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Towards a European rating system for sustainable student housing: Key performance indicators (KPIs) and a multi-criteria assessment approach

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A R T I C L E I N F O

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A B S T R A C T

The shortage of student housing in Western Europe and the high demand for student population indicate the potential of the impetus for more sustainable and better quality accommodation. The residential building sector is one of the significant contributors to greenhouse gas (GHG) emissions, yet appropriate criteria for the assessment of student housing do not exist. Decisions to evaluate student housing are still primarily based on rental cost or anecdotal evidence when assessing their performance and living quality. Multi-objective criteria are needed to assist with the selection of sustainable student housing for higher education institutions students. Therefore, the objective of this paper is to identify key performance indicators for assessing sustainable student housing, and to develop a simple tool for the selection and measurement of the sustainability of student housing. The overarching aim is to improve the quality and sustainability of student accommodation in Europe. The methodology is based on a mixed-method research approach comprising a literature review on rating systems, a survey questionnaire with 610 student respondents, and a ranking analysis acquired from the severity index calculation. A total of 44 key performance indicators were identified, and a simple interactive tool was developed and tested. The proposed tool is demonstrated using a case study with two students as the decision-makers. The tool provides a novel approach to assess student housing. This creates an opportunity for a pan European environmental policy and an increase in market competitiveness to attract European and overseas students.

1. Introduction

The demand for student housing is consistently surpassing supply across Europe and Worldwide (Ong et al., 2013). According to the 2017 European student housing report that summarizes six European markets, more European universities are offering courses taught in English, leading to an increase in demand for student housing (JLL, 2017). Student housing attracts the greatest proportion of cross border investors of both multifamily and student accommodation (Savills, 2018). The report states that the student housing sector across continental Europe is coming of age. Moreover, there is a rapid increase in the proportion of the student population demanding better quality accommodation that corresponds to a sustainable lifestyle (Alamel, 2015). For example, the sustainable activism of students during the last ten years (2010–2020), including the global climate strikes (protests), has resulted in thousands of students pledging their support for sustainable student housing (Alamel, 2015; RE Cotton and Alcock, 2013; Roy and Caird, 2001). The report also highlights a key trend identified in six European markets in which the sector is poised for a demand of eco-friendly technologies resulting in energy-efficient and sustainable housing, namely in France, Germany, Ireland, Italy, The Netherlands, and Spain.

In the Belgian market, the focus country of this study, the shortage of student housing, is affecting students' lives (Raynaud et al., 2015). Student housing is gaining importance in Belgium because many international students desire to attend Belgium universities. Belgian Universities have a good international reputation, and their tuition fees are low (Benjamin and Joost, 2014). Conditions in student housing are notoriously poor, as attested by the fact that the sector contains a higher proportion of the oldest and least energy-efficient properties (De Vogelaere, 2012, 2017; Duhaut, 2013). Until 2015, there was no student housing owned or managed by any public social housing cooperation in the Walloon Region (Cornelis, 2016). Belgium comprises the Flemish Region in the north, the Walloon Region in the south, and Brussels Capital Region in the center. In 2015, 49 housing units were constructed in Louvain La Neuve (Brabant Walloon), which represents 0.05% of the available public social housing stock (Anfrie et al., 2013; Anfrie and Gobert, 2016). Students in the Brussels Capital Region face a shortage of public housing

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Abbreviations

EPC	Energy Performance Certificates
EU	European Union
GDPR	General Data Protection Regulation
IEQ	Indoor Environmental Quality
KPIs	Key performance indicators
Kot	Accommodation rented to students it is composed of: one bedroom and common rooms; a form of a communal accommodation
SSHS	Sustainable Student Housing Selection
SUS	System Usability Scale
UK	United Kingdom
UN	United Nations

each academic year (Parras and Jaspard, 2011). Similarly, the student housing market in the Flemish Region has a significant lack of available high-quality housing units (Van de Sande and Otten, 2018). While many students are able to find decent housing by turning to the private sector, others are unfortunate victims of dishonest housing owners. Student housing has a close relationship with residential use in many countries. Several housing agencies and several real estate agencies and investors recognize the problem and report students' complaints that are associated with poor building conditions and the high price of student housing (De Vogelaere, 2012, 2017). Around many universities and technical schools across the country, student accommodation is available in the form of individual or collective student housing, with shared services (kitchen, toilets, etc.). However, student housing units are often described as being too small and may even be dangerous regarding fire safety, comfort, and security, to cooking, electrical plugs and heating systems (Demeuse, 2016; Olivier, 2016). In addition, there are administrative and social problems related to facility management, rigid contracts, discrimination, and students' friendliness. These problems are issues that often prevent students from achieving high cognitive performance and affect their wellbeing. As a consequence, students require a large budget to secure decent student housing. The recurring youth movements to tackle climate change demand actions to promote environmentally friendly lifestyles and a sustainable built environment, including sustainable living (Bandura and Cherry, 2019).

In 2018, the total number of international students worldwide reached 6.3 million, up from 4.1 million in 2014, and expectations of student accommodation have increased (Emilio Di Meglio, 2018). Therefore, European universities must take into account the need for modern and sustainable student accommodation if they are to remain globally competitive (Kuleshova, 2018). There is a shortage of student housing provisions in most European cities (Savills, 2018). Worldwide, there is interest in improving student welfare and outcomes, encouraging retention, and examining the issues involved, with an increasing demand for sustainable student accommodation (Delaney et al., 2010). However, in the European market, there are no rating systems or assessment schemes that combine safety, comfort, security, and sustainability. Students are looking for modern and sustainable housing units. Thus, there is a serious need to set key performance indicators (KPIs) and a multi-criteria approach for assessing sustainable student housing in Europe. Such an assessment approach offers opportunities for the evolution and integration of eco-friendly technologies at different speeds for student housing across Europe. Moreover, the assessment approach brings Europe closer to the United Nations (UN) Sustainable Development Goals (SDG), which is the core of the 2030 Agenda for Sustainable Development. The SDGs are extremely important because they address goals that are strongly related to student quality of life, including good health and well-being (Goal 3), quality of education (Goal 4), affordable and clean energy (Goal 7), sustainable cities and communities (Goal 11) and climate action (Goal 13).

Therefore, the overarching aim of this research is to allow the evaluation of student housing in terms of quality and sustainability. This can be achieved through a multi-criteria approach for assessing sustainable student housing. As a first step, we had to characterize the student housing stock in Belgium. A characterization was carried out through field audits and quantitative surveys. The characterization enabled us to identify the problems and needs of students in terms of living and learning conditions. Once the problems and needs were identified, the next step was to define the different criteria for evaluating student housing units so that a tool can be created, which will then make it possible to assess and evaluate the different housing units.

The originality of this paper is twofold. First of all, no previous evaluation system with a scientific approach was found in the literature for the assessment of student housing. Most existing labels or certification schemes for student housing are based on essential functional criteria that do not address social and environmental sustainability. Secondly, we developed a multi-criteria approach and applied a data analysis method based on a survey with more than 610 respondents. This allowed us to identify the most important criteria to take into account for the improvement of future student housing units. The methodology used to carry out this work is divided into three complementary stages. In the first stage, we collected key performance indicators, based on a literature review, and conducted a student opinion poll. Once the data were classified into different categories, we ranked these criteria in order of importance using statistical analysis (Stage 2). In the third stage, we implemented a model (function) for housing evaluation; this model of evaluation allowed us to determine a final rating considering the performance of each criterion as well as its importance.

Once these various stages were completed, a simple tool was created, enabling the global visualization of the data and various assessment categories and indicators. The objective of the new tool is to allow students to assess different housing units and select the best options. It could also be used to assist the policy decision-makers and housing experts in controlling and improving the housing quality. In most northern and western EU member states, on average young people left home in their early 20s (Belgium: 24 females and 26 males) (Jezard, 2018). With an increase in demand for student housing across Europe, this tool could also help architects and building engineers with future construction. The paper also discusses the identified key sustainability criteria for student housing from the international perspective and its overall contribution to the new body of knowledge of sustainable student housing.

This paper is organized into five sections. Section 1 introduces the research theme, the context of the problem, objective, significance, method used, and audience. Section 2 summarizes the state of the art of existing labels, evaluation systems for existing sustainable buildings, and similar studies. Section 3 presents the methodology used to carry out this work, and Section 4 outlines the obtained results. Section 5 consists of discussions and conclusions on the study outcomes.

