LEED and BREEAM Green Building Certification Systems as Possible Game Changers in Attaining Low-Cost Energy-Efficient Urban Housing Projects

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Abstract: The aim of this research study is to illustrate the role of the Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Design (LEED) within low-cost urban housing projects through the analysis of multiple factors and motivations impacting the outcome of construction projects. The rate at which climate change is advancing demands that the construction industry change their practices to decrease the natural resources it consumes as well as improve the environmental efficiency of the world's building stock. The introduction of BREEAM and LEED in 1990 and 2000, respectively, provided a system where buildings are evaluated on their energy performance. Issues, however, began to develop as research that illustrated the system's drawbacks undermined its utility. In turn, the role of the green building certifications ought to be researched so that policy and stakeholder communication frameworks can be developed by contractors and designers to ensure the success of BREEAM and LEED projects. The research study was completed through a literature study of prior research as well as by the publishing of a snowball sampling-based survey questionnaire undertaken between practitioners, architects, engineers as well as researchers involved in the UK construction industry. The results of the survey were then collated using IBM's Statistical Package for the Social Science (SPSS) and then a confirmatory factor analysis as well as a correlation matrix was completed. The confirmatory factor analysis illustrated that the two most important factors were climate change and quality. Thus, contractors and designers ought to develop practical policies and stakeholder frameworks to achieve value for money for the market demographic. The results of this study hold potential to increase the application of BREEAM and LEED. The improvement of practice in low-cost urban housing projects will improve the accessibility of BREEAM and LEED housing projects and, in turn, the energy efficiency and sustainability of new building stock. **DOI: 10.1061/JUPDDM.UPENG-4292**.

Author keywords: Climate change; Green building certificate system; LEED; BREEAM; Low cost; Energy-efficient projects.

Introduction

The construction industry accounts for 40% of total energy use, 40% of total waste, 30% of total energy-related greenhouse gas emissions, and 12% of total water consumption in addition to employing 10% of the labor force worldwide (Alawneh et al. 2019). While previously the environmental impact of the construction industry was not prioritized, the increase of impetus from consumers on "green" or "low-energy" initiatives creates motivation for organizations to pursue more environmentally conscious alternatives (Passila et al. 2015; Maqbool and Amaechi 2022). It is therefore paramount to decrease the impact of the construction industry on climate change as well as meet the increased consumer demand (Greer et al. 2019). This motivation generated a myriad of issues for the institutions that regulate the construction industry as public pressure fostered an environment where contractors, designers, and suppliers placed greater emphasis on green and sustainable practices (Ogunbiyi et al. 2014). As a result, multiple certification systems were developed to harness the problem. The green building certification (GBC) systems create the question of how to implement systems that accurately accredit construction projects that decrease their energy consumption both during project completion and within use while also developing a valid rating system (Ospina et al. 2016; Greer et al. 2019; Gurgun and Arditi 2018).

The main goal of Leadership in Energy and Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM) standards and certifications is to evaluate the energy performance of developed buildings. The standards also consider and are adjusted to the temporal, spatial, and cultural environment where the building was designed (Rastogi et al. 2017). The two systems being addressed are US- and UK-based systems, therefore the two have variances in scope, categories, and scoring despite similarities in focus and motivation.

Previous research surrounding LEED and BREEAM certification systems has focused on the assessment of GBCs and the extent to which the certification systems decrease the energy consumption within construction projects, the potential impact of GBCs in developing countries, and the differences in the impact between the various versions being developed (Ospina et al. 2016; Greer et al. 2019; Gurgun and Arditi 2018; Alawneh et al. 2019; Ackay and Arditi 2017). There is, however, a gap in the literature surrounding the role of LEED and BREEAM within construction projects (Ackay and Arditi 2017; Altomente et al. 2017;

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Cole and Valdebenito 2013; Liu et al. 2019). This research paper therefore aims to unpack the primary factors and motivations that impact the role of BREEAM and LEED in low-cost urban housing projects.

There are issues within LEED and BREEAM GBCs, as it has been highlighted, that in some cases the systems do not actually provide environmental efficiency or decrease consumption of resources (Amiri et al. 2019). Thus, it must be questioned whether they are really "beneficial for the environment, and worth the money and time investment in the certification process" (Amiri et al. 2019).

Prior research has illustrated multiple factors that prevent the adoption of GBCs, such as increased construction costs and duration, lack of special knowledge and education, while in contrast the drivers are reduced utilities costs, higher rent or sale price, higher indoor air quality, and reputation and prestige for the real estate development company (Apanaviciene et al. 2020). However, within low-cost urban housing projects, tenants will be looking for lower rental rates and sale prices, despite the incurred lower utilities costs.

In order to decrease the costs ensued, greater research is required. In order for green energy certifications to be truly sustainable, the most advanced and current technologies ought to be applied to take advantage of these advancements. Similarly, the technology advancement within the industry requires additional knowledge in order to harness their full potential.

