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A SIPOC based model for the sustainable management of facilities in social housing

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Abstract. Following the collapse of the Union of Soviet Socialist Republics (USSR), the former Soviet Republics took over a significant number of real estates and social housing. In order to optimize the management of these properties and their facilities, the requirement arose for the development of intelligent sustainability management schemes. In process improvement, a SIPOC (suppliers, inputs, process, outputs, customers) is a tool that can summarize the inputs and outputs of one or more processes in table form, and is considered to be one of the most important tools that can be used to identify at a high level the potential deficiencies between what a process expects from its suppliers and what customers expect from the process. The purpose of this study is to present a SIPOC based model for the sustainable management of facilities in social housing, focusing on the case of Lithuania, an EU member and a former Soviet Republic. The case of Lithuania is of a great significance, as it combines in its building stock elements of the architecture of the former USSR, as well as it complies with the current EU legislative requirements concerning the energy and sustainability performance of the building sector. In this study, the major steps for the development of a SIPOC system for assessing the facilities management, focused mainly on social housing, are presented. The rationale behind the selection of specific requirements is elaborated and analysed. A total of 30 requirements, categorised in legislative, municipality-driven and additional requirements, were selected. The survey conducted among 43 experts for the selection of the SIPOC model requirements is presented. This study also presents the definition of the relevancies of the assessment criteria by pairwise comparison based on the Analytic Hierarchy Process (APH) by using pairwise comparison matrices, completed by experts, which resulted to the rating of the criteria. The findings of this study aspire to deliver a comprehensive model, which may be applied for the assessment of facilities management in EU member states, as well as in former Soviet Republics.

1. Introduction

The sustainability assessment of the built environment constitutes a major challenge of the scientific community. This assessment addresses a major misinterpretation often implemented by scientists and practicing engineers, which confuse sustainability with the energy performance of the built environment. The energy assessment of the built environment constitutes only one analysis parameter of the sustainability evaluation, however much more aspects should be included in a comprehensive assessment of the sustainable performance of the built environment. Some well-established schemes for the sustainable assessment of the built environment, such as BREEAM, LEED and DGNB have



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already been developed and are widely implemented worldwide. However these schemes are more commercially oriented towards new buildings. To this end the evaluation of the sustainable performance of existing buildings, which may for example be operated by public bodies, is a subject which needs to be further addressed and developed.

In this study, a new sustainability assessment scheme for public buildings was developed. This scheme took into consideration specific aspects of the building stock of Lithuania, a former USSR state and an EU member state, which needs to cope with all requirements, directives and legislations of the European Committee in the field of the energy performance of the built environment. The purpose of this study is to present this scheme and to elaborate its major aspects. Future works will follow with the implementation of this scheme on specific case studies.

2. Sustainability Assessment of Public Buildings – A Review

In this section, a comprehensive review on existing models and studies concerning the sustainability assessment of buildings of the public sector is provided.

In the study of Hakkinen et al. [1] the role of municipal steering in sustainable building and refurbishment is described. The study emphasizes the need of appropriate training mechanisms, as well as of the requirement of sufficient resources to achieve sustainable buildings in the public sector. Particularly the study examined the role that the local authorities will have in the improvement of the awareness and commitment of stakeholders to help them understand the potentials of sustainable buildings. The study revealed that workers involved in construction projects should possess the required knowledge and background to implement practices which result to sustainable buildings at the pre-construction stage. Should sustainability be promoted only during the construction stage, the sustainability level of the buildings was found to be inadequate. Building control authorities need more and continuous training in order to maintain the ability to give guidance in a situation where new demanding requirements are constantly stated for sustainable building. According to this study, the traditional role of municipalities as an enforcer of national building regulations is changing.

Carvalho et al [2] discussed on the essential role of the sustainability aspects of Building Information Model (BIM) in the Architecture, Engineering, and Construction industry towards optimizing buildings performance and reducing its environmental impacts. In this study practical ways of integrating building sustainability assessment (BSA) schemes into BIM tools are discussed and presented. Particularly the study introduces and presents a tool, named SBToolPT. Overall in this study, it was revealed that even though BIM is still not oriented to building sustainability, it has great potential in this field. The study shows that with the integration of BSA into BIM models, the sustainability assessment is articulated with all the other project disciplines, improving information-sharing among stakeholders. The assessment of buildings from designers will be able to assess buildings sustainability from the early stages of the project, allowing a sustainable oriented decision making on the construction of the building. The restrictions observed in this approach include the neighbourhood modulation and the technique to aggregate the results from several different software, which may not be compatible among them.