2. Literature review

The literature review consists of two main parts. In the first part, we review major rating systems for student housing with a focus on Europe and Belgium. In the second part, we briefly review the rating system and certification schemes for sustainable buildings. This review aims to learn from similar studies found in the literature or practice.

2.1. Definition of student housing

There are several types of student housing worldwide. Each type has its benefits. In this study, we cover all of living scenarios listed below:

Dorm Room Student Housing: Dorms or dormitories within or close to a university campus, which is convenient for students and can have shared or independent services. Dorm rooms can have individual or multiple student occupants.

Residence Halls: Dorms or dormitories that are within or close to a university campus that is convenient to students. In residence halls, students have individual rooms and can have shared services or independent services in each room.

Private Apartment/House: Regular apartments or houses that can be shared by students.

Kot: Lodging apartments that are refurbished study rooms. They are privately rented to cater to students with shared amenities. *Kots* are used in Belgium and mean a small shelter, which most of the time has a common kitchen and bathroom.

Room in a private house: Private rooms that are leased by a house owner who lives in the same house.

Studio: Have larger spaces than dorm rooms and can be shared by one or two persons. A studio has its own kitchen and sanitary services.

2.2. Rating systems for sustainable student housing

In the world of student housing, we have seen that there are a few labels for student housing in other cities and countries. The existing labels we could identify are described below.

In the last ten years, Belgium witnessed the proliferation of several rating systems for student housing. The first rating system is the KotWeb label, which was developed in Antwerp based on an initiative taken by the student union and municipality. The label requires a membership fee and protects students through a standard contract. Its main added value remains in its ability to assure safety (fire), contract quality, and minimum hygienic housing quality for students (Anfrie et al., 2013; Kotweb, 2017). Another successful example in the Flemish Region is the LOKO label developed between Leuven University and the municipality of Leuven. The aim of the label is to increase transparency regarding student housing conditions. The label has two certification schemes. The first is Blue LOKO, which certifies that the student housing provides minimum safety, security, and hygiene conditions and is operated by Leuven University. The second scheme is Green LOKO, which includes additional quality measures such as contract quality and student friendliness and indicates that the student housing is operated by the municipality. The LOKO label must be renewed every ten years. There is also a quality housing label in Mons in the French-Speaking region of Belgium. However, the most recent label is in Brussels and is named Label Kot. The objective of this label is to assure housing quality regarding security, safety, fair cost, building services, and hygiene. The label has been developed by the union of French-speaking students and is mandatory, starting September 2018.

Moving from Belgium to the United Kingdom (UK), the UK has a well-established student housing label called ANUK/Unipol National Codes. The label is owned by a consortium consisting of three organizations, namely the Accreditation Network UK (ANUK), the National Union of Students (NUS) – the representative body for students in the UK, and Unipol Student Homes – a not-for-profit student housing organization that operates accreditation schemes for off-street student accommodation (National Code, 2017). The label requires a membership fee and controls two aspects of housing quality. The first quality aspect of the ANUK/Unipiol National Codes is the housing safety, security, building services, and hygiene. The second quality aspect of the label is the housing facility management.

France has two student housing quality labels. The first label is called Lokaviz, which was established by a public institution serving student well-being. The label is organized to address housing quality, housing rent, compliance with laws and standards, and the relation between the owners and the tenants (Lokaviz, 2017). The label is credit-based, awarding points to reach different scores. The other label is called MyRoom, which was developed by a private company. The label requires paying a membership fee and allows students to create their own housing selection criteria. The label is generic and allows highlighting personal preferences for the following main criteria: location, comfort, security, access, and price (Myroom-residence, 2017).

Finally, we grouped the best available data on rating systems for student housing in Table 1. The Table allows us to compare different labels and helps to identify various limitations. The investigated labels are not based on scientific housing sustainability evaluation approaches; the criteria that are defined for establishing these labels have not necessarily been defined while taking into account the students' feedback; these labels are local labels and are not extended to other cities or countries, which limits their maturity and reliability in the long term. None of the available rating systems or labels promotes a sustainable lifestyle and sustainable technologies in students' lives.

After reviewing the existing student labels, the aim is to see if there are evaluation systems for sustainable buildings that are applicable and relevant for student housing.

2.3. Rating system for sustainable buildings

As part of our review, we explored the most relevant rating systems for sustainable buildings that are linked to student housing. While we could not find specific rating systems or labels for green or sustainable student housing, we identified five widely used rating systems that are based on a multi-criteria approach. A summary of each rating system is listed below:

- BREEAM (Building Research Establishment Environmental Assessment Method)

Table 1
Label and existing evaluation system for student accommodation.

Reference	Study parameters	Focus	Findings
Anfrie et al. (2013). Évaluation de la pertinence de la mise en œuvre d'une labellisation dans le secteur du logement étudiant (Doctoral dissertation, Centre d'Etudes en Habitat Durable).	Comparative study of two experiments on the labeling of student housing	Case of the United Kingdom Case of Antwerp (Belgium)	Two different label systems are operating with different actors. Labels realized with the aim of improving the living conditions of students
	Online Student Choice Questionnaire Survey	Characterization of student housing stock Students' opinion on the establishment of a label.	Almost all students face at least one health problem. The majority of students in Wallonia agree to the implementation of Labels according to the survey.
Le label Lokaviz - Lokaviz (2017). Lokaviz.fr. from https://www.lokaviz.fr/n/le-label-lokaviz/n:60	The functioning of the Lokaviz label	Its advantages and its main axes.	Based on a grid of criteria assigning points to these. The awarding of points will or will not allow you to obtain the label.
Pour votre logement, exigez le Label Qualité MyRoomMyRoom. (2017). Myroom-residence.com. from http://www.myroom-residence.com/label-my-room/	The functioning of the MyRoom label	It is functioning and its basic criteria.	They define the labels according to their own criteria and ensure the rental management of the accommodation.

BREEAM is a British rating system for evaluating the environmental performance of buildings. The rating system has in total ten sustainability categories and more than 70 key performance indicators to assess buildings (Attia, 2014; Roderick et al., 2009). BREEAM Multi-residential offers an assessment method that is intended for use on multi-occupancy residential buildings and dorm room student housing.

- LEED (Leadership in Energy and Environmental Design)

LEED is a North American system for the standardization of high environmental quality buildings. LEED Multifamily is intended for use on multi-occupancy residential buildings and can assess dorm room student housing (USGBC, 2019).

- Level(s) (a common EU reporting framework of core sustainability indicators for office and residential buildings)

Level(s) is an EU reporting framework of core indicators for the sustainability of office and residential buildings. The framework provides a set of indicators and common metrics for measuring the sustainability of a building over the course of its life cycle (Dodd et al., 2017).

- LBC (Living Building Challenge)

LBC applies prerequisites and credit systems name as Core Imperatives and Normal Imperatives. LBC has seven main categories, Place, Water, Energy, Health and Happiness, Materials, Equity, and Beauty (ILBI, 2019). The system is not based on a point-scoring system but rather a compliance or noncompliance approach. All imperatives must be met. LBC imperatives are generally harder to achieve compared to LEED and BREEAM (Genkov et al., 2015). The latest version of LBC is promoting a carbon-neutral building design and operation approach strongly.

- DGNB (German Green Building Council)

The basis for the system was developed for new construction of office and administration buildings. The evaluations can encompass up to 40 sustainability criteria with a focus on life cycle assessment and performance. The rating system is distinguished by focusing on ecology and environment similar to LBC when compared to LEED and BREEAM. Moreover, it has a unique set of criteria that focus on social, economic and cultural aspects (Hamedani and Huber, 2012). DGNB is the youngest rating system among the four reviewed rating systems and is widely considered in Germany and Scandinavian countries for office buildings.

After reviewing the five rating systems for green buildings, we have found that these rating systems are not intended for student accommodation; most of them are for new buildings and not for existing buildings. The BREEAM, LEED, LBC and DGNB certification processes are quite cumbersome processes and the fees for certification are relatively high. At the same time, the EU Level(s) framework is still under development and is mainly focused on office and residential buildings.

More importantly, the rating systems above do not cater to students (Dodd et al., 2017). They are meant to bring owners and design teams, including contractors, together. In this sense, students and their relationship with the landlord is not addressed. This confirms the need to develop a specific and stand-alone rating system or label for student housing.