The objectives of this research project are to illustrate and discuss the critical supporting factors for the LEED and BREEAM energy certification in attaining low-cost sustainable housing construction projects. The specific objectives are as follows:

- To highlight relationships and comparisons between LEED and BREEAM factors, cost, time, and energy performance of the housing projects.
- To address the other key drivers for LEED and BREEAM green energy certifications, such as whether the client or the contractor organizations push for the accreditation and the extent to which it is used as a way to keep construction costs low.

Previously there has been significant research on the comparison between BREEAM and LEED GBCs and their successes within construction projects. However, there has been a gap in research into how the drawbacks of their application have a significant impact on the role they undertake. Therefore, there ought to be greater research into the multiple factors and motivations that impact the role of BREEAM and LEED. In addition, increased public demand for green housing and urbanization has necessitated more accessible green housing for those with lower incomes. The research undertaken within this study will provide a framework for contractors and designers to implement BREEAM and LEED in low-cost urban housing projects due to the deeper understanding of how the factors and motivations involved can improve the success rate of BREEAM and LEED projects.

Fig. 1 illustrates how the literature study is structured.

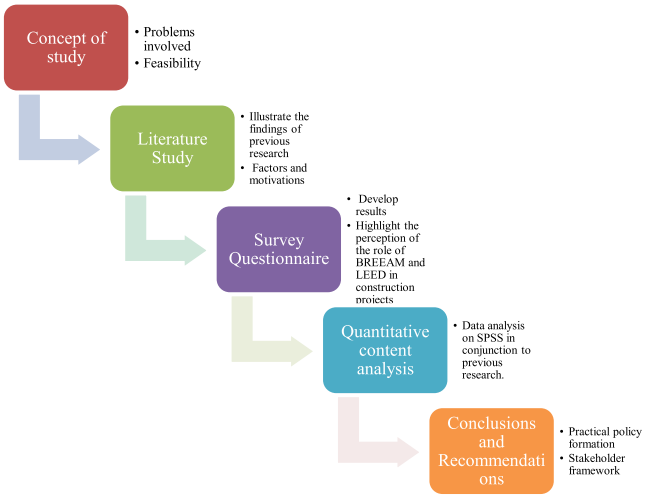

Fig. 1. Structure of research.

Literature Study

The Role of BREEAM and LEED in the Construction Industry

The main goal of these standards and certifications is to evaluate the sustainability and energy performance of buildings (Rastogi et al. 2017). In turn, the systems drive behavior by people, organizations, and municipalities interested in pursuing sustainable infrastructure (Greer et al. 2019). The scope of the number of green certified buildings will decrease the energy and resource consumption of the built environment over time.

The following subsections will focus on the application, use, and methods used in both BREEAM and LEED construction projects.

BREEAM Certification System

Research studies have illustrated the influential impact BREEAM has had on other GBCs (Scofield and Doane 2018; Doan et al. 2017). It is widely agreed that all later certification systems such as LEED are under the influence of BREEAM. It is praised for its flexibility and applicability to projects worldwide and to date 2,250,700 buildings have been BREEAM certified in the United Kingdom and beyond (NBS 2021). BREEAM developed assessment systems for the whole lifecycle of a building: design stage, completed building, in-use, and renovation, therefore providing a utilitarian system that can be continuous throughout the building (Apanaviciene et al. 2020).

The use and application of BREEAM has been debated within studies. Greer et al. (2019) argued that the GBC simply acts as an approach to creating a shared understanding of what it means to achieve building sustainability, whereas others have ascertained that GBC systems such as BREEAM ought to diversify in order to implement sustainable actions and practices (Doan et al. 2017). Since its introduction, BREEAM has been developed into multiple versions in order to meet innovations in technology and some studies have argued that there has been a shift from green to sustainable practices due to development within the discourse (Doan et al. 2017).

LEED Certification System

It is broadly argued that LEED and BREEAM are the two most dominant GBCs used in the construction industry and LEED has been celebrated for its ability to be applied to multiple countries (Scofield and Doane 2018). In terms of urban housing projects, there have been diverging studies on the utility of LEED. Rastogi et al. (2017) argued that multifamily midrise buildings benefit from the pursuit of LEED ratings as it will decrease the energy consumption during the building's use. However, Scofield and Doane (2018) argued that in Chicago, GBCs use 10% less energy on site than nonaccredited buildings; however, this does not translate into source energy savings because LEED-certified buildings use relatively more electric energy. The two studies are at juxtaposition

to each other, which instigates debate surrounding how the roles of LEED vary between the contractor and the consumer in urban housing projects, as the contractor will want to decrease consumption during the construction period, while the consumer will want a decreased cost during the building's use.

LEED and BREEAM Comparison

The comparison between BREEAM and LEED has saturated research on GBCs (Cole and Valdebenito 2013). Therefore, in order to be concise, the following section will highlight some of the arguments regarding the diverging and converging attributes within the versions, categories, rating systems, and application worldwide.

