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A Framework for Early Stages of Socially Sustainable Renovation of Multifamily Buildings with Occupants' Participation

Kosa Golić [1], Vesna Kosorić [2,3,4,*] and Siu-Kit Lau [5]

1 Faculty of Construction Management, University Union-Nikola Tesla, 11000 Belgrade, Serbia; kgolic@unionnikolatesla.edu.rs
2 Balkan Energy AG, 4656 Starrkirch-Wil, Switzerland
3 Daniel Hammer Architekt FH AG, 4600 Olten, Switzerland
4 BauLab GmbH, 4656 Starrkirch-Wil, Switzerland
5 Department of Architecture, National University of Singapore, Singapore 117566, Singapore; slau@nus.edu.sg
* Correspondence: vesna.kosoric@gmail.com; Tel.: +41-(79)-2712768

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Abstract: Research shows that in most cases occupants are not actively involved in the design process but only informed about the decisions already made. This paper proposes a framework for the early phases of socially sustainable renovation design of multifamily buildings enabling occupants' active and timely involvement by defining appropriate mechanisms for participation in a structured manner. It further considers the interdependence of the social, environmental and economic aspects of renovation design and underlines the significance of their simultaneous consideration. The presented research shows the existence of significant heterogeneity, complexity and interdependence of a number of factors that need to be considered in order to adequately conceptualize sustainable building renovations. Finally, the paper discusses future directions for the development of the proposed model.

Keywords: building diagnosis; building renovation; design optimisation; design process; early design stage; fuzzy multicriteria decision making; multifamily buildings; occupants' participation; social sustainability; socially sustainable retrofitting

1. Introduction

The environmental aspect, along with the economic aspect, has a greater focus in research compared to the social aspect [1–4], despite the increasing need for inclusion of the social sustainability dimension. Consequently, the currently available tools, techniques and methodologies supporting sustainable design and development are biased toward environmental sustainability [5]. Also, according to Diaz-Saratoga et al. [6], Kamari et al. [7], Missimer et al. [8], Pombo et al. [9] and Sierra et al. [10], among others, the social aspect of sustainability has not been sufficiently researched and the concept of social sustainability still remains vague [10–14]. A clear formulation of social sustainability goals is not an easy task and often diverges in different directions, causing difficulties in practical application [10].

For renovation projects to be sustainable (to encompass all three pillars of sustainability), it is important to focus on both the objective and subjective system of human values throughout the entire project life cycle [7]. According to Fricker [15], social sustainability is described as "the non-material aspect of life—the impulsive, emotional, inventive and spiritual, for which we need to engage all our ways of learning". Thus, social sustainability does not only refer to "social measures"; the social

aspect of sustainability is "first and foremost a negotiation process, a discourse for the design of the future" [16].

Implementation of the social dimension in a sustainable renovation process requires a different set of skills and instruments, as well as effective participation and communication of building occupants and other stakeholders [5]. Moreover, the social sustainability analysis needs to be integrated into the early phases of renovation planning in order to complement the environmental and economic analysis [7]. In that way, a more complete process can be conducted for the benefit of occupants, developers and building owners who will have the opportunity to compare alternatives and finally chose an option which offers significant long-term sustainability benefits in return for an acceptable increase in costs [5]. For example, the results of the surveys among Zurich residents [17,18] confirm that social sustainability principles are in line with the needs and expectations of the people. The residents of Zurich highly appreciate the spontaneous encounters in parks, bars, sport areas, etc., attaching high importance to the need for socialisation and belonging in addition to the need for identity reflected in the high appreciation of historical, cultural or architectural values of buildings [18]. The results of the surveys also demonstrate that the majority of residents value living with people of a different lifestyle more than with similar ones [17].

In practice, interventions in the existing built environment that are aligned with the social aspect of sustainability are highly demanding and still face many obstacles [19]. For example, until several years ago, the real estate industry in Switzerland placed the environmental dimension of sustainability at the forefront; however, they strongly emphasise the social dimension of sustainability today [17,19–21].

Thus, the main goal of this paper is to define a framework for the early stages of socially sustainable renovation of multifamily buildings, including all relevant elements: the characteristics of the building and its surroundings, socio-political and urban development trends and owners'/occupants' needs, by enabling their active and effective participation during the entire process. In addition, the framework will provide decision-makers with flexibility in defining project objectives based on their value system or by adopting the objectives and criteria defined in the assessment methods published in the literature. Moreover, it identifies and points to close interdependence with environmental, social and economic parameters and the need for simultaneous consideration of these three aspects in order to arrive at a well-founded project solution in terms of sustainability perspectives.

The model aims to provide support to designers, project managers and owners/investors in planning and decision-making during the early stages of multifamily building renovation and to enable occupants' timely and effective involvement by defining suitable mechanisms for participation in a structured manner.

In this paper, the term "renovation" or "retrofitting" will be used as a general term for improvement of the performance of an existing building; it can be in the form of rebuilding, refurbishing or retrofitting of a building as part of modernisation or adaptation to a changed use. Buildings of cultural or heritage value or buildings located in places of special value are of particular national interest and should be considered separately. Therefore, they are beyond the scope of this research.

The paper is structured as follows: after the introductory section, the review of relevant literature is presented in Section 2, followed by the description of the methodology in Section 3 and the results are presented in Section 4, while the discussion and conclusion are given in Section 5.

2. Literature Review

Environmental and economic aspects, as mentioned previously, still overshadow the social aspect of the sustainable retrofitting of multifamily buildings in both theory and practice [2]. Only in the last decade has the social dimension of sustainability received more extensive consideration, but there is still no general consensus about the main criteria and indicators, applicable renovation methodologies, tools and methods [7]. For example, based on the "Knowledge Matrix" [22], Mjörnell et al. [5] have developed social indicators focusing on the following six vital categories of social sustainability: "Cohesive city", "Social interaction, teamwork and meetings", "A well–functioning everyday life",

"Identity and experience", "Health and green urban environments" and "Safety, security and openness", which are further elaborated into 35 indicators in order to facilitate the social sustainability assessment of the renovation projects.

Kamari et al. [7] have analysed the most important theoretical methodologies for the renovation projects and the methods widely used in practice such as BREEAM (by British Research Establishment, LEED (by US Green Building Council), CASBEE (by Japan Sustainable Building Consortium), SBTool (by Natural Resource Canada), etc., (by applying "Soft Systems Methodology" [23,24] and "Value Focused Thinking" [25]), in order to establish their strengths and weaknesses, as well as to identify appropriate sustainability criteria categories, individual criteria and indicators. As a result of their research, the following six social sustainability categories are distinguished: "Aesthetics", "Integrity", "Identity", "Security", "Sociality" and "Spatial", which are further divided into 44 indicators.

Recently, in Atanda [26], a set of social sustainability categories and indicators has been established for assessing new residential buildings, based on the analysis of the key published researches, policy papers and assessment tools, by applying the Delphi method and structured interviews technique. The established categories are: "Social equity", "Environmental education", "Participation and control", "Social cohesion", "Health and safety", "Accessibility and satisfaction", "Cultural value" and "Physical resilience". These categories are further broken down into 12 criteria and 35 indicators. In addition, the weights and measurements for the established categories and indicators are determined by applying the multicriteria decision-making (MCDM) method Analytic Hierarchy Process (AHP). The author also provides a detailed literature review regarding the social sustainability criteria for design of new buildings.