2.4. Towards a European sustainable student housing rating system

Based on the literature review continuum discussed in section 2.1 and 2.2, we can confirm that no study addressing the topic of sustainable student housing has been done before. Our literature review identifies a knowledge gap in this research domain of sustainable housing, as summarized in a lack of a comprehensive and scientific framework for the assessment/evaluation of sustainable student housing; a lack of a comprehensive list of KPIs developed specifically for sustainable student housing; and a lack of an integrated approach that embraces the KPIs of sustainability qualitatively and quantitatively.

Therefore, the purpose of this study is to implement an evaluation system with a multi-criteria decision-making approach for student housing. We are introducing a multiple attribute model to be able to set priorities for the evaluation of student housing. KPIs will be prioritized with the assistance of those involved in the management, use, and construction of student housing buildings.

3. Methodology

As a follow up of the literature review continuum, we developed a conceptual framework that summarizes and visualizes our research methodology. As shown in Fig. 1, our conceptual study framework is based on three axes that will be described in the following sections.

The methodology selected for this research comprised 1) data collection through a literature review and questionnaire survey, 2) data processing through the identification of relative importance of survey data and student housing sustainability criteria, and 3) the development and application of an assessment tool. The developed methodology follows similar methodologies found in the literature that established assessment criteria for sustainable buildings and construction (Amer and Attia, 2019; Bhatt et al., 2010; X. Chen et al., 2015; Y. Chen et al., 2010b; Idrus and Newman, 2002; Soetanto et al., 2006). Given the particular requirements of student housing, a holistic set of sustainable performance criteria was developed and translated into an easy to use tool. The following sections describe the research methodology in detail.

3.1. Key performance indicators selection (data collection)

According to Fig. 1, the methodology in this paper covers three different stages. In the first stage, the definition of sustainable student housing was determined, and existing performance indicators made for student housing in various countries around Europe were reviewed.

For our study, sustainable student housing has been defined as a building with high efficiency in the use of energy and water and improved indoor environmental quality (IEQ). The definition adapts the social, ecological and economic principles inspired by the triple bottom line approach of sustainability and is focused on the operation phase during the building use, excluding some aspects such as the environmental impact of materials (Attia, 2016, 2018b; Vanegas, 2003). This has to do with the nature of students, who are temporary users (tenants) that occupy student housing, on average for a period of 2–4 years. Also, the definition of sustainable student housing used in this study leans strongly on the adoption of sustainable management practices.

Based on our literature review, several indicators have been identified and grouped under different categories. The screening and selection of indicators aimed to identify a set of holistic performance indicators, including environmental indicators for student housing. The BREEAM rating system and Lokaviz quality label were mainly used as the basis of the tool development (BRE, 2018; Lokaviz, 2017), with which a list of initial criteria was developed. With the help of 30 students and researchers, the generated list was revised to assess the relevance of the identified performance indicators. Feedback from the respondents was collected through paper surveys, and face-to-face interviews, and the indicators were further refined and categorized.

Based on the refined list of criteria, a survey was designed by the authors. The survey enables students to identify their priorities for selecting student housing and allows them to investigate the means of future improvements of the current housing stock. The surveys consisted of background information about the respondents and their preferences to evaluate student housing. Two pilot surveys were conducted with 30 students and researchers to validate the final questionnaire. To avoid bias and increase the sample diversity, we made sure that two-thirds of the respondents were undergraduates with a gender balance around 53-47%

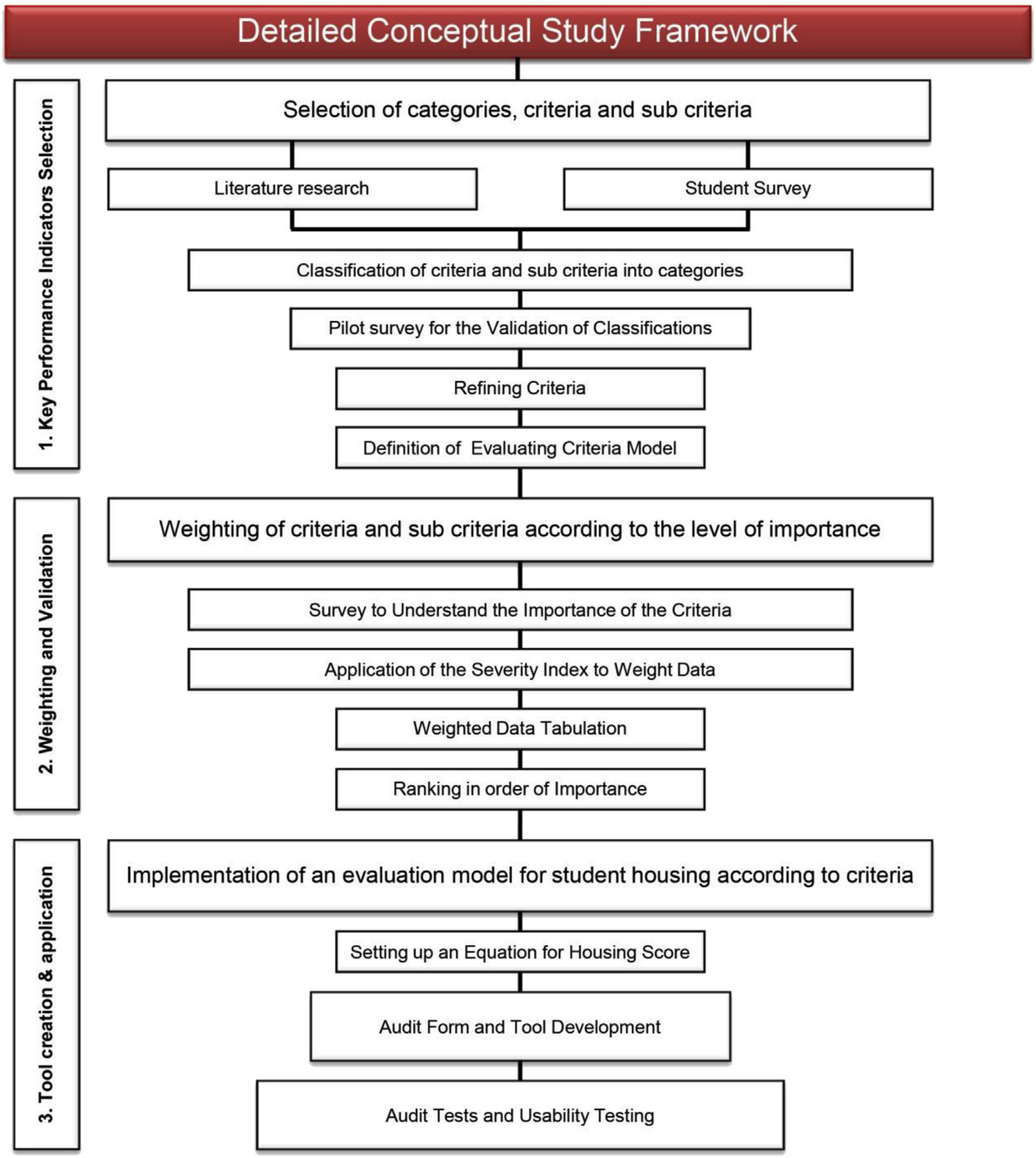

Fig. 1. Detailed description of the methodological procedure.

(female-male), including interns. The other students were postgraduates, including masters and Ph.D. students, with and without families. The gender balance was 44–56% (female-male), and the percentage of foreigners, mainly French, was around 35%. The result of the first pilot survey resulted in adding a definition for each criterion to guide respondents better to complete the questionnaire. Also, the first pilot indicated the importance of including open-ended questions to allow students to provide supplementary criteria that might not be included in the survey. The second pilot survey aimed to refine the classification of the developed criteria and shorten the survey response time. A sample of 30 people was selected, and participants were asked to rate each criterion on a scale from 0 to 5 in terms of their importance. The value 0 is "Not necessary", 1 is "Least important", 2 is "Fairly important", 3 is "Important", 4 is "Very important", and 5 is "Extremely important." As a result, the developed criteria were validated and refined. Cronbach's alpha was calculated to test the internal consistency and reliability of the generated scale. The closer alpha is to 1, the greater the internal consistency and reliability of the criteria in the scale. Cronbach's alpha values of all sub-indices (the three categories) and the aggregated index were calculated. The results indicated a high internal consistency and reliability of the criteria (see Section 4, paragraph 1).