Versions

BREEAM and LEED are both voluntary methods (Doan et al. 2017). However, according to research comparing the two certification systems, there has been an increase in application within local municipalities, communities, and contractors (Ospina et al. 2016).

Various versions of the certification methods have been introduced from their creation in order for the systems to become more nuanced to recent trends and practices within the construction sector. Most recently, it has been recognized that there has been an increase in categories in the more modern versions, which include integrative processes, location, and transportation (Doan et al. 2017). Such categories have possibly been included in order to implement more holistic construction projects that place greater emphasis on wider communities. Charoenkit and Kumar (2014) argued that the introduction of the more nuanced BREEAM community and LEED neighborhood better equipped the multiple professions in the construction sector to develop greener low-income housing projects.

Categories and Rating Systems

Research studies have illustrated that both BREEAM and LEED have many similarities within the quantity and titles of categories as well as the amount of categories (Doan et al. 2017).

LEED is classified into the following five types: "LEED Building Design & Construction," "LEED Interior Design and Construction," "LEED Neighborhood Development," "LEED Building Operations and Maintenance," and "LEED for Homes" (Rastogi et al. 2017). The most valuable version of LEED for this research project is "LEED for Homes," which has gone through transformative changes in order to be more applicable to different residential buildings (Rastogi et al. 2017). As the focus of this paper is urban housing, which tends to be midrise to high-rise building projects, LEED for Home Multifamily midrise creates an analytical lens where the role of LEED for the contractors and the multiple occupant families can be compared and contrasted. Enriching this debate is the research surrounding how LEED is a social movement as much as it is an evaluation system. Greer et al. (2019) found that LEED drives behavior by people, organizations, and municipalities interested in pursuing sustainable infrastructure.

LEED's rating system has been scrutinized; however, systems such a LEED, which award points based on meeting a site level target, often fail to echo meaningful environmental impacts or capture links among systems (Greer et al. 2019), which is in conjunction with the environmental motivations of LEED, as the contractors receive points even if the measures implemented do not create environmental benefits.

Within BREEAM, there are 10 different categories that determine the overall performance of a development assessed using BREEAM—Energy, Health and Wellbeing, Innovation, Lane Use, Materials, Management, Pollution, Transport, Waste, and Water. These are then subdivided into a range of assessment issues, each with its own aim, target, and benchmarks (BREEAM 2021a, b) and are all individually weighted in order to generate a score for a project and create a maximum total of 132 (Apanaviciene et al. 2020). The category score is then calculated by multiplying the influence of each category with the percentage of points scored and the final rating of evaluation is based on the sum of the accumulated scores (Apanaviciene et al. 2020). Research studies have argued that the weighting mechanisms had a negative impact on the efficiency of projects, as it was realized that contractors would pursuit the categories that would provide maximum rating with minimum actions or investment (Rastogi et al. 2017; Ackay and Arditi 2017).

Research studies have shown merits and disadvantages to the rating systems used in both BREEAM and LEED (Ospina et al. 2016). BREEAM awards points on an absolute basis, whereas LEED awards points on a percentage reduction relative to a predefined baseline value (Greer et al. 2019). The severity of the rating systems also differs between the two: BREEAM is stricter in its criteria for achieving credits as it sets absolute parameters, while relative percentage improvement or reduction targets are employed by LEED (Doan et al. 2017).

Points could be achieved if a project satisfies the requirement for mandatory credits in BREEAM as opposed to LEED when no point is allocated for those credits but it is compulsory to comply with the credits (Doan et al. 2017).

It has been discovered that the differences in the rating systems create problems when comparing the two certification systems due to the lack of standardization (Cole and Valdebenito 2013). Thus, greater appreciation of these differences need to be recognized when comparing their roles within urban housing projects as their rating systems will alter their intended use for the client, particularly property investment portfolios (Cole and Valdebenito 2013).

Application Worldwide

The international application differs between BREEAM and LEED. As illustrated in Table 1, LEED has reached 160 countries whereas BREEAM has only reached 77. The reason behind this is unclear; however, it has been ascertained that it could be due to LEED's additive credit system being more applicable than BREEAM's preweighted categories (Doan et al. 2017). In contrast, Cole and Valdebenito (2013) argued that the reason behind why

Table 1. Comparison of BREEAM and LEED

Category	BREEAM	LEED
Country	UK	US
Organizations	BRE	USGBC
Flexibility	77 countries	160 countries
First version	1990	1998
Main categories	Management	Integrative process
	Health and wellbeing	Indoor environment
	Energy	Quality
	Transport	Energy and atmosphere
	Water	Location and transportation
	Material	Water efficiency
	Waste	Material and resources
	Land use and ecology	Sustainable sites
	Pollution	Regional priority
	Innovation	Innovation

Source: Data from Doan et al. (2017).

this development is unclear within recent research is that there is a gap in research on the roles and contributions of the individuals and organizations that created and shaped the systems. Therefore, this research project is going to focus on the multiple stakeholders involved within low-cost urban housing and how their motivations have framed GBCs.

