alternatives of derelict buildings with an emphasis on sustainability, the author was faced with uncertainty in measuring sustainable development. In this environment applying a crisp MCDM method was complicated. Consequently, the author proposed to supplement the MCDM methods with some elements of fuzzy set theory. It was proposed to perform calculations that determine the redevelopment priorities of buildings by using fuzzified Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), fuzzified method of Complex Proportional Assessment (COPRAS) and fuzzified compromise ranking method (VIKOR).

According to the presented block-scheme (Figure 4), the initial fuzzy decision-making matrix of derelict buildings' regeneration was constructed. It was proposed to assess ratings for alternatives with respect to the criteria by using triangular fuzzy numbers. Further, a process of multiple attribute

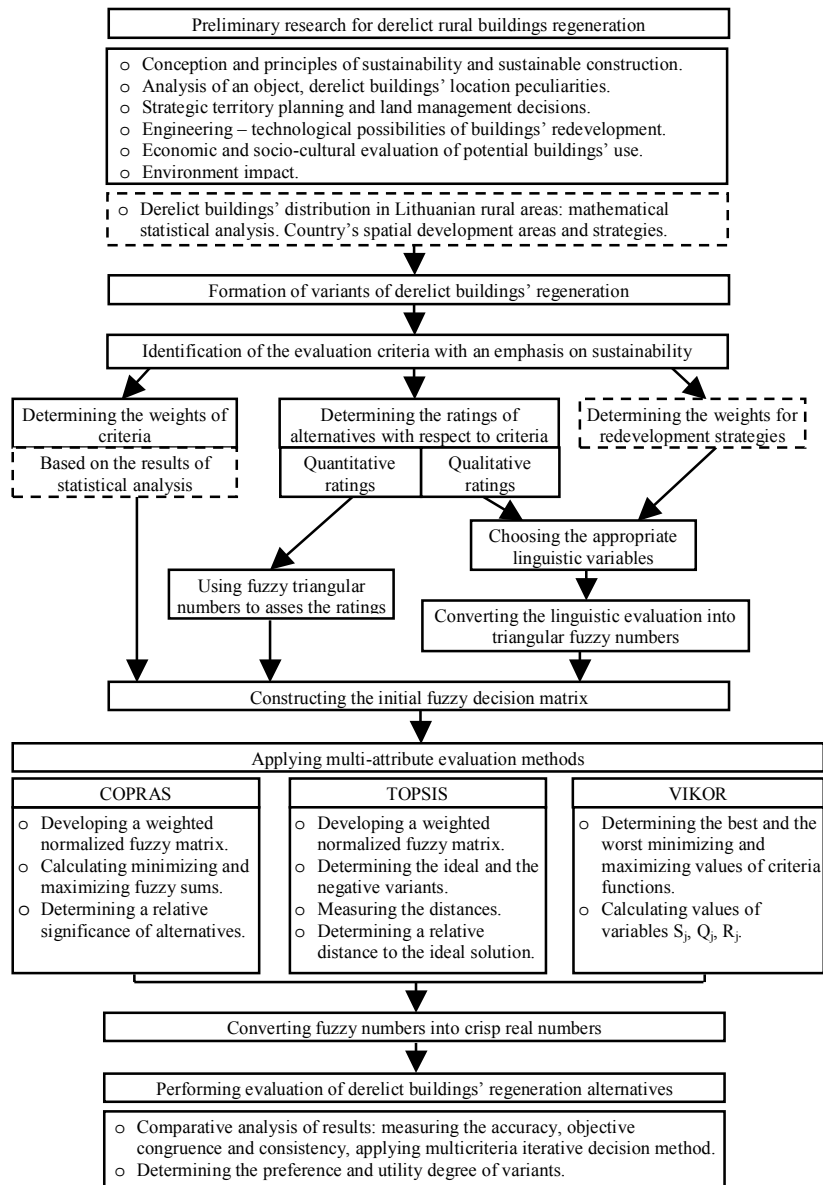


Fig 4. Model of multi-attribute analysis of buildings redevelopment under uncertainty

evaluation of variants was performed in conformity with algebraic operations of triangular fuzzy numbers.

Before estimating the preference of alternatives, the methodology for a comparative analysis of the results was developed, i.e. measuring the accuracy, objective congruence and consistency of results and applying the multi-criteria iterative decision method was proposed.

Chapter 4. Modelling and evaluating the use of derelict rural buildings in Lithuania. In the chapter the developed model was adjusted for modelling and evaluating the rational management of derelict rural buildings in Lithuania with an emphasis to sustainable construction.

The particular conversion variants of Lithuanian rural buildings were selected for a possible set of alternative solutions based on a scientific research and theoretical presumptions. The alternatives included reconstruction of rural buildings and adapting them to production or commercial activities (alternative A_1), improving and using them for farming (alternative A_2) or dismantling and recycling the demolition waste materials (alternative A_3). Potential redevelopment variants were selected according to the types of buildings, their layout and design as well as technical and technological suitability for planned activities.

Proposed redevelopment alternatives were described by using criteria (sustainability indicators). The following fifteen criteria in evaluating buildings' regeneration alternatives have been taken into consideration, including the average soil fertility grade in the area, quality of life of the local population, population's activity index, GDP in proportion to the average GDP of the country, material investments in the area, foreign investments in the area, buildings' redevelopment costs, income growth of the local population, increase of sales in the area, growth of employment, state income from business and property taxes, business outlook, difficulties of purpose-built changes, degree of contamination, attractiveness of the countryside. The choice of criteria was limited by the available data, but the use of criteria demonstrated the procedure relating to the proposed model.