In Nielsen et al. [27], a comprehensive overview of decision-support tools for the predesign and design phase of sustainable building renovation is provided together with the classification of their applicability in different areas of the decision–making process such as sustainability goals setting, weighting criteria, building diagnosis, building performance estimation, generation and evaluation of design alternatives.

On the other hand, according to some authors, Valdes-Vasquez and Klotz [28] and Vanclay [29] among others, no predetermined social criteria are required; they are only needed as references, since the concept of sustainability is a dynamic process and therefore many of the existing assessment methods and criteria are not applicable to different contexts. In [26] the following key factors are listed as barriers to the unique and widely adopted set of social sustainability criteria: difference in multicultural dimensions, climatic geography, limited amount of research in social sustainability related to the building assessment tools and most often the lack of expertise in construction and building sector. Moreover, the lack of a clear and comprehensive framework for assessing human needs and requirements as well as for establishing a relationship with certain design characteristics, render the social aspect still fuzzy and burdensome to apply in practice [30–33].

Furthermore, Alyami and Rezgui [34] have identified some of the factors that hinder wider applicability of the existing assessment methodologies including differences in: climatic conditions, geographical characteristics, potential for renewable energy gain, resource consumption (such as water and energy), construction materials and techniques used, characteristics of building stocks, government policy and regulation, appreciation of historic value, population growth, public awareness, etc.

Additionally, Chan and Lee [35] have highlighted certain factors whose absence impedes specifically socially sustainable urban development. These factors are as follows: (1) provision of infrastructure that generates opportunities for social interaction, (2) availability of job opportunities and employment for individuals (as a source of income with the working area serving as a place for social interaction), (3) ease of access to available infrastructure and residences with convenient traveling times, (4) aesthetics of the townscape that encourages communal social interactions, (5) preservation of local features for generations to come and aptitude to accomplish psychological necessities.

The Office for Urban Development Zurich first published in 2015, and subsequently updated in 2019, the guidelines "Erfolgreichsfaktoren sozial nachhaltiger Sanierungen und Ersatzneubauten"

(Success factors for socially sustainable renovation and rebuilding) [19], providing recommendations to investors, planners and administrative authorities about the requirements for socially sustainable renovation of multifamily buildings. The guidelines define the following four success factors: (1) affordable rents owing to cost reduction and space optimisation (space consumption per capita), (2) long-term renovation strategy and early communication, (3) promoting identity, community and living together and (4) ensuring diversity and flexibility of use.

3. Materials and Methods

The conducted research was multistage and encompassed different qualitative research methods, Figure 1.

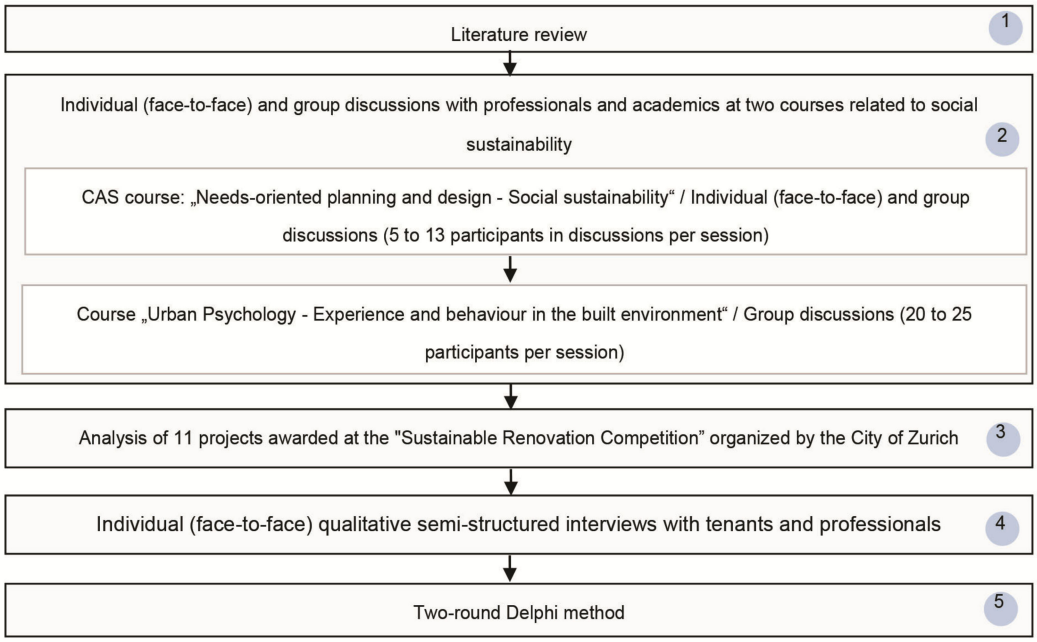


Figure 1. The methodology adopted by the authors for developing and validating the data to create the framework for early stages of socially sustainable renovation of multifamily buildings.

The first stage involved a methodic literature review related to building sustainable renovation. A number of key papers regarding socially sustainable categories and indicators, as well as decision-support tools, were first reviewed and are presented in Section 2. The sustainability assessment methods and methodologies published in scientific journals along with design recommendations were also studied in the relevant literature. They were as follows: Bundesamt für Energie (BFE) [36,37], Pombo et al. [11], Schunck et al. [38], Chantrelle et al. [39], Greiff [40], Jaggs and Palmer [41], Jensen and Maslesa [42], Licina et al. [43], Markelj et al. [44], Pasanisi and Ojalvo [45], Martinovits [21], Xiaoping et al. [46], Zavadskas [47], Zimmermann [48,49], among others and commented in Section 4. Other issues concerning the early stages of conceptual design process in renovation (identification of stakeholders' needs and priorities, process of building diagnosis, different spatial levels of built environment, determination of renovation goals, evaluation and optimisation of renovation concepts/scenarios, etc.) were investigated and are also given in Section 4. The literature review provided a systematic insight into the principles, factors and requirements that need to be met in order to achieve a sustainable building renovation process, as well as the available tools for building diagnosis and assessment of sustainable renovation alternatives. Accordingly, they are appropriately included in the proposed framework.

The review of scientific papers was followed by the analysis of first-generation rating systems, i.e., BREEAM (by British Research Establishment), LEED (by US Green Building Council), CASBEE

(by Japan Sustainable Building Consortium), GreenStar (by Green Building Council of Australia), Minergie (Swiss building label), as well as more contemporary rating systems and instruments such as Green Mark (Building and Construction Authority (BCA), Singapore), DGNB (German Sustainable Building Council), LEnSE (Label for Environmental, Social and. Economic Buildings, Europe) and SNBS (Swiss Sustainable Building Standard) which consider the socio-cultural, technical and economic aspects in addition to the environmental and energy aspects. The conducted analysis demonstrated that the SNBS in comparison to other rating systems provides a more comprehensive analysis and assessment of the building state and its context regarding the social sustainability aspect by establishing a series of indicators. Consequently, the evaluation of the existence of social practices and services in the quarter, the access to public transportation system, the access to the parcel and building, the urban development possibilities and future development of the quarter in terms of demands for residential space and service activities, etc. were also included in the developed framework. Further, placing a strong focus on user needs and encouraging their and other stakeholders' involvement (in the evaluation of the indicator "Participation" within the criteria "Planning and building process"), the SNBS involves the evaluation of informing of stakeholders, consideration and resolution of conflicts of various interests as well as the effects of the solutions found. Accordingly, a significant emphasis was given to the conflict of interests by introducing the activities which enable their proper resolution, i.e., conflict identification, mediation and conflict resolution in the developed framework.