Based on the aforementioned literature, it can be seen that the adoption of the BREEAM and LEED systems is due to their wide benefits for sustainability. This is what researchers have taken as the key reason for the adoption of these systems even if it has an initial high cost. Accordingly, it is hypothesized as:

Hypothesis 1: If the quality of BREEAM and LEED is not guaranteed, there is no high demand from consumers.

Motivation for LEED and BREEAM GBCs

Despite BREEAM and LEED being introduced in the 1990s, the following section of the literature study will focus on the more recent motivations illustrated in modern academic research and literature as this provides a closer framework for the current role of LEED and BREEAM in low-cost energy-efficient urban housing projects.

Climate Change

The environmental impact of the construction industry made it highly relevant to introduce environmental sustainability goals (Greer et al. 2019; Maqbool et al. 2022). Previous research illustrated that the energy consumption used during a project's lifecycle as well as the energy consumed throughout a building once completed required harnessing to minimize its impact on climate change (Alawneh et al. 2019; Pelin and Arditi 2018). Buildings account for 19% of global greenhouse gas emissions, 40% of total energy use, 40% of total waste, and 12% of total water consumption (Alawneh et al. 2019; Pelin and Arditi 2018). Alongside the construction industry's energy consumption, building stock changes slowly and much of the existing stock was constructed many decades ago when its impact on climate change was not a consideration (Scofield and Doane 2018). Thus, quick and efficient action is required.

The introduction of the United Nations Sustainable Development Goals (UNSDGs) also increased public knowledge of the impact of climate change, which created motivation from the consumer. Thus, there are motivations for both designers and developers to build energy-efficient buildings. Recent research on attitudes toward energy-saving methods has shown consumer demand for buildings that maximize energy saving, despite consumers' personal motivations being effected by age, education levels, and familial status (Mills and Schleich 2012). Younger generations with children tend to "adopt energy efficient technologies and energy conservation practice, and place primary importance on energy savings for environmental reasons," whereas older generations tend to place greater significance on financial savings as a motivation when considering their energy consumption (Mills and Schleich 2012). Despite the contrasting motivations by consumers for decreasing their energy consumption, recent research illustrates how being more environmentally conscious is increasingly becoming a priority within the public lexicon. For developers and designers, there is an economic motivation to adopt measures that improve the energy efficiency of buildings to meet consumer demand.

Based on aforementioned literature, this is hypothesized as:

Hypothesis 2: Climate change is the strongest motivation for the application of BREEAM and LEED.

Technology and Innovation

The increased precedence placed on climate change created a secondary effect on the construction industry, pushing for more technology and innovation as well as research and development in order to improve energy efficiency in the construction sector (Passila et al. 2015; Maqbool and Wood 2022). Research has also illustrated that the potential innovation is a motivation for the use of BREEAM and LEED certifications, as the measures in place and potential for attaining a high score provides scope to experiment on the technology, methods, and materials used (Alawneh et al. 2019). However, other studies have shown that construction industry firms are less likely to spend money on research and development as well as technological innovation (Passila et al. 2015). Notwithstanding this, other research has been more optimistic and illustrated that the development of certification systems such as BREEAM and LEED as well as the directives introduced by the EU improve the energy performance and energy efficiency in the construction industry, which perhaps funding and research will subsequently increase (Cole and Valdebenito 2013).

The motivation for greater technology and innovation in the construction industry is possibly not the key driver for the introduction for GBC systems; however, the aptitude for improvement in the use of renewable energy sources, recycled materials, and minimizing consumption of natural resources has opened a new and exciting field of research in the construction industry that ought to be explored (Maqbool 2018; Maqbool et al. 2020).

Cost Dimension

Studies have shown that cost creates concerning paradigms for the implementation of GBCs globally (Gurgun and Arditi 2018). It has been illustrated that the highest level of certification requires considerable effort and extra initial cost (Ackay and Arditi 2017). Thus a paradox is created between wanting to get a high rating while also decreasing the cost. Some research has stated that the use of new technologies could cheapen the process; however, such technologies are still in the research stages so their introduction in projects could incur costs for the customers down the line (Acemoglu et al. 2012). Similarly, the incurred costs from the increased construction time and lack of special knowledge and education deter contractors from implementing the required measures for a high rating (Apanaviciene et al. 2020). Gurgun and Arditi (2018) stated that due to prior advancements in the technology there is still a wealth of technologies that can be implemented to save costs despite not being the most recent innovations.

Apanaviciene et al. (2020) within their research into additional, unseen costs of GBCs illustrate how is not easy to decrease costs due to the variety of materials needed. Seeking LEED and BREEAM certification increases total building costs by 2%–3% and less than 2% of the total project cost, depending on the use of internal LEED/BREEAM administrator or external consultants. There has been extensive research into how the highest amount of points can be generated through lowest cost.