Management of derelict buildings was analyzed individually in three zones of development activities (area of active development, area of regressing development and 'buffer' area). The appropriate statistical parameters were calculated to compare correlation matrices that were computed in Chapter 2. It was proved that the correlation structure of derelict and mismanaged buildings in three above areas was different with the probability $p = 0.95$ and the use of different conception of derelict objects management in the particular regions was substantiated.

Development possibilities and the impact criteria were considered to be of equal importance, while weights were determined for state criteria according to the estimated statistical relations that were described in Chapter 2.

Calculations were made according to solutions suggested by the Master Plan of the Territory Development of the Republic of Lithuania. The two main strategies presented in the Master Plan, that refer to the maintenance of the existing economic potential of a region and the harmonization of regional development, were evaluated.

For the reasons mentioned above, six initial decision-making matrices were composed. Calculations that determine the redevelopment priorities of buildings were performed by using the TOPSIS that applied vector and linear normalization, COPRAS and VIKOR methods, supplemented with elements of fuzzy set theory and by using adequate operations on fuzzy triangular numbers. The results of the multi-attribute analysis of derelict rural buildings' regeneration alternatives in Lithuania are presented in Table 1.

The established regeneration peculiarities of derelict rural buildings in Lithuania showed that the same solution is hardly applicable to any building within the whole territory of a country. The results of a multi-attribute analysis outlined possible differences of buildings' redevelopment. Moreover, it was found that the priority order of alternatives was not always the same for a particular region when different above methods were applied. Consequently, a comparative analysis of results was performed.

Spearman's rank correlation was calculated and objective congruence (incongruence) of ranks that were computed by using different MCDM methods was measured. Confidence intervals of coefficients were calculated and it was found that all correlation coefficients were statistically significant with the probability of 95 percent. Accordingly, was stated that methods compared by twos produced identical ranking results with the particular probability. Also the author developed criteria of consistency (inconsistency) of the results on the ground of literature survey and applied the criteria to the experimental research, when comparing results of multi-attribute analysis of derelict building redevelopment alternatives.

The methodology for measuring the accuracy of relative significance of alternatives as a function of criteria values was developed. The accuracy of data obtained in a multi-attribute analysis of derelict buildings' rational management by applying the TOPSIS method was evaluated. The difference of relative significances of alternatives that could be considered identical within the specified limits of calculation's accuracy was assessed.

Table 1. The results of the multi-attribute analysis of derelict buildings' regeneration alternatives

MCDM method	Area	Strategy	The relative significance end the relative utility degree of alternatives			Priority
			A_1	A_2	A_3	
COPRAS	Active development	MEP*	0.52 (100%)	0.24 (46 %)	0.23 (45 %)	$A_1 \succ A_2 \approx A_3$
		HRD**	0.35 (98 %)	0.36 (100%)	0.29 (80 %)	$A_2 \approx A_1 \succ A_3$
	Regressing	MEP*	0.28 (64 %)	0.44 (100%)	0.29 (65 %)	$A_2 \succ A_3 \approx A_1$
		HRD**	0.50 (100%)	0.26 (52 %)	0.24 (48 %)	$A_1 \succ A_2 \approx A_3$
	"Buffer"	MEP*	0.44 (100%)	0.31 (71 %)	0.24 (55 %)	$A_1 \succ A_2 \succ A_3$
		HRD**	0.45 (100%)	0.31 (61%)	0.24 (53 %)	$A_1 \succ A_2 \succ A_3$
TOPSIS based on vector normalization	Active development	MEP*	0.61 (100%)	0.41 (67 %)	0.36 (59 %)	$A_1 \succ A_2 \succ A_3$
		HRD**	0.53 (100%)	0.49 (92 %)	0.36 (68 %)	$A_1 \succ A_2 \succ A_3$
	Regressing	MEP*	0.50 (89 %)	0.56 (100%)	0.46 (82 %)	$A_2 \succ A_1 \succ A_3$
		HRD**	0.61 (100%)	0.45 (74 %)	0.46 (75 %)	$A_1 \succ A_3 \approx A_2$
	"Buffer"	MEP*	0.59 (100%)	0.43 (73 %)	0.38 (64 %)	$A_1 \succ A_2 \succ A_3$
		HRD**	0.61 (100%)	0.47 (77 %)	0.36 (59 %)	$A_1 \succ A_2 \succ A_3$
TOPSIS based on linear normalization	Active development	MEP*	0.62 (100%)	0.42 (68 %)	0.37 (60 %)	$A_1 \succ A_2 \succ A_3$
		HRD**	0.49 (91 %)	0.54 (100%)	0.37 (69 %)	$A_2 \succ A_1 \succ A_3$
	Regressing	MEP*	0.46 (72 %)	0.64 (100%)	0.48 (75 %)	$A_2 \succ A_3 \approx A_1$
		HRD**	0.62 (100%)	0.46 (74 %)	0.48 (77 %)	$A_1 \succ A_3 \approx A_2$
	"Buffer"	MEP*	0.47 (87 %)	0.37 (70 %)	0.53 (100%)	$A_3 \succ A_1 \approx A_2$
		HRD**	0.64 (100%)	0.55 (86 %)	0.35 (55 %)	$A_1 \succ A_2 \succ A_3$
VIKOR	Active development	MEP*	0.38 (38 %)	0.36 (36 %)	1.00 (100%)	$A_2 \approx A_1 \succ A_3$
		HRD**	0.65 (65 %)	0.00 (0 %)	1.00 (100%)	$A_2 \succ A_1 \succ A_3$
	Regressing	MEP*	1.00 (100%)	0.00 (0 %)	0.64 (64 %)	$A_2 \succ A_3 \succ A_1$
		HRD**	0.00 (0 %)	1.00 (100%)	0.45 (45 %)	$A_1 \succ A_3 \succ A_2$
	"Buffer"	MEP*	0.67 (67 %)	1.00 (100%)	0.00 (0 %)	$A_3 \succ A_1 \succ A_2$
		HRD**	0.00 (0 %)	0.17 (17 %)	1.00 (100%)	$A_1 \succ A_2 \succ A_3$