The second stage involved discussions with professionals and academics at 2 courses related to social sustainability which the author attended. The discussions first took place within the CAS (Certificate of Advanced Studies) course, in the programme "Needs-oriented planning and design -Social sustainability" (Bedürfnisgerechtes Planen und Bauen", in German) at the Lucerne University of Applied Sciences and Arts (Hochschule Luzern, Technik & Architektur, Lucerne, Switzerland). The individual (face-to-face) and group discussions (up to 13 participants) were methods of gathering information on the social sustainability challenges within the renovation process of multifamily buildings encountered in practice. The most important issues of discussions were as follows: the factors affecting quality living-together and the problems faced in the practice of incorporating them into design, the practical experiences regarding the involvement of occupants and other stakeholders in predesign process, the applicable methods used for communicating with occupants and their advantages and drawbacks.

The second part of the individual (face-to-face) and group discussions (20–25 participants) occured at the training course "Urban Psychology—Experience and behaviour in the built environment" ("Urban Psychology—Erleben und Verhalten in der gebauten Umwelt", in German) at the Center for Urban and Real Estate Management (CUREM) at the University of Zurich. The discussion topics were the following: the parameters affecting social sustainability (common rooms and facilities, social practices and services, etc.) and the challenges regarding their incorporation into design, the challenges in finding the appropriate balance among public, semiprivate and private spaces, living-together and privacy, etc. The consulted professionals in both courses were planning and design practitioners: architects, urban planners, engineers, project managers, sociologists, psychologists, mobility experts, energy experts, property appraisers, economic experts, communication specialists and lecturers with the extensive experience in social sustainability. The discussions in the above-mentioned courses have provided insights into the significant heterogeneity, complexity and interdependence of a number of factors that need to be considered in order to adequately conceptualize sustainable building renovations, as well as the most frequent challenges design practitioners face in practice. Consequently, finding a compromise solution during the iterative design process proved to be the most appropriate way to achieve the final design solution. Therefore, the same procedure (iterative) was included in the proposed framework.

The third stage of the research was the analysis of various real-life cases of renovated multifamily buildings. The 11 projects given in Table 1, awarded at the "Sustainable Renovation Competition", organized by the City of Zurich in 2012 [20,50,51], may serve as role models for successful sustainable

renovation of other buildings. They provide valuable insights into the right balance between all 3 dimensions of sustainability, with a special focus on the quality urban design, quality design of indoor and outdoor spaces, optimisation of space (m^2/person) and materialisation, early involvement of occupants and adequate treatment of their needs, affordable renting costs and balanced life cycle costs. In the analysed projects, mostly tailored to the needs of the tenants, different strategies of the renovation process are also used; the projects nos. 3, 8, 9 and 11 were renovated in occupation (see Table 1, column 3). Duration of the renovation process varied as well; e.g., in the case of the projects nos. 11 and 4 the whole renovation lasted only 3 weeks and 5 months, respectively, while in other cases the renovation lasted longer and was even organized in stages, e.g., the project no. 8 (3 stages within 3 years). In some cases such as the projects nos. 3, 5, 6 and 7, certain privileged conditions were provided to the tenants regarding the priority of return to the renovated building or even temporary accommodation during the process of renovation (see Table 1, column 4). Those and other important occupant-related issues, project constraints and obstacles are also incorporated in the presented framework.

Table 1. Construction projects used as the basis for the framework development.

	The Project		Key Indicators of Social Sustainability Renovation(1–13) *												
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1.	Kraftwerk housing estate Heizenholz [50–54]		x 4 years before moving in	x			x	x	x	x	x	x	x	x	x
2.	Settlement Scheuchzer-hof [50,51,55]		x 5 years before renovation	x			x	x			x	x	x	x	x
3.	Building at Bertastrasse 72 [50,51,56]		x	x	x	x		x	x		x	x	x	x	x
4.	Building at Segantinistrasse 200 [50,51,57]						x	x			x	x	x	x	x
5.	Building at Müllerstrasse 65/67 [50,51,58]		x 3 years before renovation			x	x	x			x	x	x	x	x
6.	Settlement Sihlfeld [50,51,59]		x	x		x	x	x	x	x	x	x	x	x	x
7.	High-rise buildings, Sihlweid [50,51,60]		x 3 years before renovation	x		x	x	x			x	x	x	x	x
8.	Building at Billroth-strasse 14 [50,51,61]		x	x	x			x			x	x	x	x	x
9.	Building at Dufourstrasse 152 [50,51,62]		x		x		x	x			x	x	x	x	x
10.	Settlement at Nordstrasse [50,51,63]			x				x					x	x	x
11.	Settlement Arbental [50,51,64]			x	x			x				x	x	x	x

* *1*-Early informing of occupants; *2*-Participation of occupants in design process; *3*-Renovation in occupation; *4*-Provision of temporary accommodation for the tenants during retrofitting and privileged conditions for their return in the building after renovation; *5*-Social, cultural and age-related mix; *6*-Affordable rental costs; *7*-Public, semiprivate and private space; *8*-Providing spaces for social interaction; *9*-Different apartment typologies; *10*-Urban density and compliance with context; *11*-Spatial, functional and aesthetic quality; *12*-Community identity and "sense of place"; *13*-Improvement of comfort, health and well-being.

In addition to information sessions, most of the projects included occupants' participation in design process (see Table 1, column 2) such as group discussions and questionnaires or applied structured processes involving participation of the working group leader, project assistant and occupants' representatives as in the case of the project no. 1. Besides from identification of occupants' needs and priorities, the project no. 1 demonstrated that their early involvement in the participatory design process was also advantageous because it enabled tenants to get to know one another and develop a sense of community and shared responsibility [54]. Various methods of occupants' participation were also included in the developed framework.

The fourth stage included individual (face-to-face) qualitative semi-structured interviews with 20 tenants living in multifamily buildings, in order to get insight into their needs and priorities related to the renovation process. For example, they included decision-making issues in which they would like to participate (e.g., design of common outdoor spaces, common indoor spaces, entrance to the building, design of kitchens and bathrooms, etc.), ways of their involvement, techniques for communication and timeframes for early informing. The results of interviews demonstrated that almost all interviewees (18 out of 20) had a desire to participate in decision-making related to the functional layout and selection of materials in the design of the kitchen and bathroom while most of them (16 out 20) would also like to be consulted in the design of the building entrance and common outdoor and indoor spaces. All interviewees would like to be regularly informed about the progress of the renovation process, with the elderly preferring to be informed in person, and the younger ones electronically, for the reason of time-saving. However, regardless of age, all tenants would like to attend the discussions in person in decision-making processes related to their needs. As expected, they would like to be informed as early as possible about the renovation process. Apart from tenants, the semi-structured face-to–face interviews involved 5 architects experienced in renovation of multifamily buildings. The focus was on the type and flow of activities needed for successful project completion in addition to the role and involvement of various actors in the process.

The results formed the basis for the first round of the Delphi study [65] with an expert panel of 20 participants representing different types of stakeholders. First, based on previously collected information from the literature review, discussions with the professionals occurred in the first stage, analysed projects, interviews with the tenants and architects, an initial reference framework was made, after which each expert was individually asked to give an opinion on the validity of the activities/processes presented as well as on their interdependence. They were also asked to add other activities they deemed necessary and/or remove unneeded ones. While handling the second round, the outcome collected from the first round was considered and for each disputable outcome (i.e., if less than 3 panelists suggested adding or removing an activity from the presented ones), the additional specialists (usually 3 of them) were asked to review it. In accordance with their opinion, the activity was added/omitted in the second round. Based on the results of the first iteration, a new framework was designed which was again presented individually to each expert. The final form of the framework was designed based on the consent of the majority (i.e., 18 out of 20) which was reached after the second round.