Prior research includes discussion surrounding whether BREEAM and LEED have an impact on market value (Schweber 2013). Dixon et al. (2009) found that the certification systems added market value for those already committed to sustainability, whereas for others, location, cost, and availability continue to take precedence. It has also been found that BREEAM- and LEED-rated buildings do not receive a statistically significant effect on appraised value (Schweber 2013). Therefore, recovery of the costs involved may not be ensured from the purchaser, which discourages contractors from pursuing BREEAM and LEED ratings that require greater investment.

There ought to be some discussion on the public perception of household energy use behavior as this will help develop a framework of how the public perceives energy-efficient practices. It has been argued that "family age composition patterns have a distinct impact on household energy use behavior, and those with young children are more likely to adopt energy efficient technologies and conservation practice and place primary importance on energy savings for environmental reasons" (Mills and Schleich 2012). It is worthwhile including public attitudes toward the price they will pay for energy-efficient homes. This research will help develop a framework for how contractors and project owners apply GBCs in construction projects. As the demographic for low-cost urban housing projects is young professionals and younger families, it can be presumed that they will desire high ratings in GBCs in order to save costs and minimize their impact on the environment.

Based on aforementioned literature, this is hypothesized as:

Hypothesis 3: Consumers will pay an increased price only if quality, energy efficiency, and sustainability is guaranteed.

Quality Factor

Studies that have questioned the quality of BREEAM and LEED pose the following question: If the certification systems do not improve the energy efficiency of construction projects and minimize their impact on the environment, what is the role of said systems beyond a brand label to attract customers (Cole and Valdebenito 2013)?

In addition, due to the focus of this research project being low-cost urban housing projects, there ought to be consideration from the consumer perspective of the how quality provided by BREEAM and LEED has the potential to improve the communities themselves (Callaway et al. 2019). Callaway et al. (2019) argued that BREEAM community's version does not maximize the ability to improve the sustainability of housing project masterplans due to the lack of clarification on how to achieve parameters within the design stage. Studies have also recognized that BREEAM and LEED categories and versions do not improve indoor environments within accredited projects (Altomente et al. 2017). The lack of emphasis placed on these factors, Altomente et al. (2017) argued, diverted "attention from the physical, physiological and psychological impacts that the built environment has on building occupants."

Some studies have shown that the issue of quality could be rectified through simple changes within the rating systems as it will force a stronger adherence in improving the energy performance of the buildings rather than just working the system (Greer et al. 2019).

Discussion surrounding the quality recognition of the brand has led to issues undermining the role of BREEAM and LEED within urban housing projects. The introduction of the UNSDGs accelerated LEED and BREEAM into the popular lexicon, which presented them as brands of quality for consumers (Altomente et al. 2017). Research is needed into how this lens into the quality of the systems may impact the motivations for contractors to utilize BREEAM and LEED.

Time Factor

The consideration of the completion time of BREEAM and LEED construction projects ought to be included as it presents an additional motivation or demotivation for contractors to apply the certification systems. Prior research has illustrated a lack of research into the completion time of green building projects due to the difficulties involved (Chegut et al. 2019). The multiple variables involved in these projects such as management, materials used, technology used, and experience within the construction teams create deep disparities between the completion times, which may deter others from implementing the systems (Acemoglu et al. 2012). Chegut et al. (2012) found that within their sample, the average increase was about 11%, which increased the cost by an average of 6.5%. The perceived time and cost increase has been discussed as the main reason preventing a broader adoption of GBC systems (Chegut et al. 2019; Apanaviciene et al. 2020). The discussion surrounding the time increase preventing adoption provides an interesting lens of analysis as perhaps BREEAM and LEED are perceived as an obstacle within construction projects. The argument could perhaps be supported through the adoption of BREEAM and LEED only being at a rate of 5%–6% across construction projects in the UK (Chegut et al. 2019). From a consumer point of view in low-cost urban housing projects, the incurred time and thus cost increase may deter consumers from purchasing them as a home.

This argument is discussed further in the survey questionnaire provided in the Appendix, which considers whether consumers would be deterred by the incurred time and cost increase in urban housing projects.

Identified Trends and Directions Discussed in the Literature Review

Tables 2 and 3 provide an overview of the trends, discussions, and findings from the literature review. Table 2 breaks down the recognized trends that influenced the structure of the literature review. Table 3 is a framework for the multiple research studies that framed the survey questionnaire for this research study.

Methodology

Research Philosophy

A positivist research strategy was used to investigate the research questions of this study, despite positivism being difficult to pin down and outline in a precise manner due to authors applying it in different ways (Bryman 2016). However, positivism is being used in this research (Fig. 2) to apply the methods of the natural sciences in order to study the social reality of the true role of BREEAM and LEED in the construction industry (Bryman 2016).