Prodanuks and Blumberg [3] described a methodology of municipal energy plans for district heating systems. This methodology was probated in one municipality in Latvia and three midterm development scenarios have been analyzed using sustainability indicators. The methodology consisted of several steps, whereas in this study the TOPSIS method is used to establish the best scenarios for supplying hot water load in DH system. From three scenarios the results show that the installation of new wood chip boiler is the most preferable scenario for municipality.

In the study of Kamari et al. [4], aspects of sustainability focused decision-making in the field of building renovation are discussed. An overview of recent research related to building renovation in this study reveals the fact that efforts to date do not address sustainability issues comprehensively. In this study a multi-dimensional approach involving literature review is adopted, for the exploration of existing assessment methods and methodologies, individual and focus group interviews, and application of Soft Systems Methodologies (SSM) with Value Focused Thinking (VFT). The study is

base on a Delphi approach and a sustainability framework, developed to audit, develop and assess building renovation performance. The special feature of this model is that it can be applied during different project stages to assist in the consideration of the sustainability issues through support of decision-making and communication with relevant stakeholders.

Simcoe and Toffel [5] studied the influence of government green procurement policies on the private-sector demand and specifically, the impact of municipal policies requiring governments to construct green buildings on private-sector adoption of the LEED standard. The authors employed matching methods, panel data, and instrumental variables, in order to define how government procurement rules produce spill over effects that inspire both private-sector implementation of the LEED standard and investments in green building know-how. These findings suggest that government procurement policies can accelerate the diffusion of new environmental standards that require coordinated complementary investments by various types of the private adopter.

In the study of Cohen et al. [6] the relationship between satisfactions with information provided by the local municipality and community resilience scores measured using the Conjoint Community Resilience Assessment Measure (CCRAM) is studied. Adults living in small to mid-sized communities were interviewed, revealing that the CCRAM score was positively correlated with satisfaction with the information received from the municipality. Linear regression models were used to define the dependent variable CCRAMscore. The findings of this study emphasize the importance of the information provided by the municipal authorities to the population to enhance resilience for emergencies.

Valente et al. [7] introduced a methodology to support the production of Climate and Energy Plans in Norwegian municipalities. The main research question of this study is whether locally available woody biomass within the municipality, could cover the demand for heating in municipality buildings over the next 20 years. For this purpose, the following tools are exploited

- a geoprocessing tool for forestry (GEOSKOG)
- a methodology for environmental assessment (Life Cycle Assessment)
- a tool for processing geographical data (Geographical Information System).

This tool was combined with energy data of the investigated municipal buildings. The goal was to quantify the share of energy end-use (heat) that could potentially be replaced by bioenergy from forest logging residues and to calculate the potential GHG benefits from this substitution.

Annunziata et al. [8] investigated the role of local energy audit programmes to enhance energy efficiency in public buildings: Their study was based on a dataset of 322 municipalities in Northern Italy, we carried out a statistic. The authors implemented analysis to investigate which factors influence the adoption of energy efficiency in municipal buildings. Four categories of factors are examined in this study:

- (i) capacity building for energy efficiency,
- (ii) existing structure and competences for energy efficiency,
- (iii) technical and economic support for energy efficiency, and
- (iv) spill-over effect caused by adoption of “easier” energy-efficient measures.

The results of the study show that capacity building through training courses and technical support provided by energy audits is expected to affect positively the adoption of energy efficiency in municipal buildings.

Figure 1 presents an overview of the major trends in the sustainability assessment of public buildings, currently found in the scientific literature.