* Maintenance of existing economic potential in a region

** Harmonization of regional development

The values of the relative closeness of the alternatives to the ideal solution yielded by TOPSIS and based on linear normalization were assessed to be less accurate as compared to the data obtained by the method based on vector normalization of the criteria values.

Borda, Copeland, the Average weight and the Multi-criteria iterative decision methods were applied to evaluate not identical multi-attribute analysis results. Generalized conclusions were made concerning different priorities of derelict Lithuanian rural buildings' use in the particular areas of development activity on the ground carried out research (Table 2.).

Table 2. Rational use decisions of derelict rural buildings in the particular areas of Lithuania

Area	Strategy	Priority
Active development	MEP*	$A_1 \succ A_2 \succ A_3$
	HRD**	$A_2 \succ A_1 \succ A_3$
Regressing	MEP*	$A_2 \succ A_3 \succ A_1$
	HRD**	$A_1 \succ A_3 \succ A_2$
"Buffer"	MEP*	$A_1 \succ A_3 \succ A_2$
	HRD**	$A_1 \succ A_2 \succ A_3$

* Maintenance of existing potential in a region

** Harmonization of regional development

The facilities of GIS technologies for a spatial decision-making were explored and adjusted to the analyzed problem of sustainable revitalization of derelict buildings. A model for preparing the initial data by using GIS technologies and calculations by applying a multi-attribute decision making technique was proposed. A structure of a personal geodatabase of disused buildings was proposed and an example based on data of Utena region was implemented. Some data layers of sustainability indicators of a country were prepared and possibilities of analyzing and manipulating the data were introduced. A simplified example of applying the proposed techniques and using the tentative model was presented.

CONCLUSIONS AND SUGGESTIONS

1. The survey of literature showed that sustainable construction is treated rather constricted. In scientific publications a top priority is given to technical aspects that are some times coupled with a natural environment, but hardly ever social and other human aspects are included. Prominence is given to sustainability requirements for construction, while reconstruction is left out of the way in the analyzed literature.
2. To solve effectively and comprehensively a problem of derelict buildings' management and future use, the original complex model was proposed that allows solving multi-attribute problems of rational buildings' management from the perspective of sustainable development and carrying decisions that meet technical capabilities, secure a social progress, assist when achieving objectives of interest groups and are environmentally sound, also helping to maintain a high level of economic growth and employment.
3. The results of explored distribution peculiarities of derelict Lithuanian rural buildings' by using mathematical statistics methods indicated that the correlation structure of statistical relationships between derelict as well as mismanaged buildings' distribution and economic, social and

agricultural indices in the areas of a particular socio-economic development activity is different with the probability $p = 0.95$.

4. Considering the regional differences in a particular country and the established spatial distribution peculiarities of derelict buildings in Lithuanian rural areas, it was proposed to apply a differentiated conception of derelict objects' rational use by taking into account socio-economic conditions and a development potential of a particular region. The proposed management of objects could positively affect economic, social processes and a natural environment in a locality as well as the whole sustainability of a country.
5. Based on the explored theory and practice of disused buildings' management in a context of sustainable construction and according to the carried out research, fundamental premises of planning and technical procedures were determined to develop the alternatives of buildings' reconstruction and further use or dismantling. It was proposed to evaluate the alternatives in the terms of engineering – technical, social, economic and environmental aspects, i.e. from the sustainable viewpoint.
6. The survey of sustainability indicator sets and the analysis of simulated objects indicated that existing indicator sets do not accumulate all the components of a particular problem, also engineering – technical and non-technical aspects are rarely integrated. Consequently, it is hard to apply the above sets for evaluating the alternatives decisions of derelict buildings' use. Accordingly, an original hierarchic indicator system was developed that intends to describe alternatives of buildings' redevelopment and that involves the idea of sustainable construction and influences sustainable development of a locality and of a local community.
7. The theoretical research established that multi-attribute decision making methods are well suitable for objectively evaluating the sustainable technological, organizational and management decisions in construction. Considering uncertainty that related to sustainable development, it was proposed to apply some of the elements of the fuzzy set theory for solving multi-attribute problems in the fuzzy environment.
8. It was proposed to apply the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) that supplemented by some of the elements of the fuzzy sets and the first attempt has been made to introduce the fuzzy set theory into the method of Complex Proportional Assessment (COPRAS) and the compromise ranking method (VIKOR) for a multi-attribute analysis of buildings' use in the fuzzy environment.