Table 2. Identified trends in literature

Category	The role of BREEAM and LEED
Comparison of BREEAM and LEED	Research on the comparison between BREEAM and LEED has been covered extensively BREEAM and LEED can be improved through changes being made to their rating systems
The motivations for BREEAM and LEED	
Climate change	There is an increase in public knowledge of the impact of climate change and the impact of the construction industry Consumer spending patterns have changed due to climate change
Technology and innovation	The incurred cost of new technology and innovation prevent improvements being made
Cost	Cost increases come at opposition to the aims of low-cost urban housing projects
Quality	The quality of BREEAM- and LEED-certified buildings is not assured
Duration	The increased duration is a deterrent for both contractors and consumers

Table 3. Overview of prior studies

Authors	Study name	Description	Methodology
Doan et al. (2017)	Energy performance of LEED-certified apartments in Chicago	The study assessed the energy efficiency of multiple LEED-certified apartment blocks in Chicago to discover the quality and value of LEED certification.	Analysis of U values and energy performance of the apartment blocks.
Greer et al. (2019)	The climate outcomes of the energy and water category of the LEED certification	Testing the energy and water category of the LEED certification and how it may link to the building's impact on the climate.	Case study analysis in California where there is distribution of direct CO_2 and cumulative energy savings.
Alawneh et al. (2019)	Discover the relationships between LEED and the energy outcomes	The study was designed to explore if a relationship exists between LEED 2009 prerequisites and credits in the EA category and UN Sustainable Development Goals and to develop a new index for assessing the contributions of energy efficiency in LEED 2009-certified buildings.	Data collection for survey, which is then analyzed with frequencies, mean, test of statistics, P value, and relative performance index.
Ackay and Arditi (2017)	How BREEAM and LEED certification systems can be manipulated to get maximum points with minimum cost	Guide to designers in obtaining the desired numbers of earned points in the optimized energy performance credit of the energy and atmosphere category of LEED v4.	Energy simulation software programs were utilized to discover how high ratings can be generated with minimum cost.
Acemoglu et al. (2012)	The environment and technical change	The study concludes that "when inputs are sufficiently substitutable, sustainable growth can be achieved with temporary taxes/ subsidies that redirect innovation toward clean inputs" (Acemoglu et al. 2012)	Development of a Model to determine the level of "dirty" and "clean" inputs to work out how to control and limit climate change.
Callaway et al. (2019)	Embedding green infrastructure evaluation in neighbourhood masterplans – does BREEAM communities change anything?	The study aims to examine the links between green infrastructure (GI) evaluation and masterplan decision making.	Study of six English Masterplanned sites with paired case studies to examine whether the sustainable standards and BREEAM communities made an impact.
Gurgun and Arditi (2018)	Assessment of energy credits in LEED-certified buildings on certification levels and project ownership	The study wanted to identify the extent to which project teams take advantage of the energy and atmosphere credit in LEED construction projects.	Analysis of Energy and Atmosphere Credits extracted from the USGBC project database.
Mills and Schleich (2012)	Residential energy-efficient technology adoption, energy conservation, knowledge and attitudes: An analysis	The study investigated the relationship between measures of household energy use behavior and household characteristics. It was found that family age composition patterns are found to have a distinct impact on energy behavior.	Dataset analysis of approximately 5,000 households in 10 EU countries and Norway.
Altomente et al. (2017)	satisfaction with indoor environmental quality in BREEAM and non-BREEAM certified office buildings	The study found that certification schemes should balance criteria addressing energy performance with design solutions considering privacy, proxemics, and perceived control over the indoor environment.	Preliminary analysis of occupant satisfaction with indoor environmental quality in offices across the UK. Analyzed 121 different office buildings.
Rastogi et al. (2017)	Impact of different LEED versions for GBC and energy-efficient rating system: A multifamily midrise case study	The study found that midrise multifamily buildings could benefit from LEED v4 in terms of LEED credits for minimum energy performance.	Case study was carried out with energy modeling and simulation using TRACE 700 to compare the changes in energy performance.
Schweber (2013)	The effect of BREEAM on clients and construction professionals	The primary effect of BREEAM is through its impact on standard practices.	Multiple candidates were interviewed to explore the effect of BREEAM on visibilities, knowledge techniques and professional identities.
Scofield and Doane (2018)	Energy performance of LEED-certified buildings from 2015 Chicago benchmarking data	The study found that out of the 132 properties checked, LEED-certified buildings use no less source energy than similar buildings.	Cross referenced the energy usage data for 1,521 commercial properties to discover whether LEED certifications reduce the building's energy use.
Hoffman and Henn (2008)	Overcoming the social and psychological barriers to green building	The study found that the social and psychological barriers that remain in GBCs are preventing the application of the certification systems.	Literature analysis of the multiple factors that impact the implementation of LEED in construction projects.
Liu et al. (2019)	Comparison of assessment systems for green building and green civil infrastructure	Greenery, recycling of materials, water conservation, carbon emission reduction, and energy saving are considered in both green building and green civil infrastructure assessment systems.	The authors studied and summarized different key indicators and evaluation items, and made comparisons among some major assessment systems.