Finally, the sampling frame for obtaining respondents for the student survey was constructed. Simple convenience random sampling was used to select university-students across French-speaking Belgium. Three different strategies were employed in attempts to recruit university students: tablets (through recruitment campaigns), QR code flyers, and Facebook ads. Several recruitment campaigns took place in classrooms or in front of the University restaurants using paper flyers or tablets at Liege University, the Catholic University of Louvain, and the Free University of Brussels, during lunchtime. The aim of this survey campaign was to assess the importance of each indicator from the point of view of the students as end-users. The results were collected and assessed. A ranking analysis has been conducted using an average proximity matrix and severity index statistical methods. A proximity matrix scaled 1-proximity for each data point was plotted to identify coherent clusters of respondents. In cluster analysis, a "proximity matrix" is a collection of similarity estimates between each of the items (criteria) in the responses set (Dubes, 1999). For a set composed of k items, $(k * (k - 1))/2$ proximities must be acquired, such that each item is compared to every other at least once. Using the proximity matrix also allows for discrimination among levels of severity. The average response time of the survey was 5–7 min. The survey was administered online. With the help of social media, a sampling balance was achieved; reaching more than 600 valid replies were registered in the Web-survey platform (see Appendix 1). The survey was conducted in accordance with the ethical 198 standards in the Declaration of Helsinki and the European Union General Data Protection Regulation (GDPR). The survey was launched between October 2017 and February 2018. The survey was written in French and targeted students in Wallonia, Belgium. Respondents were promised to receive a copy of the survey report if they are interested. The questionnaire responses were filtered, and incomplete responses were eliminated.

3.2. Weighting and validation (data processing)

The weighting of the criteria is based on the analysis of the data obtained from the final survey. A non-inferential static analysis procedure was more suitable for the required type of results (Y. Chen et al., 2010b, 2010a). To classify the criteria according to their relative importance, we used severity index analysis. To determine the severity index, the formula used is as follows (Eq. (1)):

$$Severity\ Index\ (SI) = \left(\sum_{i=1}^{5} \omega_i \cdot \frac{f_i}{n} \cdot 100 \right) \Big/ (a \cdot 100) \quad (1)$$

i is the possible value of the scale given by the respondent, from 1 to 5 (1: « Least important,» 2: « Fairly important,» 3: « Important,» 4: « Very important,» 5: « Extremely important »);
ω_i is the weight for each point from 1-5;
f_i is the frequency of the point i given by all respondents; n is the total number of respondents;
α is the highest weight, here a = 5.

After applying this formula, each criterion obtained a severity index, which allowed us to classify them into different degrees of importance. A ranking analysis has been conducted using average proximity and severity index statistical methods. The ranking analysis arranged the developed indicators according to their relative importance to the students.

3.3. Tool development and testing

In the third and final phase, an assessment tool for student housing was developed. The tool is named the Sustainable Student Housing Selection (SSHS) tool. In this tool, each indicator was given a weighting factor based on the ranking analysis. Also, an audit form was developed based on the ranking analysis and was integrated into the tool. The audit form was refined and verified through expert knowledge. Ten real estate experts specializing in student housing were interviewed and asked to provide feedback regarding the audit form's content. Expert knowledge allowed us to focus on a manageable number of essential indicators and sub-criteria that contribute to achieving sustainability in student housing. The audit form enables users to perform reviews of existing buildings and can be used digitally in conjunction with weighing factors. The audit sheet allows any student or student housing auditor to complete an audit and fill in the audit sheet. The results can be directly visualized in the form of a tabular report or a radar graph. Accordingly, in each category of indicators, a score was given and presented in a radar chart. The radar chart serves as an interface of the visual tool that evaluates the overall sustainable performance of existing student housing and compares different alternatives.

In order to test the usability of the audit form and the newly developed SSHS tool, we took two measures. First, we tested the audit form through two real walkthrough audits. To test the validity of the proposed tool, we asked graduate students to compare two kinds of student housing in Liege. Two students, one living in a dorm room and another residing in a *Kot,* were selected. Both types of student accommodation were found to be the most common among students. The graduate students used a tablet during a 20-min visit for two housing units. The *Kot* was located in the city center of Liege city, in Outremeuse neighborhood, and was renovated by the owner in 2012. The *kot* was unfurnished and 15 m^2 in size. The second housing unit was a room in a student dorm, also located in the city center of Liege City, near an area called Le Carré. The room was unfurnished, 14 m^2, and renovated in 2010. The students were shadowed during the audit to observe how they interpret and fill in the audit form. A discussion followed each audit to clarify any concerns or suggestions regarding the audit form. Further details of the audit tests can be found in the results Section (4.4).

After testing the audit, usability testing was conducted for the SSHS tool. The main objective of the testing was to assess the usability of the interface and the ability of decision making by performing usability tests on the different prototype versions. Fifteen users, comprising mainly students, were recruited at the University of Liege to test the SSHS tool. The System Usability Scale (SUS), a paper-based questionnaire was used to collect feedback (Albert and Tullis, 2013; INCITS, n.d.; ISO, 2018). The analysis of the responses was based on the Common Industry Format for Usability Test Reports. Two iterations of usability testing have been carried out to develop the comparative nature of the tool and the weighing score visualization. Additionally, participants were interviewed after conducting each usability test to obtain more insights on the tools' limitations. The results of the usability testing were embedded in the final tool interface.

Finally, a detailed research framework and methodology description can be found in Fig. 1, which summarizes the research methodology.

4. Results

Six hundred ten students filled in the survey, forming almost half of the targeted respondents. Fifty-six percent of respondents were females, and 54% were males. The average age of respondents was 22 (61%) representing third-year bachelor students. Postgraduates formed 17% of the respondents, and undergraduates formed 83% in total. With the help of the SPSS program, Cronbach's alpha was calculated to test the reliability of the generated outcome. All alpha values were greater than 0.7 for all criteria (reliability α: 0.75, 0.78. 0.71 for sub-indices A-C and 0.74 for the aggregated index, respectively), indicating that all reliability coefficients are acceptable of the criteria included in the survey is high. In the following sections, we present the final classification criteria, ranking analysis results, developed tool, and the case study used to test the tool.

4.1. Classification of criteria

We based our criteria of classification on a hierarchical structure of 3 categories, 14 criteria, and 44 sub-criteria, as shown in Table 2 The Table represents the grouping of our selected criteria, each with an index number (column 1, 3, and 5) to identify the different criteria. This classification is a result of the questionnaire survey and the 610 responses. The classification comprises general evaluation criteria for student housing and specific criteria related to sustainability.

4.2. Weighing and ranking of criteria

Once the identification and classification of key evaluation criteria of student housing was achieved, the following step of weighing each criteria and sub-criteria was executed. The questionnaire survey results allowed ranking the criteria in order of importance. Table 3 represents the weight of every sub-criterion from the most important (top) to the least important (bottom). Every sub-criterion received a weight based on the severity index calculation. Based on this calculation, we validated the ranking and assigned the different weights. One of the interesting findings of the survey was the importance of '*Heating efficiency in the winter,*' which was ranked as the most important criterion by most students. The

Table 2
The hierarchical structure of the classification of criteria.

Index N°	Category	*Index N°*	Criteria	*Index N°*	Sub Criteria	
A	Housing configuration	*A.1*	Private space (Bedroom)	*A.1.1*	Size	
		A.2	Shared space (Living room, Bathroom, Kitchen)	*A.2.1*	Size	*A.2.2* Number of people using
		A.3	Equipment	*A.3.1*	Finishing condition (Walls and interior)	*A.3.2* Refrigerator
				A.3.3	Bed	*A.3.4* Wardrobe
				A.3.5	Desk	*A.3.6* Microwave/Oven
				A.3.7	Washing machine	*A.3.8* Internet access
		A.4	Accessibility	*A.4.1*	Disability access	*A.4.2* Car parking
				A.4.3	Bicycle parking	*A.4.4* Elevator
				A.4.5	Intercoms	
		A.5	Location	*A.5.1*	Proximity to public transport	*A.5.2* Proximity to commercial facility
				A.5.3	Proximity to university	*A.5.4* Proximity to green space
B	Environmental quality and Wellbeing	*B.1*	Air quality	*B.1.1*	General air quality	*B.1.2* Natural ventilation
				B.1.3	Mechanical ventilation	
		B.2	Thermal comfort	*B.2.1*	Thermal insulation	*B.2.2* Heating efficiency in winter
		B.3	Visual comfort	*B.3.1*	Quality of natural lighting	*B.3.2* quality of artificial lighting
		B.4	Acoustic comfort	*B.4.1*	Sound insulation inside the building	*B.4.3* Sound insulation between housing and exterior
C	Housing management	*C.1*	Housing service	*C.1.1*	Administrative standards compliance	*C.1.2* Security standards compliance
				C.1.3	Building maintenance service	
		C.2	Energy	*C.2.1*	Energy efficiency of housing	*C.2.2* Use of renewable energy
				C.2.3	Energy management system	
		C.3	Water	*C.3.1*	Reuse of rainwater	*C.3.2* Hot water installation
				C.3.3	Reduced water consumption	
		C.4	Waste	*C.4.1*	Waste separation system	*C.4.2* Waste management room
		C.5	Cost	*C.5.1*	Price of accommodation	*C.5.2* Price of water charges
				C.5.3	Price of electricity charges	*C.5.4* Price of heating charges

least important criterion was reported to be '*Bicycle parking.'* Further results interpretation can be found in the discussion section (see section 5.1).