9. It was stated that a revival or a liquidation of disused buildings in a context of country's sustainable development can be motivated according to development problems and priorities in a country as in a multipartite social, economic and ecological system. Accordingly, it was proposed to evaluate in linguistic terms the adequacy between alternative decisions and regional development strategies. It was proposed to determine the weights of criteria according to the estimated causative statistical relations of analyzed criteria in particular regions.
10. Ranking of alternatives was performed by using the above suggested fuzzified multi-attribute decision making methods. It was found that the priority order of the redevelopment alternatives of buildings was not always the same in a particular region. The degree of utility of the best revitalization alternative was compared to the worst one and ranged from 18 to 55 percent. This difference showed the importance to carry potentially the best buildings' management decision.
11. Spirmen's rank correlation coefficients were calculated to measure objective congruence (incongruence) of ranks of derelict buildings' management alternatives. It was found that every correlation coefficient was statistically significant with the probability of 95 percent. Accordingly, it was impossible to state that the methods compared by twos produced different ranking results.
12. It was found that Spirmen's rank correlation coefficients between the method of Complex Proportional Assessment (COPRAS) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) that applied vector and linear normalization of criteria values can be considered identical and depending to the same and indiscrete correlation space with the particular probability. Accordingly, multi-attribute evaluation results can be considered identical.
13. When applying the developed criteria of consistency (inconsistency) of results, it was proved that a conclusive decision should be adopted by giving the priority to the results of COPRAS and TOPSIS methods, if the ranking results of the analyzed methods differ. 59 percent of the best ranked alternatives by using the above methods and 43 percent of all ranks matched in a particular experimental set.
14. The original methodology for measuring the accuracy of the relative significance of alternatives as a function of the criteria values was developed. The accuracy of data obtained in a multi-attribute analysis of derelict buildings' rational management by applying the TOPSIS method was assessed. It was determined that the relative closeness of the

alternatives to the ideal solution with the difference ranging from 1 to 3 percent can be considered identical within the specified limits of calculation's accuracy, if mean square errors of the initial data range from 2 to 4 percent of the criteria values.

15. The values of the relative closeness of the alternatives to the ideal solution yielded by TOPSIS and based on linear normalization were assessed to be less accurate as compared to the data obtained by the method based on vector normalization of the criteria values. In terms of the standard deviations of the relative closeness to the ideal solution, the difference in the relative significance of the alternatives equal to 0.01 can be considered statistically insignificant with the probability $p = 95$ percent, if the standard deviations of the initial data make up about 2 percent of the average criteria value as in the case of linear normalization. In the case of vector normalization, the difference of the relative significance equal to 0.01 can be considered statistically insignificant if the standard deviations of the initial data reach 4 – 5 percent.
16. When Borda, Copeland and the average weight methods were applied for evaluating the multi-attribute analysis results, it was stated that the differences of relative significances of alternatives were not considered. It was suggested to apply the multicriteria iterative decision method to determine the best, objective and scientifically valid decision of derelict buildings' management in the particular regions.
17. Considering the results of a multi-attribute analysis under uncertainty, the measured accuracy, congruence and consistency of the results and the outcomes of Borda, Copeland, the Average weight and the Multicriteria iterative decision methods, generalized conclusions were made concerning different priorities of derelict Lithuanian rural buildings' redevelopment in the particular areas of development activity and when applying the strategies that refer to the maintenance of the existing economic potential of a region and the harmonization of regional development.
18. It was found that one could increase the effectiveness of derelict buildings' use decisions by integrating multi-attribute decision making methods and geographical information systems' technologies (GIS). A tentative example was implemented and it was stated that GIS is a useful supplementary tool to solve problems of derelict buildings' rational management by using multi-attribute decision-making methods because of a potentiality of data storage, analysis and presentation.

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APLEISTŲ PASTATŲ NAUDOJIMO MODELIAVIMAS DARNAUS VYSTYMO(-SI) ASPEKTU

Santrauka

Darbo aktualumas. Pastaruoju metu Lietuvoje bei kitose Europos ir pasaulio šalyse stebimas statybų veiklos aktyvumas, statoma daug naujos kokybės pastatų. Tačiau lieka senesnės statybos, šiuo metu nenaudojamų ir apleistų, netenkinančių šiandienos reikalavimų ir iškilusių poreikių pastatų perteklius. Didelę dalį tokių objektų sudaro gamybinės paskirties pastatai senuosiuose pramoniniuose Europos regionuose, taip pat pertekliniai kaimo pastatai, atsiradę kintant žemės ūkio gamybos pobūdžiui. Lietuvoje didžiausią rūpestį kelia sovietmečiu statyti, o šiuo metu apleisti ir nenaudojami žemės ūkio paskirties ir kaimo socialinės infrastruktūros pastatai.

Vertinant darnaus vystymo(-si) (angl. *sustainable development*) aspektu, naujų pastatų statyba yra ne tik teigiamas veiksnys, tenkinant naujus visuomenės poreikius, bet dažnai sukelia neigiamą poveikį gamtinei ir negamtinei aplinkai. Ši statybos procesų ir produktų poveikį galima sumažinti efektyviau naudojant esamus pastatus ir ribojant naujų objektų statybą.