Fig. 2. Deductive approach undertaken.

A deductive approach is the most suitable for this study and is built upon existing research on the quality and success of BREEAM and LEED within construction projects. Through the development of hypotheses, the study was able to allow multiple factors to be assessed (Bryman 2016).

Research Methods

To illustrate how the role of BREEAM and LEED is perceived by those in the construction sector, the research undertook a self-administered survey questionnaire (Appendix) that was distributed to professionals working within the construction industry and architecture firms. This paper examines the views of those in the United Kingdom, therefore the results of the research focus on the role of BREEAM and LEED within urban housing projects in the United Kingdom.

A survey questionnaire was utilized as these are best when employed for "cross sectional research design." As the aim of this research is to illustrate the role of BREEAM and LEED in low-cost urban housing projects, there are a multitude of factors to consider (Bryman 2016).

For this research paper, the results will provide quantitative analysis for the actual role of BREEAM and LEED in low-cost urban housing projects through asking how the respondents perceive the two certification systems.

Sampling and Data Collection

The demographics of the respondents was heavily impacted by Covid-19 as the additional precautions meant that the survey questionnaire was primarily shared among university peers, friends, family, and those with whom we work. As illustrated in Table 4, the mode age group was 18–25, which represented 42 out of 133 respondents.

The most common occupation across the respondents was project manager at 34 out of 133, which provides an in-depth analysis as project managers will have a strong idea of how BREEAM and LEED are implemented in construction projects. Similarly, the majority of respondents were Bachelor degree educated with 54 out of 133. From a more practical point of view, the majority of respondents were homeowners who lived in city central or urban areas and ran energy-efficient homes. Thus the results are framed by those who have a strong idea of energy-efficient housing programs and how our actions can impact the effect on the environment.

Prior to the data analysis, the data was gathered via a questionnaire and was inspected for any missing data, normality, and outliers.

Data Screening

There are no missing responses to any of the respondent demographics questions.

The IBM Statistical Package for the Social Sciences (SPSS) program was utilized as it is a reliable and robust software for analyzing quantitative data; the survey questionnaire responses were collated on the data section and different types of analysis took place.

The analysis of the results was produced through the results of the survey being manipulated within Excel into a contingency table. Contingency tables are "probably the most flexible of all methods of analyzing relationships in that they can be employed in relation to any pair of variables" (Bryman 2016). As the analysis included the comparison between BREEAM and LEED, the contingency tables worked well in order to compare the relationships between the two GBCs and how they link to the roles they undertake within low-cost urban housing projects. The results from the contingency tables allowed relationships and causation to be highlighted between the different factors.

Questionnaire Development

It is vital to include relevant and insightful questions in online questionnaires to ensure that there is an appropriate chain of discussion

Table 4. Respondent demographics

Demographics of respondents			
Characteristics	Category	Frequency	Percent
Age	18–25	42	31.6
	25–35	30	22.6
	35–45	15	11.3
	45–55	22	16.5
	55 plus	24	18.0
Gender	Male	102	76.69
	Female	31	23.31
	Other	0	0
Occupation	Professional Engineer	9	6.8
	Project manager	34	25.6
	Project architect	22	16.5
	Architectural Technologist	8	6.0
	Researcher	8	6.0
	University Lecturer/ Professor	18	13.5
	Other	34	25.6
Experience in the construction sector	1–5 years	34	25.6
	5–10	50	37.6
	10–15	15	11.3
	15–20	4	3.0
	20–25	18	13.5
	25 plus	12	9.0
Level of education	Higher education	2	1.5
	Bachelor's degree	54	40.6
	Masters	51	38.3
	PhD	26	19.5
Homeowner	Yes	75	56.4
	No	58	43.6
	Total	133	100.0
Type of area	City central	62	46.6
	Urban area	53	39.8
	Village	12	9.0
Energy-efficient home	Yes	73	54.9
	No	60	45.1