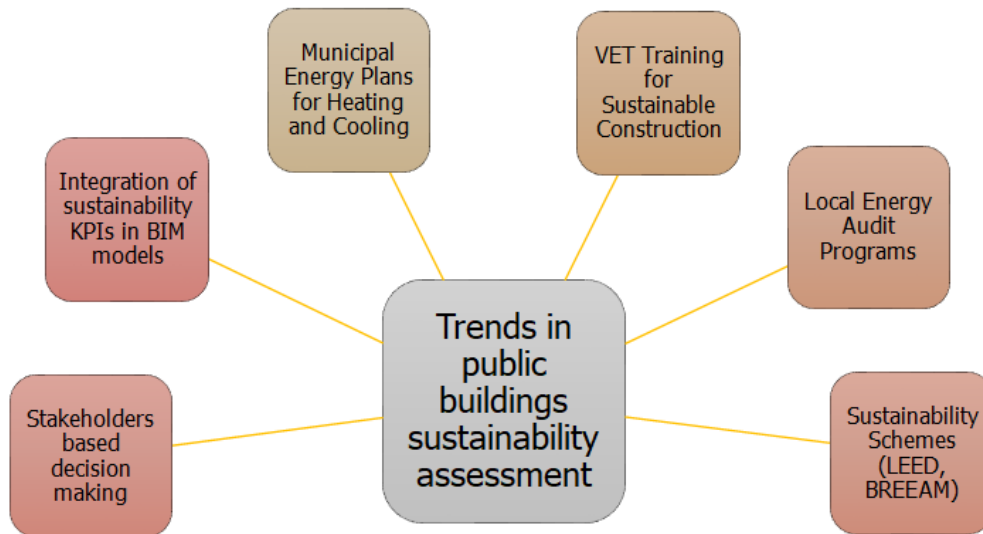


Figure 1: Trends in public buildings sustainability assessment scientific research

3. A SIPOC based model for the sustainable management of facilities in social housing

In order to use the property in accordance to specific quality standards, municipalities need to manage their real estate (RE) by applying strategic management principles directed at achieving public profit potency, rationality, and law. In terms of this study, a RE strategic management scheme for the Lithuanian municipalities was developed by the authors (Fig. 2). [9]. The proposed scheme was developed in collaboration with the Association of Municipalities of Republic of Lithuania and representatives of the municipalities of Vilnius, Kaunas, Birštonas, Klaipėda, Neringa and Plunge.

3.1. SIPOC based Model of Municipal Facilities Management

To develop a model which could be effectively pertinent at any company or organization, the stakeholders were identified, as well as the information and its yield procedure. The model was based on the SIPOC (supplier, input, process, output, and customer) principle (Table 1).

- Supplier – Systems, people, organizations, or other sources that provide data or information used in the process.
- Input - materials, information, additional resources provided by suppliers and used in the process.
- Process – A set of actions that change input data to output.
- Output – Products or services that are created during the process and used by customers.
- Clients – individuals, groups of individuals, companies, systems, or processes in the next stages, where final results are obtained [10].

According to Maier et al. (2017), the SIPOC method involves a matrix of processes to identify, characterize and assess the processes thus enabling the analysis and assessment of the aspects that should be improved or changed [10]. The method is convenient for the evaluation of particular solutions at the organizational level to increase the effectiveness of the regulatory processes. Information on every process is useful for the resource management and development of the processes, the desirable results of which are insufficient.