Nenaudojamų pastatų problema keliama bei imamasi priemonių jai spręsti darnaus vystymo(-si) požiūriu tik stiprios ekonomikos šalyse. Tačiau dažniausia įgyvendinamos pavienės bei vietinės reikšmės iniciatyvos. Darni statyba traktuojama gana siaurai, iškeliami techniniai klausimai, kai kada siejami su gamtine aplinka, tačiau beveik nevertinami socialiniai ir kiti žmoniškieji aspektai. Pasigendama kompleksinės, mokslškai pagrįstos strategijos, apimančios įvairius planavimo lygmenis bei darnaus vystymo(-si) komponentus.

Stūksantys apleisti pastatai yra stambūs antropogeninio kraštovaizdžio vizualinės taršos objektai, kelia grėsmę žmonių saugumui, didina socialinę įtampą, sukelia materialinius nuostolius. Planuojant šių pastatų racionalų naudojimą, būtina atsižvelgti ne vien tik į ekonominę naudą. Tokių objektų tvarkymas turi būti sprendžiamas kompleksiskai, įvertinant technines ir netechnines sąlygas, t.y. pagal darnios statybos principus, darnaus teritorijų ir visuomenės vystymo(-si) kontekste. Reikalingi moksliniai tyrimai ir jų pagrindu parengtos taikomosios priemonės, kurie padėtų priimti efektyvius apleistų pastatų tvarkymo ir naudojimo sprendimus. Reikia parengti kompleksinį modelį, apimančią įvairius darnaus vystymo(-si) komponentus.

Modelis suprantamas kaip loginių ir matematinių ryšių visuma, aprašanti nagrinėjamo proceso funkcionavimą ir galimus pokyčius bei jų pasekmes įvairiomis sąlygomis, atsižvelgiant į turimą praktinį patyrimą ir padarytas teorines prielaidas. Modeliavimo eigą sudaro etapai: siekiamo tikslo nustatymas, pradinės informacijos sukaupimas, nagrinėjamą procesą ribojančių bei reguliuojančių sąlygų priėmimas, struktūrinės ir funkcinės schemos sudarymas, prognozavimo metodų parinkimas ir gautų rezultatų vertinimas (pagal Malinvaud, Aivazian ir Mkhitarian, Martišių, Davis).

Tyrimų objektas – nenaudojamų, apleistų pastatų atnaujinimas kaip kompleksinis procesas; racionalių apleistų pastatų tvarkymo sprendimų paieška darnaus vystymo(-si) požiūriu.

Darbo tikslas – sudaryti kompleksinį modelį apleistų pastatų racionaliam naudojimui modeliuoti ir vertinti, skirtą daugiataksliams pastatų tvarkymo uždaviniams darnaus vystymo(-si) kontekste spręsti, padedantį priimti technologiškai įgyvendinamus, užtikrinančius socialinį progresą, įgyvendinančius suinteresuotų grupių poreikius, nedarančius žalos gamtinei aplinkai bei padedančius išlaikyti aukštą ekonominio augimo ir užimtumo lygį racionalius sprendimus.

Siekiant sudaryti efektyvų modelį, keliami šie **uždaviniai**:

- Išnagrinėti nenaudojamų pastatų pertvarkymo pagal darnaus vystymo(-si) principus teoriją ir praktiką, nustatyti trūkumus ir tobulintinas sritis, suformuluoti esmines modelio planines – technines prielaidas.
- Išanalizuoti darnaus vystymo(-si) bei darnios statybos koncepciją, darnos rodiklių sistemas ir jų formavimo procesą. Remiantis atlikta analize, parengti rodiklių sistemą pastatų tvarkymo variantams aprašyti.
- Atlikti metodų ir priemonių, taikomų darnaus vystymo(-si) ir darnios statybos uždaviniams spręsti, analizę. Pasiūlyti matematinį algoritmą apleistų pastatų tvarkymo alternatyviems sprendimams įvertinti, atsižvelgiant į uždavinio daugiatakslį pobūdį bei neapibrėžtumą.
- Pagrįsti teritoriškai diferencijuotą apleistų objektų tvarkymo koncepciją.
- Įvertinti apleistų pastatų naudojimo sprendinių rezultatų tikslumą ir patikimumą.
- Pritaikyti sudarytą modelį apleistų Lietuvos kaimo statinių racionaliam tvarkymui spręsti.
- Išnagrinėti galimybes integruoti daugiatakslių sprendimų priėmimo metodus ir geografinių informacinių sistemų (GIS) technologijas, sprendžiant apleistų pastatų naudojimą.

Tyrimų metodika. Tyrimai atlikti taikant sisteminio požiūrio ir sisteminės analizės metodologinius principus. Racionaliam apleistų pastatų

naudojimui nustatyti taikomi daugiatisliai sprendimų priėmimo metodai (artumo idealiam taškui, daugiakriterinio kompleksinio proporcingo projektų įvertinimo ir kompromisinis rangų nustatymo) ir neapibrėžtųjų aibių teorijos elementai. Daugiatislės analizės rezultatams įvertinti naudojama matematinė statistika, vidurkio, Borda, Copeland ir kartotinės selektonovacijos metodai. Apibendrinti duomenys apie apleistus Lietuvos kaimo statinius nustatyti faktinių ir oficialių statistinių duomenų analizės būdu. Statinių teritorinės sklaidos analizė atlikta matematiniais statistiniais (koreliacijos, daugianarės žingsninės tiesioginės ir atvirkštinės regresijos, pagrindinių komponenčių) metodais.