The same group of experts were interviewed about the interrelation of social with environmental and economic sustainability parameters, as well as the interconnectedness between the social sustainability categories and environmental parameters. The process was also carried out in 2 rounds, similar to the previous one. Namely, the initial diagrams of their interrelations were given to each panelist and they were asked to review it. The recommendations and comments were also considered and the final results are presented in figures presented in Section 4.

The sixth stage is the validation of the developed framework in practice and is planned to be done in future research as well as the validation of the diagrams presenting interrelations between the social, environmental and economic sustainability parameters, and interconnectedness between the social sustainability categories and environmental parameters.

4. Results—Defining a Framework for the Early Phases of Socially Sustainable Renovation of Multifamily Buildings

Holistic sustainable renovation of multifamily buildings is a complex and demanding task that requires careful planning and often a high level of occupants' involvement throughout the project lifecycle to ensure the achievement of the project's sustainability goals. In addition, it implies consideration of different project scenarios and a deeper understanding of occupants' profiles including their behaviour, habits, activities, neighbourly disputes, needs, etc., in order to ensure long-term prosperous use and stability for the occupants and reduce the risk of the building's turnover failure and vacancy, occupants vandalism and damages to the building integrity.

Research shows that in most cases occupants and users are not actively involved in the design process (especially in the early phases of the project), but only informed about the decisions already made [5,7,42,66–68]. To avoid this shortcoming, the proposed model envisages a proactive, systematic and timely engagement of occupants in the early phases of the renovation process. Moreover, the proposed framework disseminates the idea that occupants can model their own living environment, which strengthens the sense of responsibility for community issues and built environment, and fosters and develops the sense of identity and community belonging [66].

A clear division of stakeholders' roles depends on the individual expertise, as well as the size of the project, building characteristics and the project's timeline and budget. Thus, it may vary for different projects; however, the proposed framework gives the general guidelines. Also, a precise definition of the working procedures, goals, scope, quality of construction works, responsibilities, etc., is needed to define for each particular project in order to ensure that involved stakeholders are working in an efficient and effective manner.

The proposed framework envisages the assignment of responsibility to an expert (or a group of experts) to serve as the navigator and mediator between stakeholders as well as their sustainability educator when needed [69], from the very beginning of the renovation process, since efficient and timely communication plays a key role in the successful completion of the project. The public sector building projects of the Swedish team Design Med Omtanke (DMO) in which this type of communication was implemented confirms their long-term success in practice [69]. Various techniques such as live or online meetings, e-mailing, informing through social media channels or the building's website page (especially opened for this purpose) can be used to regularly inform the stakeholders and foster discussion, critical opinion and suggestions. For each particular project, one of these methods or their combination may be used throughout the project life cycle. As suggested by Smith and Iversen [70], the participation in the model includes constant (re)inventing and (re)positioning through heterogeneous forms and levels of engagement, with continuous negotiation and construction of users and research objectives, configurations of participations and project outcomes, as an integral part of the process.

Systematic and detailed descriptions of the early phases: initial phase (phase 1) and conceptual design development and preliminary feasibility study (phase 2), their subphases and key activities are given in Sections 4.1 and 4.2.

4.1. Initial Phase—Phase 1

The diagram in Figure 2, comprised of five subphases, illustrates the flow of activities (processes) needed in order to achieve the following main objectives: (1) analysis and assessment of the existing state of the building and its context, (2) analysis and determination of socio-political and urban development trends, (3) identification of main stakeholders' needs, priorities and aspirations, (4) diagnosis of the building's most frequent problems (such as problems in renting, maintenance, occupants' structures, etc.) and (5) determination of the project constraints and obstacles. In order to properly perceive and assess the existing state of the building (subphase 1 in Figure 2), it is necessary to perform simultaneous assessments under all three pillars of sustainability, due to their significant interdependencies.

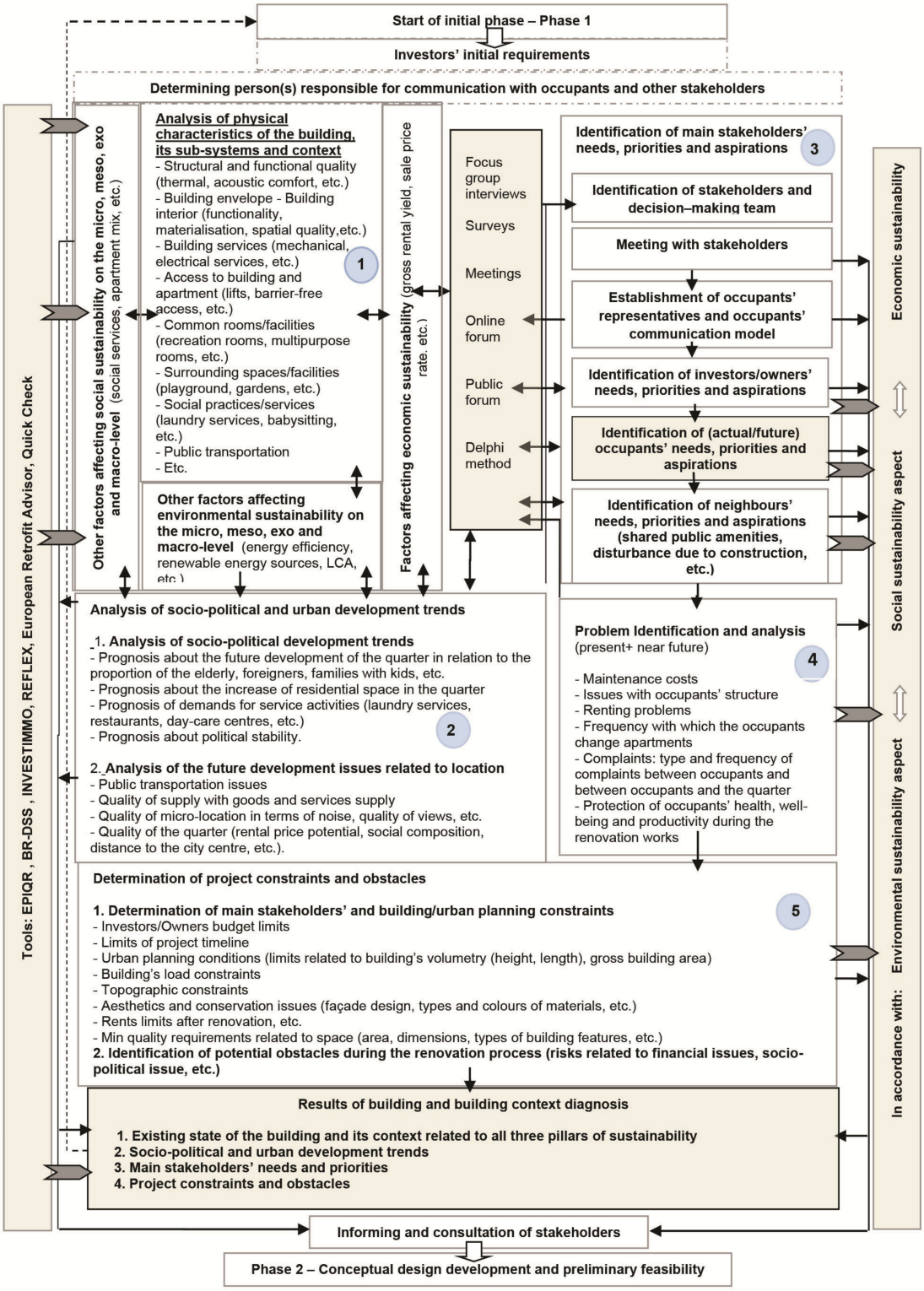


Figure 2. Phase 1—Activity flow for the diagnosis of the existing building state and its context.