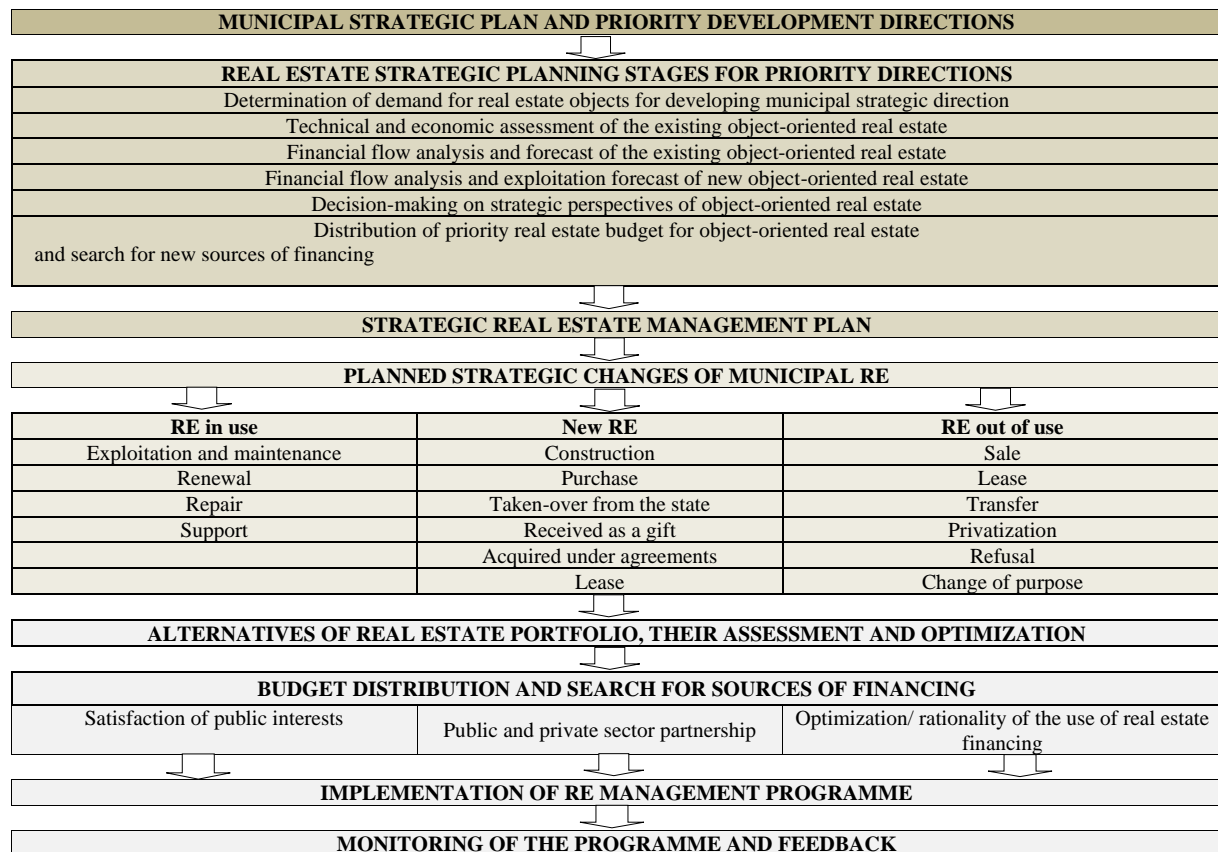


Figure 2: Strategic management plan of municipal RE (developed by the authors)

By developing a SIPOC based model for the sustainable management of facilities in social housing, process suppliers, input and output data, process and users are defined as shown in Table 2. The primary purpose of the model is to meet customer needs and requirements, which are:

- 1) Rationally, publicly, and effectively managed RE.
- 2) Prioritization of buildings and modeling of the selection of alternatives.
- 3) Proposals for municipal facilities management.
- 4) Publicly available asset management information system.
- 5) Simplifying RE management and planning.

The main goal of the model is that the output data should satisfy customer needs and requirements, i.e., the RE should be managed publicly, rationally, and effectively. The priority queues of the facilities are made, the selection of alternatives is modeled, the offers for facilities management are made, and a public access real estate management information system is launched, as a result of which, the RE management and planning becomes more effortless.

3.2. Municipal Facility Assessment Method

The model developed for the assessment of municipal facilities involves the system of requirements applicable to the municipal facilities and the methods of identifying the compliance of the facilities with the applicable requirements and the rating of the facilities based on their compliance with the requirements (Fig. 3).

Table 1. SIPOC model of municipal facilities management process (developed by the authors)

Supplier	Input	Process	Output	Customer
Seimas of the RL	Legal requirements	Selection of requirements for facilities	Making the RE priority queue	
Ministry of Environment	STR requirements			
Ministry of Health	Requirements of hygiene norms			
Lithuanian Builders Association	Construction regulations			
Municipality	Requirements for facilities			
Experts	Weights and relevance of requirements for facilities	Assessment of requirements following the expert method	Public accessed facility management information system	Municipality
		Selection of facilities assessment criteria	Rationally, publicly and effectively managed RE	
Technical maintenance managers	Technical facility assessment data	Technical assessment of facilities	Offers for facilities management	Tenants of social housing
Center of Registers	Statistical data			
Environmental protection Agency	Air pollution data			
“Kauno Energija” JSC	Statistical data			
Municipality	Requirements for facilities; data; rent price data; list of the queue for accommodation; financing			
Information Technology and Communications Department	Statistical data			
Independent RE assessor	Facility price data			
Statistics Lithuania	Statistical data			
			Simpler RE management and planning	Society

The authors identified the main stages of the model, which are the following:

1) Development of the arrangement of requirements appropriate to municipal facilities based on legal regulations, corporate functions, and additional requirements. The documents related to the use of municipal residential buildings were analysed.

The requirements for municipal social housing selected from the residential building requirements outlined in the regulations, municipal, and other requirements that make a residential house more attractive and appealing to the residents. The requirements were clustered so that to lessen their amount. The residential building requirements amounted to a total of 106 requirements which were categorized into the following three groups:

- 43 legal requirements;
- 26 municipal requirements for residential buildings;
- 37 additional requirements.