Mokslinis darbo naujumas:

- Apleistų pastatų tvarkymas sprendžiamas darnaus vystymo(-si) aspektu, derinant inžinerinius – techninius, ekonominius, socialinius ir gamtinės aplinkos komponentus.
- Pasiūlytas teorinis darnos rodiklių sistemos modelis apleistų pastatų racionaliam naudojimui pagrįsti.
- Darniam pastatų naudojimui modeliuoti pritaikyti daugiatisliai sprendimų priėmimo metodai.
- Pasiūlyta daugiatislę apleistų pastatų naudojimo analizę esant neapibrėžtumui papildyti neapibrėžtųjų aibių teorija. Pirmą kartą neapibrėžtųjų aibių teorijos elementai integruoti į daugiakriterinio kompleksinio proporcingo projektų įvertinimo ir kompromisinį rangų nustatymo metodus.
- Parengta metodika alternatyvų santykinio reikšmingumo, kaip rodiklių reikšmių funkcijos, tikslumui įvertinti.
- Matematiniais statistiniais metodais įvertinti apleistų pastatų racionalaus naudojimo daugiatislių uždavinių rezultatų objektyvūs (ne)sutapimai.
- Apleistų pastatų naudojimo sprendimų efektyvumui padidinti integruotos daugiatislių sprendimų priėmimo metodų ir geografinių informacinių sistemų technologijos.

Teoriniai ir praktiniai darbo rezultatai:

- Sudaryta universali hierarchinė darnos rodiklių sistema apleistų pastatų racionaliam naudojimui įvertinti, apimanti darnios statybos, vietovės bei vietos bendruomenės darnaus vystymo(-si) idėją.
- Parengtas apleistų pastatų racionalaus naudojimo daugiatislio vertinimo proceso, esant neapibrėžtumui, algoritmas.
- Parengta originali metodika pastatų tvarkymo alternatyvų santykinio reikšmingumo tikslumui ir (ne)sutapimams įvertinti, kuri gali būti taikoma įvairaus pobūdžio daugiatislių uždavinių rezultatams analizuoti.

- Sudarytas teorinis kompleksinis modelis apleistų pastatų racionaliam naudojimui modeliuoti ir vertinti, skirtas daugiatisliams pastatų tvarkymo uždaviniams darnaus vystymo(-si) kontekste spręsti.
- Modelis pritaikytas apleistų Lietuvos kaimo statinių racionaliam sutvarkymui analizuoti. Nustatyti apleistų Lietuvos kaimo statinių tvarkymo prioritetai, diferencijuoti skirtingo raidos aktyvumo regionuose.
- Sudarytas integruoto GIS ir daugiatislių sprendimo priėmimo metodų taikymo racionaliam apleistų Lietuvos kaimo pastatų naudojimui vertinti bandomasis modelis.

Darbo aprobavimas ir praktinis rezultatų naudojimas. Disertacijoje išdėstytų tyrimų rezultatai paskelbti 19 mokslinių publikacijų Lietuvos ir užsienio recenzuojamuose periodiniuose mokslo leidiniuose bei konferencijų leidiniuose. Pagrindiniai darbe nagrinėjami aspektai ir suformuluoti teiginiai pristatyti 4 tarptautinėse ir 8 respublikinėse konferencijose.

Kai kuri darbe išdėstyta medžiaga panaudota mokymo procese (Subalansuota teritorijų plėtra STSM02305), rengiant bakalaurų ir magistrų baigiamuosius darbus.

Apimtis ir struktūra. Darbą sudaro įvadas, keturi skyriai, išvados ir pasiūlymai, literatūros šaltinių sąrašas (401 šaltinis), autorės mokslinių publikacijų sąrašas (19 publikacijų) ir reziumė anglų kalba. Darbo apimtis – 165 psl.

Pirmajame skyriuje konstatuota pastatų racionalaus naudojimo problema ir pagrįsta apleistų pastatų atnaujinimo svarba darnaus vystymo(-si) požiūriu. Analizuojama darnaus vystymo(-si) bei darnios statybos koncepcija, principai, rodiklių sistemos ir jų formavimo procesas. Išnagrinėta nenaudojamų statinių pertvarkymo pagal darnaus vystymo(-si) principus teorija ir praktika, daugiatislės sprendimų metodikos taikymo galimybės darnios statybos uždaviniams spręsti.

Antrajame skyriuje nustatyti apibendrinti duomenys apie neūkiškai laikomus ir šeiminkų neturinčius Lietuvos kaimo statinius. Matematiniais statistiniais metodais atlikta statinių teritorinės sklaidos analizė ir nustatyti teritoriškai diferencijuoti sklaidos ypatumai.

Trečiajame skyriuje sudarytas kompleksinis modelis racionaliam apleistų pastatų naudojimui nustatyti: suformuluoti modelio planiniai – techniniai sprendimai, pastatų tvarkymo variantų formavimo principai, sudarytas darnos rodiklių sistemos modelis pastatų tvarkymo variantams įvertinti, pasiūlytas daugiatislio sprendimų priėmimo, esant neapibrėžtumui, algoritmas.