The diagram in Figure 3, presenting the interrelationship of the social sustainability parameters (given in the form of criteria and indicators in Swiss Sustainable Building Standard (SNBS) [71] and the recommendation of the Swiss Society of Engineers and Architects (SIA), SIA 112/1:2017 "Sustainable Architecture–Building Construction" [72]) with environmental and economic dimensions was created using the Delphi method (see Section 3). The results indicate that all nine social categories are

interrelated (directly or indirectly) with environmental categories; i.e., 31 out of 31 social parameters are interrelated with environmental aspects, while almost all (30 out of 31) are interconnected with the economic aspects.

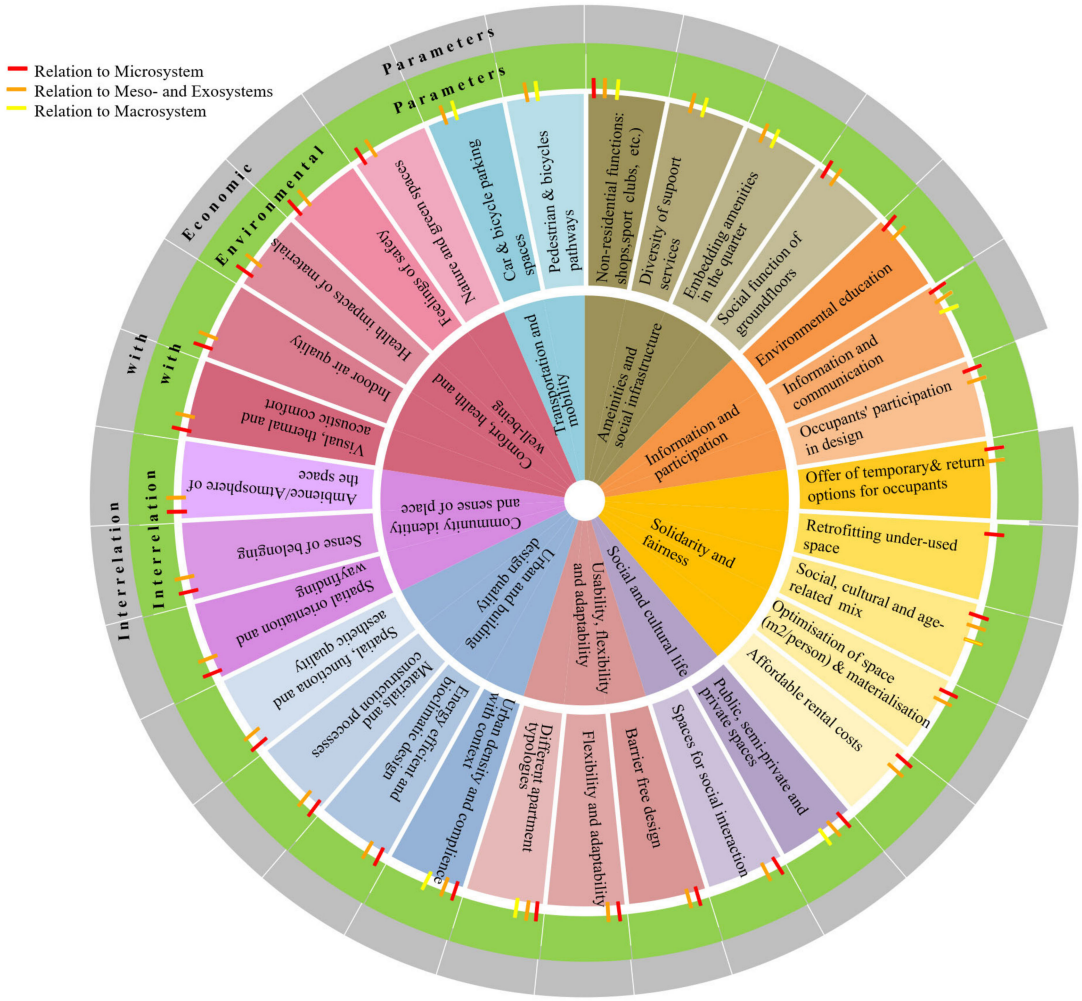


Figure 3. Interrelation of the social with environmental and economic sustainability parameters.

Their interconnectedness is clearly shown on the diagram presented in Figure 4, where for each individual social category a connection to the corresponding environmental parameters is indicated with the full arrows, while the dashed arrows indicate indirect connections to the environmental parameters related to the potential occupants' involvement in the participatory design of the building and its context. The presented diagram in Figure 4 was also derived using a Delphi study.