Expert optimization of the requirements system was achieved by perceiving the essential requirements (fig. 4). Appraisal of a building based on 106 requirements would be a significant overwhelming assignment; hence, it was chosen to diminish the number of demands by selecting ten essential requirements from each group. For this reason, a poll based survey was prepared, and a team of 43 experts was interviewed, comprising of certified civil engineers, municipal officers who works in RE departments, and RE researchers. The RE characteristics were initially assessed on the grounds of the general criteria, then they were analyzed and evaluated as the most significant (rated one if most significant and rated ten if least pertinent).

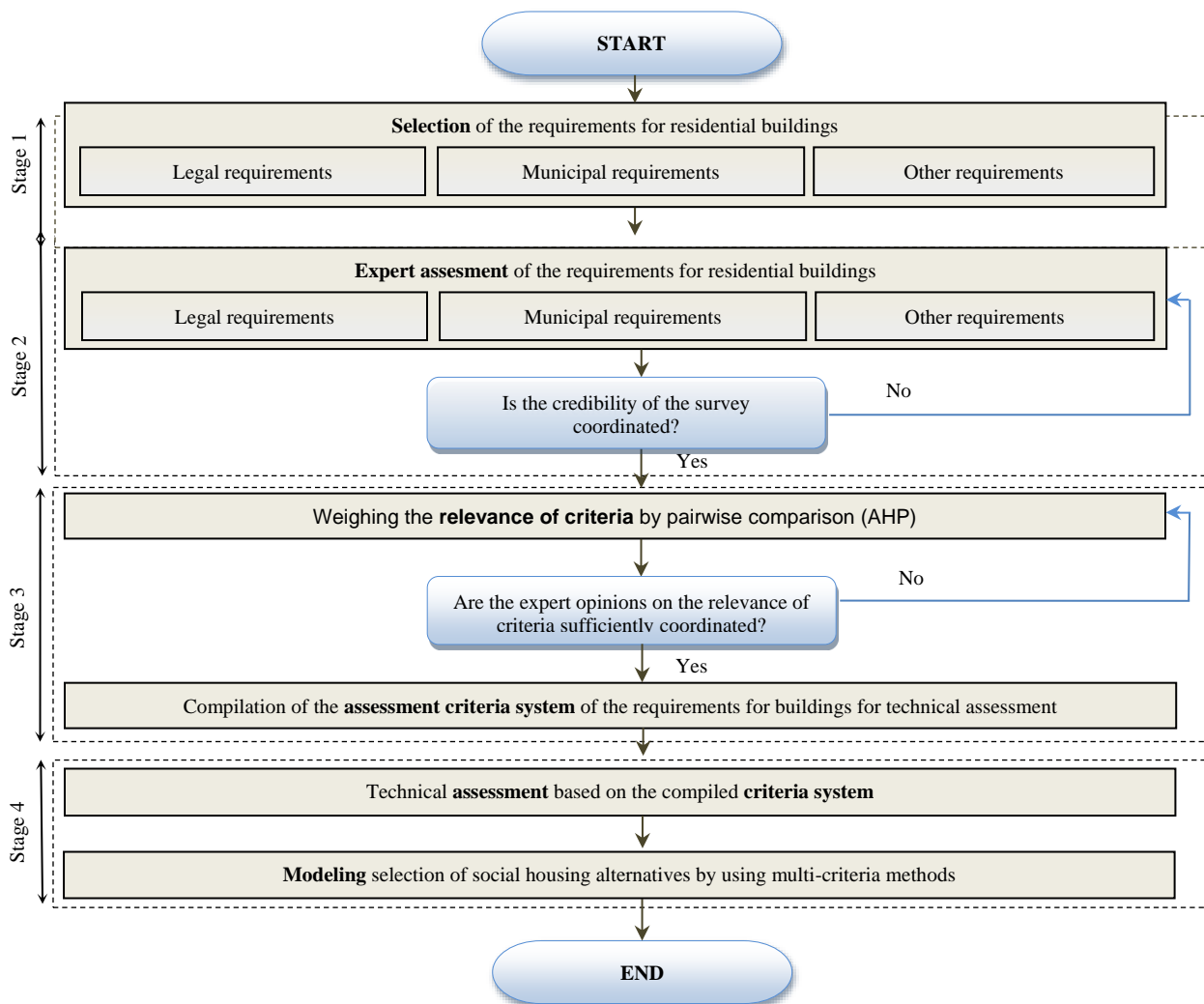


Figure 3: Implementation stages of the municipal facilities assessment model (developed by the authors)

2) Ten requirements of each group with the lowest score were selected after summing up the assessments given to the requirements in all the three categories by each and every expert (Table 2). The consistency of the survey was verified, and, upon receiving positive results, sets of the selected requirements were defined as criteria and were later used in the next stage of determining the respective relevancies.