4.3. Student housing audit form and tool development

Once the ranking and weighing and ranking of each criterion were achieved in Tables 2–4, the audit form was developed. This audit form allows us to evaluate different housing units in reality and is mainly based on transforming the indicators and hierarchy of Table 2 into an audit form. Table IIA in Appendix II represents the audit form, where each criterion has been transformed into a representative question. The criteria in the audit form are graded based on two approaches. The first approach allows us to grade a criterion based on a Likert of 7 nuances. A grade of 7 indicates excellent performance, and a grade of 1 is used for poor performance. The second approach allows us to confirm or negate criteria through a 'yes' or 'no' choice. The structure and grouping of the criteria of the audit form followed the classification introduced earlier in Table 4. Ten local experts specializing in student housing real estate validated the audit form and provided insights on the identification of the most important sub-criteria.

The following step comprised integrating the results of Tables 3 and 4, and Table IIA (appendix II) into a simple tool. With the help of Excel, the tool was created to help potential student housing seekers. An introduction page explains briefly to users the aim and purpose of the tool and the process, from filling in the input to visualizing the results and making a decision. The introduction page is followed by the audit form page that can be easily printed or directly filled via a tablet or laptop (see Table IIA (appendix II)). The user can create several audit forms within this page. This allows users to compare several buildings and audit them, after which the user can move to the audit results page where the audit results get executed and presented in a tabular form (see Table IIB (appendix II)). All criteria listed in Table IIB (appendix II) are associated with a specific weight based on the severity index. This output is directly presented under the three main criteria categories or individual criteria or sub-criteria. The higher the total score of a housing unit, the better it is. The same data gets visualized automatically in the form of a radar graph that allows the user to compare single student housing or multiple housing units. Through a case study, we show the use of the new tool in the next section.

4.4. Tool testing

As shown in Table IIB (appendix II) and Fig. 2, the second housing apartment scored significantly higher than the first apartment and was recommended by the student. Overall, the reactions were notably positive in terms of the tool's effectiveness and ease of use. The radar graph in Fig. 2 represents category scores illustrated in Table IIB (appendix II). The graph allows the user to compare several dwellings in a visual way, mainly by representing the weighted score of the three main categories of the two dwellings.

By examining both units, the authors confirmed the output results. The most significant part of this experiment was revealed when we interviewed the graduate student after using the tool. We asked the student explicitly how he could fill in the data requested in category B (Environmental quality and Well-being). In fact, the audit questionnaire forced the student to look for experience from neighbors to answer the questions. This reveals that the tool not only helped to identify the key sustainability concerns related to student housing. Also, the tool informed the students during the field visit or walkthrough audit about the essential questions that need to be answered next to category C (Housing Management) and category A (Housing Configuration). The case results show that the tool decision brings significant guidance during short walk-in visits. This helps to extend the application of the tool to guide the decision making regarding functional, economic, and sustainable housing selection criteria.

Table 3
Weighting and ranking of criteria.

Rank	Index N°1	Category	Index N°2	Criteria	Index N°3	Sub Criteria	Severity Index
1	*B*	Environmental quality and Wellbeing	*B.2*	Thermal comfort	*B.2.2*	Heating efficiency in winter	0,91
2	*C*	Housing management	*C.1*	Housing service	*C.1.2*	Security standards compliance	0,86
3	*C*	Housing management	*C.3*	Water	*C.3.2*	Hot water installation	0,86
4	*B*	Environmental quality and Wellbeing	*B.2*	Thermal comfort	*B.2.1*	Thermal insulation	0,86
5	*C*	Housing management	*C.1*	Housing service	*C.1.1*	Administrative standards compliance	0,86
6	*B*	Environmental quality and Wellbeing	*B.4*	Acoustic comfort	*B.4.2*	Sound insulation between housing and exterior	0,85
7	*B*	Environmental quality and Wellbeing	*B.4*	Acoustic comfort	*B.4.1*	Sound insulation inside the building	0,84
8	*B*	Environmental quality and Wellbeing	*B.3*	Visual comfort	*B.3.1*	Quality of natural lighting	0,82
9	*C*	Housing management	*C.5*	Cost	*C.5.1*	Price of accommodation	0,81
10	*A*	Housing configuration	*A.3*	Equipment	*A.3.8*	Internet access	0,80
11	*A*	Housing configuration	*A.2*	Shared space (Living room, Bathroom, Kitchen)	*A.2.2*	Number of people using	0,76
12	*B*	Environmental quality and Wellbeing	*B.3*	Visual comfort	*B.3.2*	Quality of artificial lighting	0,76
13	*A*	Housing configuration	*A.3*	Equipment	*A.3.2*	Refrigerator	0,75
14	*C*	Housing management	*C.4*	Waste	*C.4.1*	Waste separation system	0,74
15	*C*	Housing management	*C.5*	Cost	*C.5.3*	Price of electricity charges	0,72
16	*C*	Housing management	*C.5*	Cost	*C.5.4*	Price of heating charges	0,72
17	*A*	Housing configuration	*A.1*	Private space (Bedroom)	*A.1.1*	Size	0,72
18	*A*	Housing configuration	*A.5*	Location	*A.5.3*	Proximity to university	0,72
19	*C*	Housing management	*C.5*	Cost	*C.5.2*	Price of water charges	0,72
20	*A*	Housing configuration	*A.2*	Shared space (Living room, Bathroom, Kitchen)	*A.2.1*	Size	0,71
21	*A*	Housing configuration	*A.3*	Equipment	*A.3.1*	Finishing condition (Walls and interior)	0,70
22	*B*	Environmental quality and Wellbeing	*B.1*	Air quality	*B.1.1*	General air quality	0,70
23	*A*	Housing configuration	*A.5*	Location	*A.5.1*	Proximity to public transport	0,70
24	*B*	Environmental quality and Wellbeing	*B.1*	Air quality	*B.1.2*	Natural ventilation	0,69
25	*A*	Housing configuration	*A.3*	Equipment	*A.3.3*	Bed	0,69
26	*A*	Housing configuration	*A.5*	Location	*A.5.2*	Proximity to commercial facility	0,68
27	*C*	Housing management	*C.2*	Energy	*C.2.1*	Energy efficiency of housing	0,68
28	*C*	Housing management	*C.1*	Housing service	*C.1.3*	Building maintenance service	0,67
29	*C*	Housing management	*C.3*	Water	*C.3.3*	Reduced water consumption	0,66
30	*A*	Housing configuration	*A.3*	Equipment	*A.3.6*	Microwave/Oven	0,64
31	*C*	Housing management	*C.4*	Waste	*C.4.2*	Waste management room	0,64
32	*A*	Housing configuration	*A.3*	Equipment	*A.3.5*	Desk	0,63
33	*A*	Housing configuration	*A.3*	Equipment	*A.3.4*	Wardrobe	0,63
34	*C*	Housing management	*C.2*	Energy	*C.2.3*	Energy management system	0,62
35	*C*	Housing management	*C.2*	Energy	*C.2.2*	Use of renewable energy	0,59
36	*C*	Housing management	*C.3*	Water	*C.3.1*	Reuse of rainwater	0,57
37	*A*	Housing configuration	*A.5*	Location	*A.5.4*	Proximity to green space	0,56
38	*B*	Environmental quality and Wellbeing	*B.1*	Air quality	*B.1.3*	Mechanical ventilation	0,53
39	*A*	Housing configuration	*A.4*	Accessibility	*A.4.5*	Intercoms	0,48
40	*A*	Housing configuration	*A.4*	Accessibility	*A.4.1*	Disability access	0,46
41	*A*	Housing configuration	*A.4*	Accessibility	*A.4.2*	Car parking	0,44
42	*A*	Housing configuration	*A.4*	Accessibility	*A.4.4*	Elevator	0,43
43	*A*	Housing configuration	*A.3*	Equipment	*A.3.7*	Washing machine	0,42
44	*A*	Housing configuration	*A.4*	Accessibility	*A.4.3*	Bicycle parking	0,40

5. Discussion

Student housing is in high demand, with estimates that there is as much as 4–5€ billion in capital looking for student housing stock across Europe (JLL, 2017). The rapid increase in the student population, demanding better quality accommodation and sustainable student accommodation is growing. By 2020, international student numbers are set to reach 2 million in the European Union. Therefore, European universities and cities must take into account the need for modern and sustainable accommodation to remain globally competitive. Our study proposed an approach for the classification and ranking of student housing evaluation criteria. Based on a sample of 610 students, we selected the most relevant criteria for sustainable student housing selection and ranked them in order of importance.