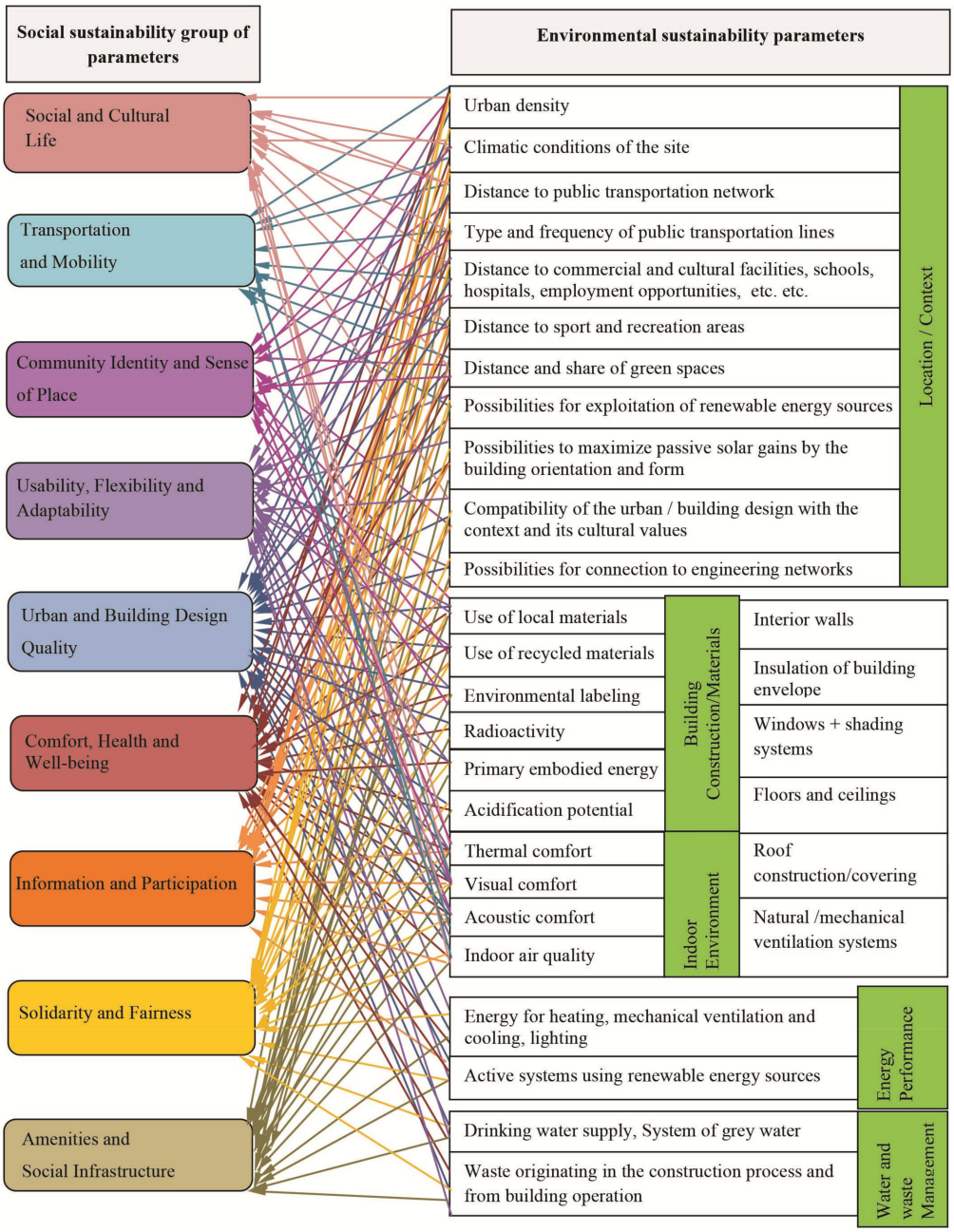


Figure 4. Interrelations between social sustainability categories and environmental parameters.

These interrelations have been recognised in the literature, but have not been adequately accounted for. Acre and Wyckmans [73,74] and Hvejsel et al. [75], among others, state that the transformation towards a more energy-efficient building system "often involves profound changes to the existing built environment influencing the perceived spatial quality". Therefore, the analysis of the existing state of the building (as well as the planning and design of renovation alternatives) requires simultaneous consideration of all three aspects of sustainability in order to ensure that the improvement of one parameter from the considered aspect does not affect significantly the quality of any of the two other aspects of sustainability. Due to considerable complexity and interdependence between the parameters of different aspects as well as the interdependencies between individual parameters within the same aspect, only their parallel consideration gives an adequate insight into the level of sustainability of a building. The same applies to the design of renovation alternatives. Namely, given the complexity of human nature and the significance of the social aspect for human well-being, it may happen that

maximisation of the quality of the environmental aspect to the detriment of some important parameters of the social aspect brings benefits for investors/occupants in the short run, while the final long-term result may be negative. Thus, a compromise solution that to the highest possible degree meets the desired set of requirements for all three aspects of sustainability is the best solution in the long run.

However, insufficient attention has been paid to these interrelationships in the relevant literature. The simplified analyses (i.e., independent consideration of environmental or social aspect) are usually justified by the need to design simple-to-use tools that enable easy and fast insight into the building conditions; however, in many cases these simplifications may lead to inadequate findings and decisions.

Undoubtedly, simplicity and ease of use should be some of the key principles in tool design, but not at the expense of the quality and relevance of the analysis. Finding an adequate compromise is a delicate issue and further research in this area is needed in order to address the problem properly.

Moreover, these parameters need to be considered at different levels (Figure 3), i.e., microsystem (living unit, apartment), meso and exosystem (housing block, immediate neighbourhood, support services) and macrosystem (wider neighbourhoods, interest groups, infrastructure systems, city) in order to provide compliance and harmony between different levels of built environment and ensure appropriate quality and connectedness of all spatial systems [76,77].

The next subphase 2 (analysis of socio-political and urban development trends) (Figure 2) is performed in order to evaluate the future housing demand in the quarter and investment profitability, since socio-political and urban development policy have a direct impact on the building market. Accordingly, this analysis supports the decisions on whether to upgrade (or not) the existing built structure by, for example, adjusting the roof space and/or adding a new floor, etc.; in addition, it supports decisions as to what extent the reconstruction should be carried out and what kind of materials and work quality should be provided to ensure profitability. Thus, the following factors are investigated: types of occupants (proportion of the elderly, foreigners, families with children, etc.) at present and trends in the future; predictions regarding residential space augmentation in the surrounding quarters; future demand related to various types of services (e.g., laundry service, childcare services, restaurants, etc.), stability of the political situation, etc.

Furthermore, the analysis of existing and future issues related to the quarter development is conducted in order to assess the existing quality of the quarter, which makes it (un)attractive to occupants, as well as to project its future development. The most important are the following: public transportation issues; quality of goods and services supply; quality of microlocation in terms of noise, views, greenery, etc.; quality of the quarter in terms of rental prices, socio-demographic structure, supporting services, safety issues, etc. This information may be gathered from professional plans and reports published by the city administrative bodies such as Department for the Urban Development and/or on-site observations, relevant surveys and interviews.

The process of the identification of main stakeholders' needs, preferences and aspirations is performed in the subphase 3 (Figure 2), after the precise determination of stakeholders' roles and responsibilities. Depending on the project character, number of occupants and their profiles, the techniques such as focused group interviews, surveys, questionnaires, Delphi studies, etc., adequately tailored for this purpose may be used. Bearing in mind different levels of occupants' education (or the lack of it), the questions concerning social and environmental sustainability need to be clearly defined and cover all issues that may be of concern for occupants. The occupants' preferences (weights) attached to different needs, can be identified by introducing a qualitative scale (for example: equally important, little more important, moderately more important, strongly more important, extremely more important), as it is a more natural way for occupants to compare needs (which are both subjective and qualitative in nature) on such a scale. The weights can be further modelled by applying the fuzzy set theory, because this theory can better incorporate the uncertainties and vagueness associated with subjective and linguistic estimates in comparison with the traditional theory based on crisp (unfuzzy) sets.

The needs of apartment owners/investors can be identified in a similar way (by introducing questionnaires, interviews, etc.) while also taking into account all the relevant economic parameters in order to determine their consent and willingness to financially support the stated needs and wishes.

The embodiment of social functions and services within common spaces outside the building (playgrounds, greenery zones, etc.) should be considered, taking into account neighbours' needs in the case of common property. However, consideration and appreciation of neighbours' opinions and needs are suggested in all other situations as well, for the sake of long-term good relations. A process similar to identifying occupants' needs should also be applied when examining neighbours' needs.

In literature, the computer tool REFLEX [45] was developed to support the process of identifying owners and occupants' wishes and needs regarding the environmental dimension; however, a new tool is needed that also takes into account the social and economic dimensions of sustainability and their interdependences.

The next subphase 4 in Figure 2 is performed to determine the existing problems in the building at the present time and those that might occur in the future. It is based on the analyses performed in the previous subphases 1 to 3, as well as on the analysis of types and frequency of complaints, rental problems, maintenance costs, issues related to occupants' structure, etc. These data serve to give an insight into the most frequent and most important problems the occupants and owners encounter in the building. They can be collected from the building operator (if any) or by conducting specially tailored surveys and/or focus group interviews depending on the number and profile of occupants.

The subphase 5, determination of the project constraints and obstacles (Figure 2), is conducted in order to comprehend investors/owners' limits and constraints regarding financial issues, urban planning conditions (building's volumetry, gross building area), building's load limits, aesthetics and conservation issues (façade design, types and colours of materials, etc.), project timeline, etc.