3) Determination of the relevancies of the assessment criteria for municipal residential buildings (AHP, Analytic Hierarchy Process) by using pairwise comparison matrices completed by experts [11]. This method was chosen because the relevancy of the criterion revealed the expert's/specialist's opinion on the importance of the criterion when selecting the best alternative from the list of available options. The method is convenient to use as the criteria can be compared in pairs [12][13].

The third stage comprised of the following six smaller steps:

- 1) Compilation of the expert group for determining the relevancies of criteria by pairwise comparison;
- 2) Completing the pairwise comparison surveys to assess the relevancies of criteria;
- 3) Survey assessment (only suitably completed surveys of each group assessed);
- 4) Calculating the mean value of the relevancies (q_j^k) of the criteria determined by the experts;
- 5) Verification of survey coordination;

- 6) Development of the system of assessment criteria for residential buildings based on the calculated relevancies (fig. 5).

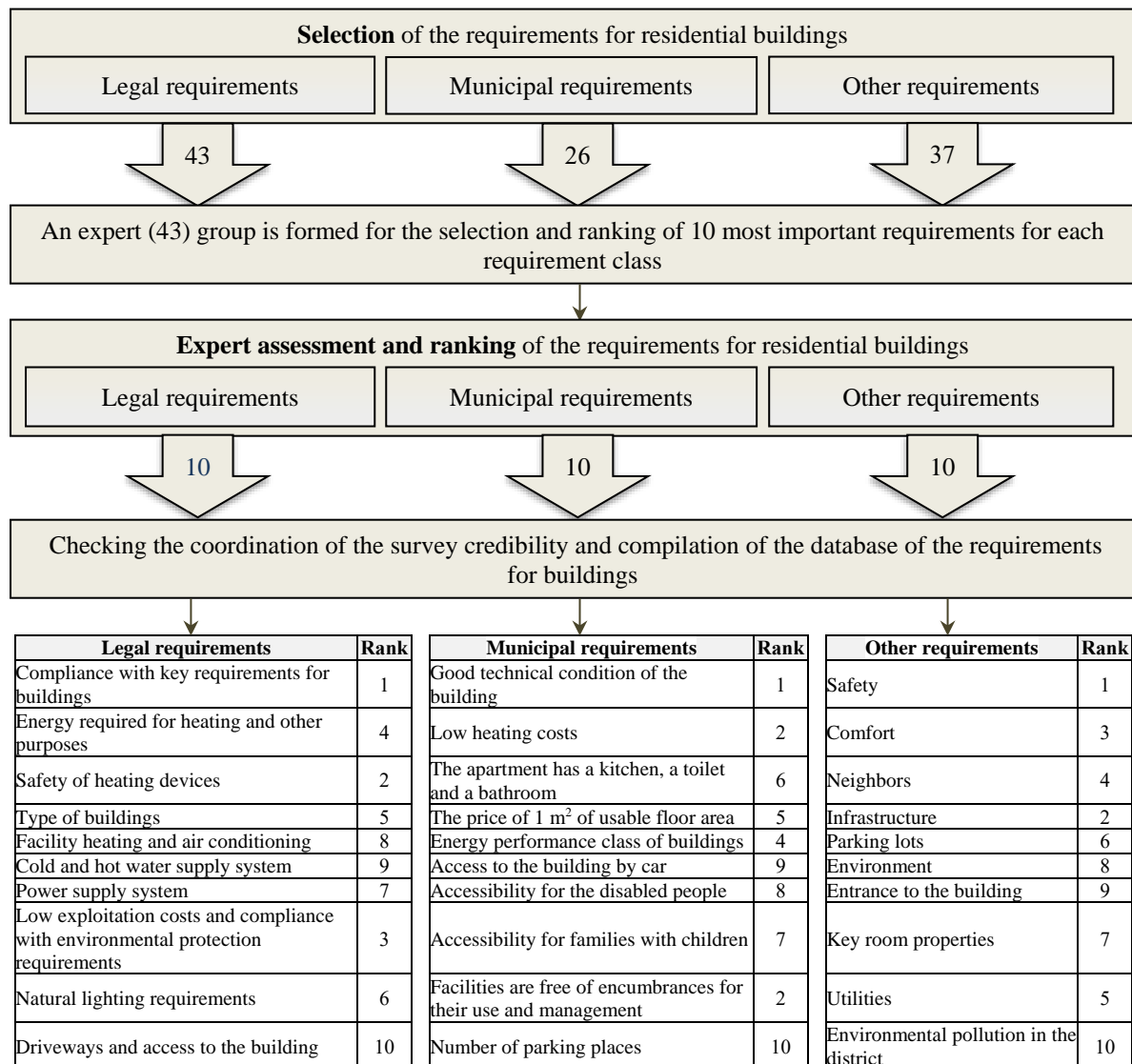


Figure 4: IInd stage of the municipal facilities assessment model (developed by the authors)

34 experts were requested to complete the pairwise comparison surveys. Each expert had to complete three pairwise comparison tables. The relevancies reflecting the opinion of each expert were determined, and the consistencies of the pairwise comparison matrices were verified by using the pairwise comparison table data and the AHP method. Out of 34 experts:

- 11 experts completed the pairwise comparison matrices and assessed the criteria of the building requirements outlined in regulations;
- 13 experts completed the pairwise comparison matrices and evaluated the needs of the municipal requirements;
- 10 experts correctly completed the pairwise comparison matrices and assessed the criteria of the additional requirements.

Consistency index S of the pairwise comparison matrices of the said experts either did not exceed 0.1 or exceeded it only slightly [13][14][15][16][17][18]. Any further calculations of criteria relevancies involved only the pairwise comparison matrices of these experts. Following the criteria relevancies measured based on expert data, the requirements rated.