5.1. *Key findings*

The most important criteria (Top 10) focus mainly on the Housing Management and Environmental Quality and Well-Being categories. The Top 10 criteria include functional criteria such as internet access, compliance with security standards, length of lease for tenants, and the affordability of the rent. In addition, we identified sustainability criteria such as efficiency of heating system during winter, the presence of thermal insulation, and the quality of daylighting. However, including the cost of utilities (energy, water, and waste) makes energy efficiency and sustainability, not matter for student tenants. The survey results suggest that in addition to a focus on the cost of the rent, students consider comfort as an important factor when selecting student housing. Indoor air quality was not reported as a significant issue by most

Table 4
Proximity matrix for the 14 main criteria.

Criteria	Thermal comfort	Housing service	Water	Acoustic comfort	Visual comfort	Cost	Equipment	Shared space	Waste	Private space	Location	Air quality	Energy	Accessibility
Thermal comfort	0.00	0.02	0.05	0.05	0.010	0.02	0.02	0.15	0.25	0.02	0.25	0.25	0.03	0.25
Housing service		0.00	0.02	0.20	0.20	0.02	0.03	0.10	0.09	0.25	0.25	0.23	0.20	0.25
Water			0.00	0.25	0.25	0.10	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Acoustic comfort				0.00	0.23	0.15	0.20	0.09	0.25	0.08	0.08	0.25	0.25	0.25
Visual comfort					0.00	0.18	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Cost						0.00	0.08	0.06	0.25	0.10	0.02	0.25	0.20	0.02
Equipment							0.00	0.10	0.25	0.25	0.28	0.12	0.02	0.25
Shared space								0.00	0.25	0.25	0.25	0.25	0.25	0.25
Waste									0.00	0.25	0.25	0.25	0.25	0.25
Private space										0.00	0.25	0.25	0.25	0.25
Location											0.00	0.20	0.25	0.02
Air quality												0.00	0.09	0.25
Energy													0.00	0.25
Accessibility														0.00

students. This has to do with the perception of comfort in many of Belgium's old buildings (Geng et al., 2017; Singh et al., 2016). The majority (63%) of investigated undergraduate students was interested in *kots* with shared facilities and was not enthusiastic about student flats (residence halls). Undergraduate students prefer common facilities that can be shared and cleaned by themselves. However, graduate students showed a preference for residence halls and individual dorm room student housing as they prefer not to clean common facilities unless they are part of their rooms.

On the other hand, the least important criteria are mainly related to housing configuration, including car parking, washing machine, elevators, and the presence of bicycle parking. The interpretation of these preferences is related to the fact that 78% of respondents spend their weekends at their family home. Those who wash their clothes would visit a laundromat, which is abundantly available in most neighborhoods in Walloon cities. Most investigated students (64%) possess neither a car nor a bike (94%). The ranking analysis presented reflects current students' priorities in French-speaking Belgium. Although the average ranking of sustainability (Environmental Quality and Well-Being) criteria is not as high as the Housing Management (including cost), the results showed that there is an environmental awareness among the investigated students. By following the severity index for the weighed green building indicators, in Table 3, students did not prioritize several environmental aspects such as water-saving, energy efficiency, waste reduction, and air quality.

5.2. *Strengths and limitations of the study*

For this study, we developed sustainable performance criteria for sustainable housing based on the literature and a cross-sectional survey involving 610 students. We have also developed an audit form, reflecting students' preferences, which can be used during walkthrough student audits. The audit form allows each criterion to be scored individually and at a global level. The audit form is integrated into the first tool to assess student housing, combining performance and importance (priority). The tool uses a radar graph, despite its simplicity, to provide an easy and quick to understand visual representation after the walkthrough audit of student housing is achieved. The tool's strength is its capacity to inform students when selecting student housing, while managing several criteria in a simple, comprehensible, fast, and comparative format. Also, the identified criteria for a sustainable student housing are in line with the outcomes of other studies found in the literature (Bebronne et al., 2018; Muslim et al., 2012; Ong et al., 2013; Thomsen and Eikemo, 2010).

Therefore, the tool is embedding a knowledge-base that involves the severity index calculation, which helps inexperienced students. The use of statistical analysis to weight each housing selection criterion, based on a collective consensus, provided insight on the importance of sustainable indicators and sustainable approaches to student housing design and operation. Basing the tool on a large scale survey is reinforcing the tools' ranking validity and certainty in decision making. The tool can help environmentally conscious students as well as novice students to select the best available student housing in a rational and objective way, while creating a variety of alternatives in a short time. Better and conscious student choices will improve the quality of student housing in terms of quality and sustainability.

As shown in Table 5, the comparison between BREEAM, LEED, Level(s), UN SDG, and the SSHS tool indicates that the SSHS tool is better customized than the others. The SSHS is strongly distinguished from other sustainability rating tools due to its focus on the operational stage aspects of the building's life cycle. The SSHS is focused on the relation between the student and the landlord, the monthly or annual energy and water consumption, and the integration of renewable energy systems. Special attention is dedicated to comfort and well-being, goal 3 of the UN SDG. Thus, the SSHS is less exhaustive, compared to the other rating systems and does not address many issues such as carbon emissions or building materials' embodied carbon. Also, the aspect of circularity is

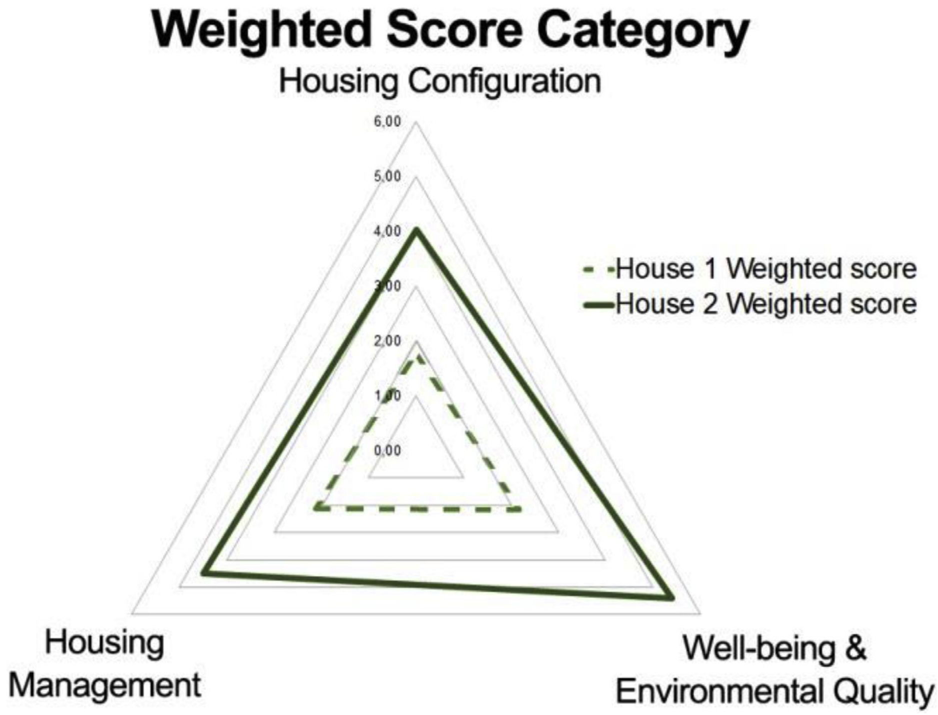

Fig. 2. Radar graph visualizing the comparison of the two housing units.