The existing computer tools such as EPIQR [41], BR-DSS [47], INVESTIMMO [78], REFLEX [45,79], European Retrofit Advisor [48], Quick–Check Ersatzneubau [80], etc. can be used to facilitate the process of building diagnosis, bearing in mind that the social aspect has not been treated to a satisfactory extent. Accordingly, a new tool with a more profound social assessment is needed in order to obtain an adequate insight into the existing state of the building from the social sustainability standpoint.

4.2. Design Concept Development and Preliminary Feasibility Study—Phase 2

The main purpose of this phase is the determination of renovation goals and selection of an optimal renovation scenario for the achievement of established goals. The diagram in Figure 5 graphically presents the activity flow in this phase consisting of two subphases. The renovation process in this research is seen as a dynamic process, sensitive to the particular characteristics of each building and its context, occupants/investors' divergent needs and cultural values, specific climate conditions, political situation, investors' financial limits, etc. Thus, occupants' participation in the defining of renovation goals and priorities, along with the possibility to discuss and contribute in assigning/determining the alternatives (renovation scenarios) is considered to be a crucial part of the renovation process. Although the renovation project is often challenging, it nevertheless provides the opportunity to eliminate or minimise the existing and potential future conflicts between occupants and promote living together [69,81].

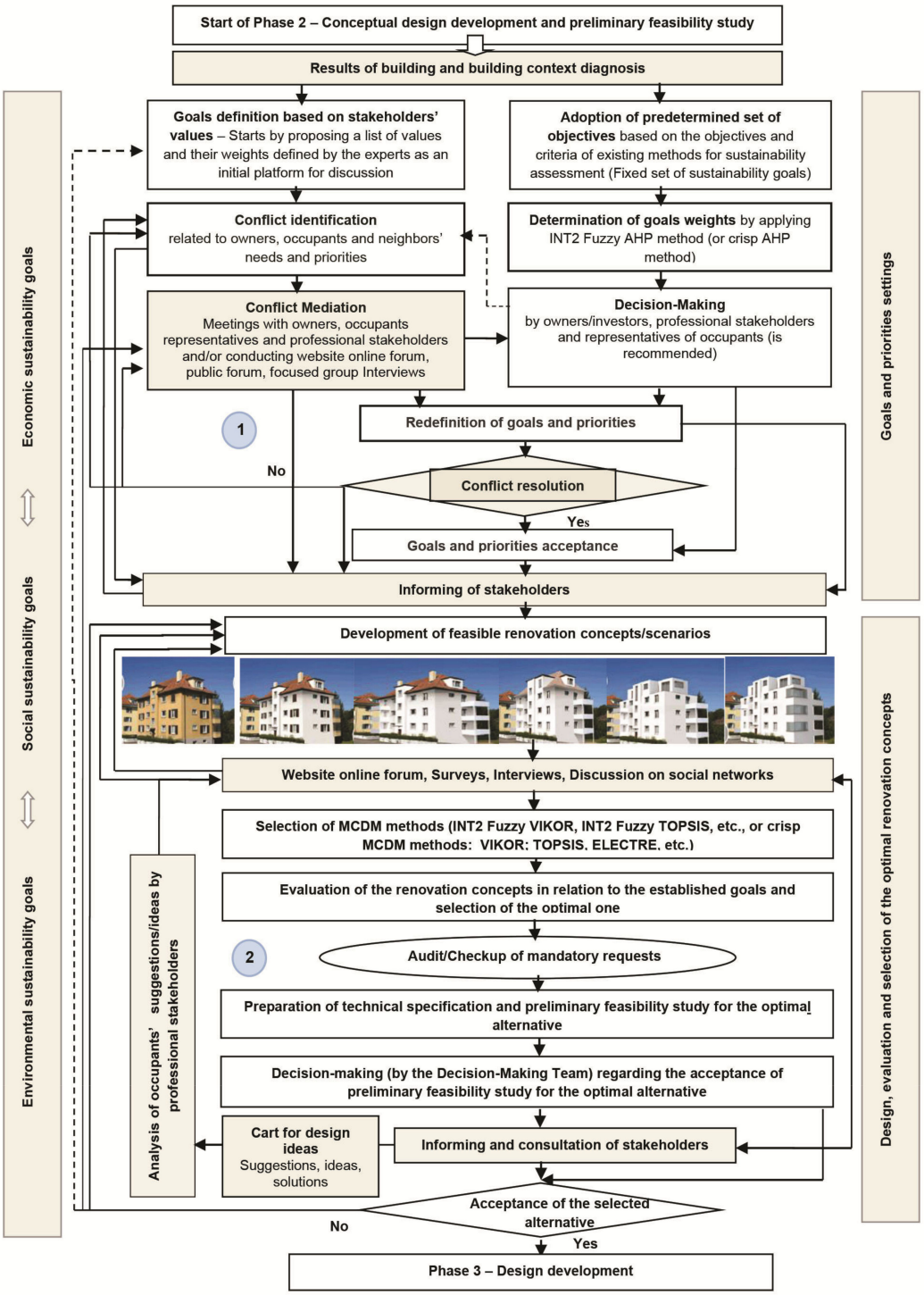


Figure 5. Phase 2—design concept development and feasibility study (images from the software tool European Retrofit Advisor [82]).

The proposed model suggests two basic methods for defining appropriate renovation goals. Both of them start with the analysis of results of the building diagnosis (performed in the previous phase) in order to determine the buildings' deficiencies and potentials as well as investors/occupants' needs and project constraints; however, they diverge in the way in which the goals are defined.

The first one includes the formulation of the initial set of values (retrofitting goals) and their weights by the design team, which are then presented to investors and occupants as a starting

platform for consideration and discussion before setting a definitive one, as proposed in [42]. Due to problem complexity, stemming from the stakeholders' different, often conflicting values and interests, compromises are an inevitable part of this process and they need to be made throughout this phase. Hence, an iterative procedure is adopted to solve the problems (conflicts).

A professional mediator/facilitator and/or a member of the design team with the conflict resolution skills should be employed to guide the process toward a compromise solution, i.e., the set of values acceptable by all parties concerned—a "win-win" situation—Figure 5, subphase 1. Further, the role of mediator as an educator in sustainability and integrative design is also of crucial importance, because it enables people to develop realistic expectations, and reduces resistance to change [83,84].

Another way to define goals is to adopt in advance a set of sustainability renovation objectives based on the criteria laid down in the existing methods for building sustainability assessment and present them to investors and occupants for prioritization (Figure 5), as suggested in BR–DSS [47], MDCM–23 [85], Multi–variant Design [86], among others. However, within the proposed framework, decision-makers still have an opportunity to discuss and redefine them in case they consider it necessary (i.e., to adopt the goals and priorities that best suit the needs and expectations of all parties). Although the final decision is always in the hands of the main decision-makers (owners/investors), the understanding of and sensitivity to occupants' needs is highly recommended (i.e., a "win-win" situation, Figure 5).

Among the most important tools that can help in determining the renovation goals are RENO–EVALUE [42] and Total Value Model [38], although RENO–EVALUE is primarily developed for a larger perspective—a group of buildings. Namely, it has been proven that using a tool to determine the goals and criteria weights helps the stakeholders to understand the sustainability aspects in a deeper sense and facilitates problem solving [87], adding value to the process [88].