The analysis revealed 30 essential criteria, delivering relevancies of the standards comprising the system of municipal facilities assessment criteria. This technique is utilized to hold out the technical assessment of the buildings, whereas multi-criteria methods accustomed perform the modeling of assets alternatives. It should be stated that the modeling of choices may be met by assessing all the thirty criteria at one time. The consistency among every team individually also can be evaluated to carry out the additional elaborated analysis. The developed model may be an expertly tailored to suit buildings of any type, or, in our case, to use to public social housing that has chosen because of the rationale that its management looks to boost the majority of issues for municipalities.

4) Authors suggest the use of multi-criteria methods to work out the priority queue. Then, the 25 % of buildings which might be within the back of the line would be analyzed, as a result of in step with the literature review and municipal real estate management follow roughly such an amount of the worst buildings impacted by the failure to fulfill the essential requirements.

Table 2. Ratings of the requirements for residential buildings

Legal requirements applicable to buildings		Rating
m1n	Compliance with key requirements for buildings	1
m2n	Energy required for heating and other purposes	4
m3n	Safety of heating devices	2
m4n	Type of buildings	5
m5n	Facility heating and air conditioning	8
m6n	Cold and hot water supply system	9
m7n	Power supply system	7
m8n	Low exploitation costs and compliance with environmental protection requirements	3
m9n	Natural lighting requirements	6
m10n	Driveways and access to the building	10
Municipal requirements applicable to residential buildings		
m1s	Good technical condition of the building	1
m2s	Low heating costs	2
m3s	The apartment has a kitchen, a toilet and a bathroom	6
m4s	The price of 1 m ² of usable floor area	5
m5s	Energy performance class of buildings	4
m6s	Access to the building by car	9
m7s	Accessibility for the disabled/people with special needs	8
m8s	Accessibility for families with children	7
m9s	Facilities are free of encumbrances for their use and management	2
m10s	Number of parking places	10
Other requirements applicable to residential buildings		
m1k	Safety	1
m2k	Comfort	3
m3k	Neighbors	4
m4k	Infrastructure	2
m5k	Parking lots	6
m6k	Environment (plants, children's playgrounds, rest areas)	8
m7k	Entrance to the building	9
m8k	Key room properties	7
m9k	Utilities	5
m10k	Environmental pollution in the district	10