Table 5
Comparison between the SSHS tool and the other green building indicators.

Categories	BREEAM	LEED	Level(s)	LBC	DGNB	LBC	UN SDG	SSHS
Site/Land use	✓	✓	✓	✓	✓	✓	✓	×
Mobility	✓	✓	×	✓	✓	✓	×	✓
Water	✓	✓	✓	✓	✓	✓	✓	✓
Energy & Environment	✓	✓	✓	✓	✓	✓	✓	✓
Materials	✓	✓	✓	✓	✓	✓	✓	×
IEQ	✓	✓	✓	✓	✓	✓	✓	✓
Waste	✓	✓	✓	✓	✓	✓	✓	n/a
Management & Safety	✓	×	×	✓	✓	✓	×	✓
Cost	×	✓	×	✓	✓	✓	×	✓

n/a: not available.

missing. The SSHS is mainly focused on short-term sustainability issues, housing services quality and maintenance, and rental cost-related issues. It reflects strongly on the pragmatic needs of students and their understanding of basic.

On the other hand, the study findings indicate that students did not prioritize some green building indicators (see Table 3), such as energy efficiency, water-saving, and domestic waste management. The findings actually work slightly against the study hypothesis that Europe needs sustainable student accommodation. As mentioned earlier in the findings (Section 5.1), student tenants seem not to be interested in or not aware about energy efficiency and sustainability (regarding energy, water, and waste). However, we believe that this is related to the hidden cost drivers of those indicators. In most cases, students or their parents pay a fixed rent cost for an annual contract. The monetization of those aspects makes students widely misperceive the energy, water use, and associated carbon emissions (Schley and DeKay, 2015). Our survey indicates that most students are unaware of Energy Performance Certificates (EPC), which state the energy efficiency of building facilities and barely ever see or pay an energy or water bill (Taranu and Verbeeck, 2018). Also, the absence of waste separation bins for recyclables or organic waste makes many students ignore this practice of waste reduction and waste separation. Students tend to be insufficiently sensitive to a wide range of environmental impacts related to building operations. One of the solutions to help students increase their awareness and accessibility to those indicators is to encourage complete carbon footprint calculations. And to disaggregate their total energy and water use (and their associated carbon emissions) of all the devices they use, including washing machines and the waste they produce, through smart applications.

Therefore, this study sets the foundation for a future similar approach and study for sustainable student housing. The approach used to carry out this study is a universal approach and could be applied to other types of buildings. However, the tool in its current state remains limited to serving those residing in French-Speaking Belgium; the usability testing results revealed that the tool seems more useful if used by domestic students studying in Belgium. The following section explains how this tool can be scaled to meet ambitions beyond Belgium.

5.3. Implications for practice and future research

Higher education is becoming increasingly global in nature, giving rise to a growing student demand for quality housing in Europe. In recent years, there has been a considerable increase in the number of international students coming into the region. With the stringent energy and environmental regulation of the European Union, there is a chance to marry this demand for housing modernization with sustainability. In this study, we developed a set of criteria and a tool that can assist with the selection of sustainable housing accommodation. The tool is a starting point to provide a better assessment of student housing to identifying sustainable student housing.

More importantly, the criteria and tool can be transferred to other European regions or cities. The SSHS tool can be easily coupled to EPC and footprint calculation tools. This can be achieved based on the Level(s) reporting framework developed by the EU. The *Level(s)* sustainability reporting framework is a valuable opportunity to incorporate an environmental life cycle assessment into the overall evaluation of student housing. It can address the initial and end-stage of the student housing life cycle. In the long term, the tool can be expanded to include indicators on students' lifestyle impacts, including food and mobility, similar to the work of Marique et al. ((Anne-Francoise Marique et al., 2014; Anne-Françoise Marique and Reiter, 2012)). In the future, we hope to extend our investigation and include more European countries to develop a European assessment framework that provides for standard sustainability criteria, audit schemes, and assessment tools for sustainable student housing. The easy accessibility of students to information related to energy and water use, waste quantities, and recycling opportunities, together with renewable resources on a monthly basis or weekly basis, will be essential. The use of applications via smartphones and personal computers can increase the access to information on the real purpose of resources and their environmental impact (Attia, 2018a). Smart and sustainable student housing that is connected with appliances and devices can provide practical and reliable information that can alter the behavior of students.

The tool in its current state has significant limitations and remains elementary because students will still require more information in order to make an informed decision. However, we see our tool and our study overall as an approach to cater to those in need of domestic student housing. Therefore, we wish to extend our research with a focus on overseas students in a pan European context. Across Europe, there is a limited prevalence of both university-owned housing and private operators. There is even a lack of regulation and institutional infrastructure to offer affordable, sustainable, and modern student housing stock. Thus, the lack of supply in many markets in Europe is providing an opportunity for private homeowners to offer low-quality student housing. Therefore, it is essential to address the problems of student housing on a higher level and develop rating systems, schemes, or certifications with service provision for students on the European regional level. Student housing sustainability can be linked to the European framework of core indicators for the sustainability of office and residential buildings, named *Level(s)*. The level framework can enable actions to be taken for student housing and improve the quality of living across Europe, taking into account the contributions of students, researchers, building legislators, and policymakers.

6. Conclusion

The aim of this article is to develop key performance indicators and outline a multi-criteria approach for assessing sustainable student housing based on an online survey. A literature review allowed us to screen sustainability performance indicators for student housing. Then, a survey comprising 610 student responses, helped identify the most important criteria and sub-criteria (44), as well as the relatively less critical criteria, according to students. The ranking analysis revealed that sub-criteria classified under the Housing Management and Environmental Quality and Well-Being categories are of the highest importance level with a focus on comfort. However, considering the environmental impacts and sustainability of student housing, in particular, there is a lack of approaches or methods to evaluate their performance objectively and in a context-specific way. Thus, the other objective of the article was to develop an assessment tool that helps students evaluate, compare and select their future student housing. It is proposed to use an audit form that was validated through student surveys and expert knowledge. The audit form was translated into an interactive and visual tool that assists students in their decision making. The usability and feasibility of this new tool was investigated through a case. The ability of the tool to impact the selection process and guide the identification of sustainable housing was tested. The tool provides an easy starting point to introduce sustainability into student housing projects. Universities can also use our weight scoring system and key performance indicators to guide their decision choices when building a new dormitory, leasing, buying an existing building, or providing other campus housing. The ultimate purpose of this new tool is to set out a path towards a new generation of student housing assessment approaches across Europe and worldwide that contribute to the creation of policy objectives in areas such as energy, material use and waste, water, and indoor air quality.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.indic.2020.100052.

References

Alamel, A., 2015. An Integrated Perspective of Student Housing Supply and Demand: Sustainability and Socio-Economic Differences [PhD Thesis]. Loughborough University.

Albert, W., Tullis, T., 2013. Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics. Newnes.

Amer, M., Attia, S., 2019. Identification of sustainable criteria for decision-making on roof stacking construction method. Sustain. Cities Soc. 47, 101456.

Anfrie, M.N., Gobert, O., 2016. Les chiffres-clés du logement public en Wallonie (p. 179). Centre d'Études en Habitat Durable.

Anfrie, M.N., Cassilde, S., Kryvobokov, M., Pradella, S., 2013. Évaluation de la pertinence de la mise en œuvre d'une labellisation dans le secteur du logement étudiant. Centre d'Etudes en Habitat Durable.

Attia, S, 2014. The usability of green building rating systems in hot arid climates. First International ASHRAE Conference on Energy and Indoor Environment for Hot Climates, , Doha, Qatar 1 (1), 56–64.

Attia, S., 2016. Towards regenerative and positive impact architecture: a comparison of two net zero energy buildings. Sustain. Cities Soc. 26, 393–406.

Attia, S., 2018a. Net Zero Energy Buildings (NZEB): Concepts, Frameworks and Roadmap for Project Analysis and Implementation. Butterworth-Heinemann.

Attia, S., 2018b. Regenerative and Positive Impact Architecture: Learning from Case Studies. Springer.

Bandura, A., Cherry, L., 2019. Enlisting the power of youth for climate change. Am. Psychol. 5 (6), 110–118. https://doi.org/10.1037/amp0000512, 31436438.

Bebronne, E., Demeure, G., Pei, A., Stobbe, B., Vanderheyden, M., 2018. Etude générale relative au logement: Étudiant en provinces de Liège et de Luxembourg. HEC Consulting Group.