Ketvirtajame skyriuje pagal sudarytą teorinį modelį atliktas eksperimentinis apleistų Lietuvos kaimo statinių naudojimo modeliavimas ir

vertinimas. Pasiūlyta metodika daugiatislio vertinimo rezultatų tikslumui nustatyti ir (ne)sutapimų analizei atlikti. Parengtas eksperimentinis pavyzdys, pritaikant GIS technologijas daugiatisliam pastatų naudojimui modeliuoti.

Išvados ir pasiūlymai

1. Atlikta analizė rodo, kad mokslinėje literatūroje darni statyba traktuojama gana siaurai, iškeliami techniniai klausimai, kurie kai kada siejami su gamtine aplinka, tačiau beveik nevertinami socialiniai ir kiti žmoniškieji aspektai. Literatūroje sureikšminami darnos reikalavimai naujai statybai, rekonstrukcijos darbus paliekant antrame plane.
2. Siekiant efektyviai ir visapusiškai spręsti aktualų apleistų pastatų sutvarkymo ir naudojimo ateityje klausimą, siūlomas originalus autorės sudarytas kompleksinis modelis daugiatisliams racionalaus pastatų naudojimo uždaviniams darnaus vystymo(-si) kontekste spręsti, padedantis priimti technologiškai įgyvendinamus, užtikrinančius socialinį progresą, įgyvendinančius suinteresuotų asmenų poreikius, nedarančius žalos gamtinei aplinkai bei padedančius išlaikyti aukštą ekonominio augimo ir užimtumo lygį racionalius sprendimus.
3. Matematiniais statistiniais metodais atliktų apleistų Lietuvos kaimo statinių pasiskirstymo ypatumų tyrimo rezultatai rodo, jog su tikimybe $p = 0,95$ galima teigti, kad pagal krašto erdvinės raidos pobūdį skirtingose ekonominio socialinio vystymo(-si) teritorijose neūkiškai naudojamų bei šeimininkų neturinčių kaimo statinių sklaidos ir ūkinių, ekonominių, socialinių rodiklių koreliacinės priklausomybės struktūros yra skirtingos.
4. Įvertinant regioninius skirtumus šalies teritorijoje bei nustatytus neturinčių šeimininko ir neūkiškai naudojamų Lietuvos kaimo statinių teritorinės sklaidos ypatumus, siūloma, rengiant bendrą ir diferencijuotą detaliąją apleistų objektų bei jų aplinkos tvarkymo koncepciją, statinių racionalų naudojimą spręsti diferencijuotai, atsižvelgiant į vietovės socio-ekonomines sąlygas ir raidos potencialą, kad objektų pertvarkymas teigiamai veiktų ekonominius ir socialinius procesus bei gamtinę aplinką vietovėse bei įneštų indėlį į visos šalies darnų išvystymą.
5. Pagal išanalizuotą nenaudojamų statinių pertvarkymo darnios statybos kontekste teoriją bei praktiką ir atliktus tyrimus, nustatytos esminės planinės – techninės prielaidos pastatų rekonstravimo bei ateities naudojimo ar išmontavimo alternatyviems sprendiniams, aprašytiems atitinkama rodiklių sistema, suformuoti. Sudarytas pastatų sutvarkymo alternatyvas siūloma įvertinti inžineriniais – techniniais, socialiniais, ekonominiais bei aplinkos aspektais, t.y. darnaus vystymo(-si) požiūriu.

6. Atlikus esamų darnaus vystymo(-si) rodiklių sistemų bei modeliujamų objektų analizę nustatyta, kad esamos darnaus vystymo(-si) rodiklių sistemos neapima visų konkrečiam sprendimui aktualių komponentų, retai integruoja inžinerinius – techninius ir netechninius aspektus, todėl yra sunkiai pritaikomos apleistų pastatų naudojimo alternatyviems sprendimams įvertinti. Autorės pasiūlyta originali hierarchinė rodiklių sistema, aprašanti pastatų tvarkymo variantus, atspindinčius darnios statybos idėją ir įnešančius indėlį į vietovės bei vietos bendruomenės darnų vystymą(-si).
7. Teorinių tyrimų metu nustatyta, kad darnios statybos alternatyviems technologiniams, organizaciniams ar valdymo sprendiniams objektyviai įvertinti tinkami daugiataksiškai sprendimų priėmimo metodai. Atsižvelgiant į su darniu vystymu(-si) susijusį neapibrėžtumą ir nepastovumą, pasiūlyta pritaikyti neapibrėžtųjų aibių teorijos elementus daugiataksiškiems uždaviniams neapibrėžtose situacijose spręsti.
8. Siūloma daugiatakslę apleistų pastatų naudojimo analizę esant neapibrėžtumui atlikti artumo idealiam taškui metodu (TOPSIS), papildytu neapibrėžtųjų aibių elementais bei pirmą kartą pasiūlyta neapibrėžtųjų aibių teoriją pritaikyti daugiakriterinio kompleksinio proporcingo projektų įvertinimo metode (COPRAS) ir kompromisiniame rangų nustatymo metode (VIKOR).
9. Nustatyta, jog nenaudojamų statinių atgaivinimą arba jų likvidavimą darnaus šalies vystymo kontekste galima pagrįsti atsižvelgiant į šalies, kaip daugialypės socialinės, ekonominės ir ekologinės sistemos, raidos problemas bei prioritetus. Todėl pasiūlyta lingvistiniais kintamaisiais įvertinti alternatyvių sprendimų atitikimą regionų plėtros strategijoms. Rodiklių reikšmingumus siūloma nustatyti pagal matematiniais statistiniais metodais apskaičiuotą nagrinėjamų rodiklių priežastinių ryšių stiprumą regionuose.
10. Atlikus skaičiavimus pasiūlytais daugiataksiškių sprendimų priėmimo metodais, papildytais neapibrėžtųjų aibių teorijos elementais, nustatyta, kad ne visais atvejais nagrinėtų apleistų pastatų tvarkymo alternatyvų prioritentinė eilė regionuose sutampa. Geriausiai ir blogiausiai vertinamų alternatyvų santykinio naudingumo laipsnio skirtumas 18 – 55 procentai, todėl svarbu objektyviai priimti potencialiai geriausių pastatų tvarkymo sprendimą.
11. Objektyviems pastatų tvarkymo variantų rangų (ne)sutapimams įvertinti apskaičiuoti Spirmeno ranginės koreliacijos koeficientai ir nustatyta, jog visi koreliacijos koeficientai su 95 proc. tikimybe statistiškai reikšmingi,