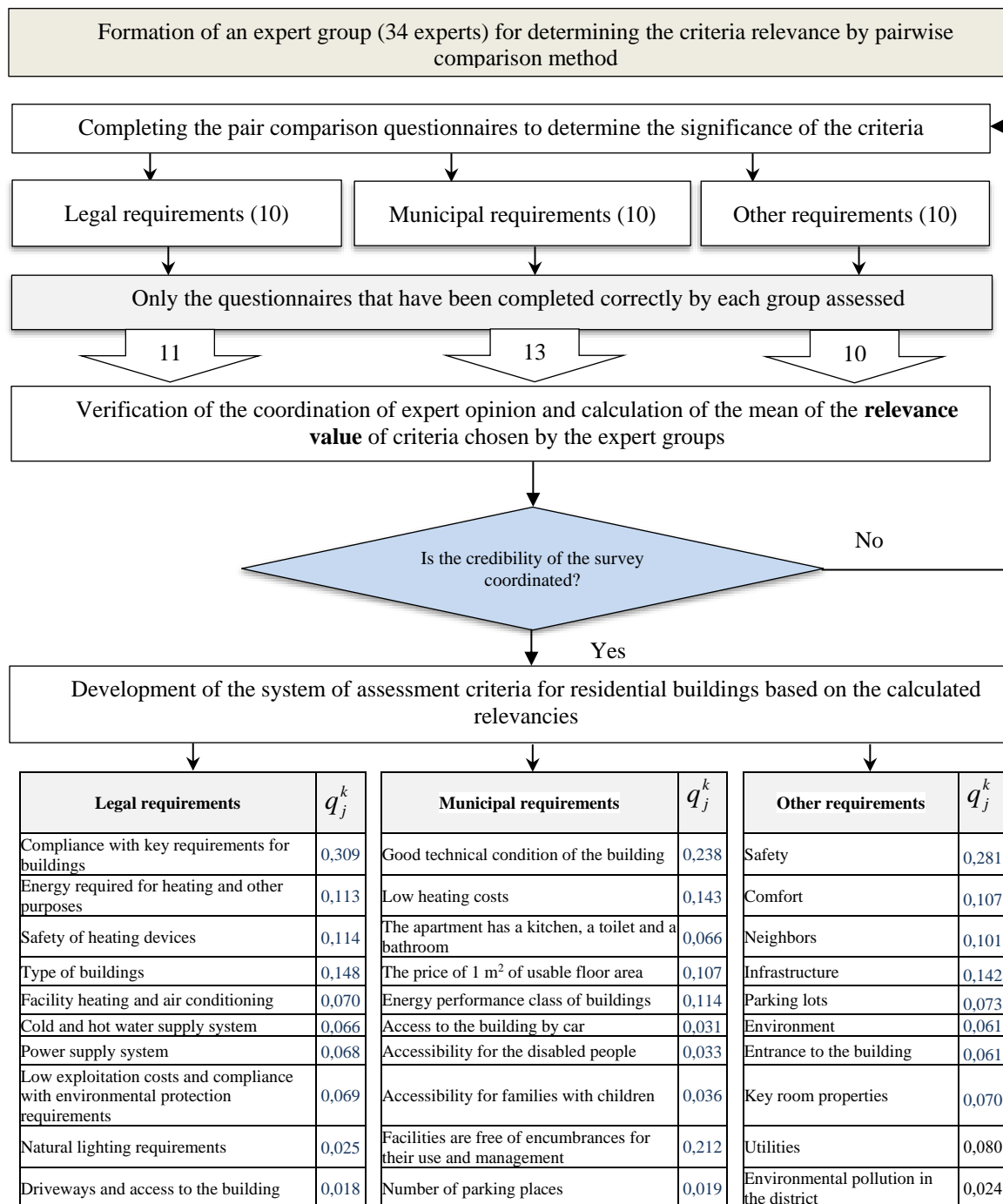


Figure 5: IIIrd stage of the municipal facilities assessment model (developed by the authors)

4 Conclusions

The review of scientific literature and regulatory documentation has revealed that efficient management of municipal property mainly requires complete information on property to be available, public presentation of the correlation of the RE with the functions entrusted to municipalities and reliance on modern decision-making approach when it comes to the analysis of RE management alternatives. The model of assessment of municipal real estate includes a system of requirements applicable to municipal buildings, evaluation of compliance of buildings to the set requirements, rating of buildings based on compliance with requirements in place and assessment of alternatives of decision-making when it comes to property management. After the analysis of the requirements of

municipal buildings (total - 106 requirements), pairwise comparison method has been used to select and rank ten each group requirements: 1) compliance with regulatory documentation; 2) requirements on municipal functions; 3) public administration requirements. An expert assessment has revealed that the most relevant indicator pointing to the legal compliance of municipal housing is meeting the essential requirements applicable to buildings and low heating costs, while the decision-making is least affected by the access to buildings and the number of parking places. For municipalities, the key criteria when looking for alternatives is the good condition of a building, while experts believe safety is the most important when considering other requirements apply.

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