Benjamin, W., Joost, V., 2014. L'enseignement supérieur et Bruxelles. J. Res. Brussels 1 (1), 1–15. https://journals.openedition.org/brussels/1214.

Bhatt, R., Macwan, J.E.M., Bhatt, D., Patel, V., 2010. Analytic hierarchy process approach for criteria ranking of sustainable building assessment: a case study. World Appl. Sci. J. 8 (7), 881–888.

BRE, 2018. BREEAM UK New Construction, Technical Manual: Version: SD5078—Issue: 3.0.: Vol. Issue: 3.0.

Chen, Y., Okudan, G.E., Riley, D.R., 2010a. Decision support for construction method selection in concrete buildings: prefabrication adoption and optimization. Autom. ConStruct. 19 (6), 665–675.

Chen, Y., Okudan, G.E., Riley, D.R., 2010b. Sustainable performance criteria for construction method selection in concrete buildings. Autom. ConStruct. 19 (2), 235–244.

Chen, X., Yang, H., Lu, L., 2015. A comprehensive review on passive design approaches in green building rating tools. Renew. Sustain. Energy Rev. 50, 1425–1436.
Cornelis, 2016. Enquête sur le logement étudiant à Namur. Namur University, pp. 1–73. http://www.enquete-logement-etudiant-namur.be/rapport.pdf.
De Vogelaere, 2012. La pénurie des kots est réelle. Le Soir Newspaper. http://www.lesoir.be/archive/recup/%25252Flouvain-la-neuve-une-enquete-agl-cgee-sur-562-etudiants_t-20120210-01TRZQ.html.
De Vogelaere, 2017. Les étudiants inquiets de leur précarité. Le Soir Newspaper. http://www.lesoir.be/118360/article/2017-10-09/les-etudiants-inquiets-de-leur-precarite.
Delaney, L., Bernard, A., Harmon, C., 2010. Eurostudent Survey III: Report on the Social and Living Conditions of Higher Education Students in Ireland, 2006/2007.
Demeuse, R., 2016. Division de maisons unifamiliales en petits logements et kots d'étudiants: Quelle politique pour la Ville de Liège?.
Dodd, N., Cordella, M., Traverso, M., Donatello, S., 2017. Core Sustainability Indicators for Office and Residential Buildings.
Dubes, R.C., 1999. Cluster analysis and related issues. In: Handbook of Pattern Recognition and Computer Vision. World Scientific, pp. 3–32.
Duhaut, A., 2013. Les prix des kots. Le Soir Newspaper. http://www.lesoir.be/archive/recup/299036/article/studeo/2013-08-14/prix-des-kots-explosent.
Emilio, Di Meglio, 2018. Living Conditions in Europe—2018 Edition. Eurostat, p. 148. https://ec.europa.eu/eurostat/statistics-explained/index.php/Living_conditions_in_Europe_-_housing_quality.
Geng, Y., Ji, W., Lin, B., Zhu, Y., 2017. The impact of thermal environment on occupant IEQ perception and productivity. Build. Environ. 121, 158–167.
Genkov, A., Kudryashova, A., Mo, T., 2015. Certification Schemes for Sustainable Buildings: Assessment of BREEAM, LEED and LBC from a Strategic Sustainable Development Perspective.
Hamedani, A.Z., Huber, F., 2012. A comparative study of DGNB, LEED and BREEAM certificate systems in urban sustainability. In: The Sustainable City VII: Urban Regeneration and Sustainability, p. 1121.
Idrus, A.B., Newman, J.B., 2002. Construction related factors influencing the choice of concrete floor systems. Construct. Manag. Econ. 20 (1), 13–19.
ILBI, 2019. Living Building Challenge, 4.0. International Living Building Institute.
INCITS, A. (n.d.). 354. 2001report. Common Industry Format for Usability Test Reports. Standard.
ISO, 2018. ISO 9241-11: Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs): Part 11: Guidance on Usability. ISO.
Jezard, A., 2018. When do young Europeans leave home? https://www.weforum.org/agenda/2018/05/chart-of-the-day-when-do-young-europeans-leave-home/#:~:text=In%20most%20northern%20and%20western,late%2020s%20or%20early%2030s.
JLL, 2017. European Student Housing Report. http://www.jll.nl/netherlands/nl-nl/Research/European%20Student%20Housing%20Report%20-%202017.pdf?cb1a15df-4322-4fef-8244-d8f74da97d2d.
Kotweb, 2017. Quality label student kot. https://www.studentkotweb.be/en/quality-label.
Kuleshova, A., 2018. Student Housing. A New Perspective.
Lokaviz, 2017. Le label Lokaviz. https://www.lokaviz.fr/n/le-label-lokaviz/n:60.
Marique, Anne-Françoise, Reiter, S., 2012. A method to evaluate the energy consumption of suburban neighborhoods. HVAC R Res. 18 (1–2), 88–99.
Marique, Anne-Francoise, De Meester, T., De Herde, A., Reiter, S., 2014. An online interactive tool to assess energy consumption in residential buildings and for daily mobility. Energy Build. 78, 50–58.
Muslim, M.H., Karim, H.A., Abdullah, I.C., 2012. Satisfaction of students' living environment between on-campus and off-campus settings: a conceptual overview. Procedia Soc. Behav. Sci. 68, 601–614.
Myroom-residence, 2017. Label qualité MyRoom. http://www.myroom-residence.com/label-my-room/.
National Code, 2017. National code—assured accommodation. http://www.nationalcode.org/.
Olivier, C., 2016. Le Logement Étudiant, Un Réveil Tardif Mais Salutaire. Centre d'Archives et de Documentation. http://www.cpcp.be/medias/pdfs/publications/logement_etudiant.pdf.
Ong, S.-E., Petrova, M., Spieler, A., 2013. Demand for university student housing: an empirical analysis. J. Hous. Res. 22 (2), 141–164.
Parras, J., Jaspard, M., 2011. Recherche sur l'(in) adéquation entre l'offre et la demande de kots dans les principales villes estudiantines wallonnes. Université de Liège. SEGEFA.
Raynaud, Nakhlé, Verger, Donders, 2015. Panorama de la vie étudiante à Bruxelles: pratiques urbaines et rapport à la ville. Agence Dev. Territ. 1 (1), 1–105. http://www.adt-ato.brussels/sites/default/files/documents/ADT_Synt_Etudiant_FR_Ed-02_v05.pdf.
RE Cotton, D., Alcock, I., 2013. Commitment to environmental sustainability in the UK student population. Stud. High Educ. 38 (10), 1457–1471.
Roderick, Y., McEwan, D., Wheatley, C., Alonso, C., 2009. Comparison of energy performance assessment between LEED, BREEAM and Green Star. In: Eleventh International IBPSA Conference, pp. 27–30.
Roy, R., Caird, S., 2001. Environmental actions to reduce household ecological footprints. Int. J. Environ. Educ. Inf. 4 (2), 315–332.
Savills, 2018. Global Living, Student, Senior Housing & Multifamily Occupier Demands. Savills World Research, pp. 1–13. https://www.savills.co.uk/research_articles/229130/267688-0/267684-0.
Schley, D.R., DeKay, M.L., 2015. Cognitive accessibility in judgments of household energy consumption. J. Environ. Psychol. 43, 30–41.
Singh, M.K., Attia, S., Mahapatra, S., Teller, J., 2016. Assessment of thermal comfort in existing pre-1945 residential building stock. Energy 98, 122–134.
Soetanto, R., Dainty, A.R., Glass, J., Price, A.D., 2006. Empirical evaluation of structural frame performance criteria: realizing the potential of hybrid concrete construction. J. Construct. Eng. Manag. 132 (3), 278–290.
Taranu, V., Verbeeck, G., 2018. A closer look into the European Energy Performance Certificates under the lenses of behavioural insights—a comparative analysis. Energy Effic. 11 (7), 1745–1761.
Thomsen, J., Eikemo, T.A., 2010. Aspects of student housing satisfaction: a quantitative study. J. Hous. Built Environ. 25 (3), 273–293.
USGBC, 2019. Leadership in Energy and Environmental Design V4. 1.
Van de Sande, Stijn, Otten, H., 2018. Tekort aan koten veroorzaakt prijsstijging in Mechelen. https://www.standaard.be/cnt/dmf20180824_03681987.
Vanegas, J.A., 2003. Road map and principles for built environment sustainability. Environ. Sci. Technol. 37 (23), 5363–5372.