The tools for criteria weights determination published in literature are thoroughly systemized by Nielsen et al. [29] and include: the "Knapsack" model [89], MCDM–23 [85], ORME [90], SST tool [91], BR–DSS [47], Multi-variant Design [86,92,93], OLSC [94,95], MAMVA, DSS–CRP [96] and European Retrofit Advisor [48,97]. They are mostly based on AHP or Grading Method [29].

In this paper we suggest the application of interval type-2 (INT2) fuzzy AHP, described thoroughly in [98,99], among others, since fuzzy sets can better model experts/stakeholders' linguistic and subjective judgments regarding the relative significance of individual goals (e.g., less important, equally important, moderately more important, strongly more important, extremely more important, etc.) and account for uncertainty and vagueness inherent in such estimates in comparison with traditional (unfuzzy) sets.

Life-cycle assessment (LCA)-based tools (Sméo and Tool for 2000-Watt-Society-sites (Rechenhilfe II für 2000-Watt-Areale, RH II)) both developed for the Swiss built environment context: buildings and neighbourhood projects [100,101] can also support decision-making in renovation projects in case that ranges of relevant input data are provided. However, previous research reveals a low rate of penetration of LCA software applications among professionals due to their deficiency to support design process in the early stages, in addition to high costs, low functionality and no user-friendly interface [102]. Furthermore, they are limited only to the environmental impact assessment. However, practitioners expect many more design support functionalities, including multicriteria approaches, sensitivity assessments, etc. [102,103].

The next step in the second phase is the definition of possible renovation concepts/scenarios (subphase 2, Figure 5) and their individual evaluation and optimisation through an iterative process by applying MCDM method in order to select the optimal one. Unlike the previously proposed crisp MCDM methods, the authors of this research suggest the application of the MCDM method based on fuzzy sets type-2, since fuzzy set theory can better model experts/stakeholders' linguistic judgements, expressions, knowledge and values, as the majority of social sustainability goals and criteria are qualitative and subjective in nature. One of them, adequate for this type of problem, is interval type-2 (INT2) fuzzy VIKOR, described in detail in [104,105], among others, due to its capacity to make a trade-off between "the maximum group utility of the majority" and the "minimum individual regret of

the opponent" in addition to the possibility of testing the robustness of the alternative "optimality" by applying sensitivity analysis. The method can be applied both in the early stages of assessment of renovation concepts/scenarios and selection of the optimal one (where the price error magnitude is up to 50%), as well as in the later phases of evaluation of renovation design alternatives where the price error magnitude is lower. Apart from INT2 fuzzy VIKOR, other MCDM methods based on interval type-2 fuzzy sets such as INT2 fuzzy TOPSIS, INT2 fuzzy PROMETHEE, INT2 fuzzy EECTRE, INT2 fuzzy QUALIFLEX, etc. can be applied as well.

Finally, based on the results of the evaluation process and feasibility study, as well as on consultations with occupants and other stakeholders, the final decision on accepting the optimal alternative (i.e., the best compromise solution) is made by decision-makers. In the case of nonacceptance, the process is repeated with modification of the existing and/or formulation of new alternatives based on the acquired knowledge, until an acceptable solution is achieved (Figure 5, subphase 2).

As can be seen from the diagram in Figure 5, occupants and other concerned stakeholders are regularly and timely informed throughout the entire process regarding all important decisions and project advances as well. Furthermore, they are invited to raise questions, express disagreements or give suggestions and solutions (block "Cart for design ideas", Figure 5, subphase 2), which are then considered by professionals in order to examine their validity and acceptability (block "Analysis of occupants' suggestions/ideas by professional stakeholders", Figure 5, subphase 2). In this way, many dissatisfactions, misconceptions, omissions, etc. can be detected and corrected in time; otherwise, due to the complexity of social parameters and the design process itself, it is not always possible to foresee them in advance. In addition to ensuring better cohabitation among occupants, this ensures trust and long-term good relations between all stakeholders. Similarly as in the framework for sustainable whole systems design, defined by Blizzard and Klotz [76], the design process is based on the sharing of goals, learning and information. The entire process is beneficial for all and may serve as a significant driver for future business cooperation.

5. Discussion and Conclusions

Previous research has shown that occupants are rarely actively involved in the renovation process, especially in the early phases, which are critical for the success of the project, because that is when strategic decisions on design are made; in most cases, they are only informed about the decisions already taken. Thus, this paper proposed a framework for active, systematic and timely participation of occupants in the early phases of the sustainable renovation design process. Furthermore, the framework promotes the idea that occupants can participate in modelling their own living environment, which fosters the sense of responsibility for built environment and community belonging. The means to achieve this are the following: giving occupants the opportunity to discuss and shape project goals (activity "Goals definition based on stakeholders' values", Figure 5); fostering discussion and critical opinion about the design alternatives (activity "Stakeholders' informing and consultation ", Figure 5); and allowing and encouraging occupants to propose concrete design ideas or solutions (block "Cart for design ideas", Figure 5).

As emphasized in the relevant studies, despite the drawback of being highly time-consuming, the participatory design process can lead to high-quality outcomes precisely because it allows the participation of end-users, enabling better understanding of user needs and desires and their more adequate incorporation into the design [69]. In addition, this process also has an educational role for end-users about sustainability; it can be an incentive to embrace more sustainable behavior and actions in other aspects of life as well [69].

Appreciating the significance of the social aspect for human well-being and analysing interdependencies between the parameters of different sustainability aspects, this paper suggests their parallel consideration in order to obtain an adequate insight into the sustainability level of the existing state of the building as well as during the development and evaluation phase of project alternatives (concepts). Only in this manner could the negative final outcome be prevented, i.e., the possibility that

by maximizing one of the aspects some important parameters of another are significantly worsened. Moreover, these parameters need to be considered at different levels: microsystem, meso and exosystem and macrosystem in order to ensure compliance between different levels of built environment and appropriate quality and harmony of all spatial systems.

The application of INT2 fuzzy AHP is recommended for prioritising project goals, and INT2 fuzzy MCDM methods such as INT2 fuzzy VIKOR method, INT2 fuzzy TOPSIS, etc. for a comprehensive evaluation of renovation alternatives, because fuzzy sets can better model uncertainties related to stakeholders' linguistic judgments [106,107] which are mostly qualitative and subjective in nature.

In addition to the research directions already proposed in recent studies [26,27], it can be added that further research about the new tools for building diagnosis and design of sustainable renovation alternatives should include indices of the social sustainability aspect in a more detailed (profound) way. However, these new tools need to be flexible enough to take into account different socio-political and environmental conditions (i.e., climate, topographic, urban, cultural, political, planning policies, etc.); capable of differentiating between and assessing various existing states of buildings, as well as take into account the interrelations between all three levels of built systems (micro, meso and macro-level). They also need to be user-friendly but still ensure reliable results. Given the complexity of the problem, finding an adequate compromise is a delicate issue and further research in this area is needed.

Efficient tools for identifying owners', occupants' and neighbors' needs that could enable deeper understanding of their profiles, including their behavior, habits, activities, neighborly disputes, values, etc., and relate them to the building characteristics [26] are crucial in order to ensure long-term prosperous use and stability of the building and occupants' wellbeing. Given the complex relationship between the characteristics of built environment and a multitude of other factors influencing human well-being, large-scale studies including interdisciplinary teams of scientists (architects, building scientists, social scientists, health researchers, etc.) will probably be needed to achieve the above goals. However, emerging technologies may facilitate and accelerate the process.

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