t.y. negalime teigti, kad poromis lyginami metodai pateikia skirtingus alternatyvių sprendinių prioritetus.

12. Nustatyta, kad daugiakriterinio kompleksinio proporcingo projektų įvertinimo metodo (COPRAS) ir artumo idealiam taškui metodo (TOPSIS), naudojant vektorinį bei tiesinį rodiklių reikšmių normalizavimą, rezultatus siejantys Spirmeno ranginės koreliacijos koeficientai gali būti su tam tikra tikimybe laikomi tapačiais ir priklausančiais bendrai vienaalytei koreliacinei erdvei, todėl daugiatislio vertinimo rezultatai su tam tikra tikimybe gali būti laikomi sutampančiais.
13. Pagal suformuluotus rezultatų neprieštaravimo įvertinimo kriterijus nustatyta, kad, sprendžiant pastatų racionalaus naudojimo uždavinį ir esant rezultatų, gautų skirtingais metodais, skirtumams, galutinį sprendimą, atsižvelgiant į iširtą rezultatų (ne)prieštarumą, verta priimti suteikiant prioritetą COPRAS ir TOPSIS rezultatams. Eksperimentinėje imtyje šiais metodais geriausiai įvertintos alternatyvos sutapo 59 proc., o visa prioritetų eilutė 43 proc. atveju.
14. Parengta originali metodika ir įvertintas alternatyvų santykinio reikšmingumo, kaip rodiklių reikšmių funkcijos, tikslumas, sprendžiant daugiatislį apleistų pastatų racionalaus tvarkymo uždavinį TOPSIS metodu. Nustatyta, kad apleistų pastatų tvarkymo alternatyvų santykiniai atstumai iki idealaus sprendinio, kurių santykinis naudingumas skiriasi 1 – 3 proc., esant pradinių duomenų vidutinėms kvadratinėms paklaidoms 2 – 4 proc. nustatytos rodiklių vertės, gali būti laikomi sutampančiais jų nustatymo paklaidų ribose.
15. TOPSIS metodo, taikant tiesinį rodiklių reikšmių normalizavimo būdą, rezultatų tikslumas nustatytas mažesnis, nei taikant vektorinį rodiklių normalizavimą. Atsižvelgiant į apskaičiuotas apleistų pastatų tvarkymo alternatyvų santykinio atstumo iki idealaus sprendinio vidutinės kvadratinės paklaidas, tiesinio normalizavimo atveju santykinio reikšmingumo skirtumas 0,01 dydžiu gali būti laikomas statistiškai nereikšmingu, esant rodiklių vidutinėms kvadratinėms paklaidoms, lygioms apie 2 proc. pradinių rodiklių verčių. Vektorinio normalizavimo atveju 0,01 santykinio reikšmingumo skirtumas laikomas nereikšmingu, kai pradinės paklaidos 4 – 5 proc.
16. Atlikus rezultatų vertinimą vidurkio, Borda ir Copeland metodais nustatyta, jog vertinimo metu neatsižvelgiama į alternatyvų santykinio reikšmingumo skirtumus. Norint priimti objektyvų ir moksliskai pagrįsta sprendimą, nustatant potencialiai geriausius apleistų pastatų tvarkymo variantus regionuose, pasiūlyta taikyti kartotinį selektonovacijos uždavinį.

17. Atsižvelgiant į išnagrinėtus daugiatislės analizės rezultatus esant neapibrėžtumui, nustatytus (ne)sutapimus, (ne)prieštarumą ir tikslumą, vidurkio, Borda, Copeland ir selektonovacijos kartotinio metodų rezultatus, padarytos apibendrintos išvados dėl diferencijuoto apleistų Lietuvos kaimo statinių tvarkymo trijuose skirtingo raidos aktyvumo regionuose, taikant esamo regiono potencialo palaikymo ir netolygios raidos balansavimo strategijas.
18. Nustatyta, jog pastatų panaudojimo sprendimų efektyvumą galima padidinti integruojant daugiatislių sprendimų priėmimo metodų ir geografinių informacinių sistemų (GIS) technologijas. Parengtas eksperimentinis tokios sistemos elementų pavyzdys ir nustatyta, jog dėl duomenų kaupimo, analizės ir pateikimo galimybių verta GIS naudoti kaip papildomą priemonę apleistų pastatų racionalaus naudojimo klausimams spręsti daugiatisliais sprendimų priėmimo metodais.

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