Table 5. Questionnaire focal points and reasoning

SR. No	Factor	Question focus	Items	Sources
1	Respondent demographics	The inclusion of background information such as occupation, construction experience, education, what type of area they live in and whether the interviewee is a homeowner will provide a framework for analysis into how these factors my impact the way they perceive BREEAM and LEED. In order to receive a diverse group of responses, the survey questionnaire was shared via both email and LinkedIn. The method of survey administration however could have led to sampling error, as the administration of survey questionnaire online means that there is not a rapport built between the interviewer and the interviewee, and it also means that it includes those who do not have the relevant understanding to provide insightful answers (Bryman 2016). In order to prevent this sampling error having a big impact on the results, a survey questionnaire was only sent to those within the construction industry and put in construction industry groups on LinkedIn.	7	(Bryman 2016)
2	Motivations	The analysis for the motivations for the implication of BREEAM and LEED were discussed and the results were then analyzed to develop an in-depth analysis for why people will choose energy-efficient options; from these results discussion on how these motivations from the consumer frame how contractors act within construction projects. Similarly, the insight provided from those within the construction sector is beneficial as they have experience of how contractors utilize BREEAM and LEED GBCs.	13	Greer et al. (2019), Scofield and Doane (2018), and Alawneh et al. (2019)
3	Cost dimension	The inclusion of cost was vital due to the research focusing on low-cost urban housing projects as it creates a framework surrounding how contractors develop low-cost house projects when the consumers may not be able to pay for the incurred price increase. It also discusses the cost of the innovation and research required to implement the new technologies.	7	Ackay and Arditi (2017)
4	Quality factor	The quality intended on bringing in the discussion surrounding if BREEAM and LEED do not produce energy-efficient homes, what is their true role within low-cost urban housing projects.	3	Rastogi et al. (2017) and Gurgun and Arditi (2018)
5	Time factor	The incurred time increase of implementing BREEAM and LEED practices can prevent it being applied in urban housing projects and deter customers from wanting to purchase these accredited homes. Therefore time and scheduling was included to bring in discussion regarding how this could frame contractors use of BREEAM and LEED.	3	Liu et al. (2019)

with which to engage the participants (Bryman 2016). However, owing to the short time period involved within the research project, the questions were developed through research from previous studies.

The survey questionnaire format varied across the different questions in order to develop a clear framework for discussion. A Likert scale was used to understand the views and perspectives toward BREEAM and LEED (Park 2021). In this case, a score of 1 represented "strongly disagree" and a score of 5 represented "strongly agree," and after reading the statements, the respondents selected their response. A 5-point Likert scale was used in order to include a neutral option if the respondents do not wish to answer from the extreme choices (Park 2021). Through the respondents selecting their agreement with different motivational statements, discussion surrounding the most popular motivations could be developed in relation to the hypotheses.

The other questions required respondents to rank the BREEAM and LEED categories from 1st to 10th place in order to provide an insight into how the respondents viewed the various BREEAM and LEED certification parts.

The multiple sections covered in the survey questionnaire are provided in Table 5 to explain the reasoning behind their inclusion.

Reliability and Validity Tests

Reliability Test

Both reliability and validity tests have been utilized in order to check the robustness of the research. Cronbach's reliability was used to "test the reliability of the survey" to determine whether the answers are viable (Ogunbiyi et al. 2014). Within research projects there are usually three strategies for estimating reliability:

1. Test retest reliability.
2. Equivalent forms of reliability.
3. Internal consistency reliability.

Owing to the time period of this research project, internal consistency reliability was tested as it prevented having to administer the test twice or having two different forms of the test (Brown 2002).

A Cronbach's reliability analysis was undertaken across all of the Likert scale questions within the survey to discuss the variance between the survey respondents. As illustrated in Table 6, the two motivations above the guideline of 0.7 were climate change and quality (Brown 2002).

It can be ascertained that there is a consistent variance within the survey respondents. Across the respondents there is a range of construction sector experience as well as occupations, therefore there may be disagreements between how contractors and consumers ought to act within low-cost urban housing projects.

Validity Test

Validity tests are utilized in order appraise the integrity of the conclusions that are generated from a piece of research (Bryman 2016). An internal validity test utilizing the Pearson method was applied so that the strength between the multiple factors and their statistical association with each other could be explored within the discussion.

Table 6. Reliability analysis of scale

Factor	Cronbach's alpha	No. of items
Climate change	0.765	7
Technology and innovation	0.552	4
Cost	0.689	3
Quality	0.714	7
Duration	0.755	2

Exploratory factor analysis (EFA) was used to determine the factor and factor loading of measure variables and to confirm what is expected on the basic or pre-established theory (Statistics Solutions 2021).

A Kaiser–Meyer–Olkin (KMO) and Bartlett's test was completed in order to indicate the suitability of the data for structure detection (IBM Docs 2021). As shown in Table 7, the result of the Bartlett's test of sphericity was 0.7, so as the result was close to 1, we can deduce a factor analysis will benefit the research data.

Table 8 presents the factor loading component matrix for each of the 23 variables included in the survey questionnaire. The factor loading of each variable above the acceptable minimum value of 0.5 is shown in bold (Maskey et al. 2018). Factor loading is the correlation coefficient for the variable and factor, as this shows the variance explained by the variable on that particular factor (Statistics Solutions 2021). The oblimin with the Kaiser Normalization rotation method was used as the prior standard was less than 0.32.

It can be deduced from Table 8, the two most important motivations for BREEAM and LEED in low-cost urban housing projects are the consideration for minimizing the impact for climate change and the quality of the housing projects. Therefore, it can be deduced that those purchasing and working on BREEAM and LEED-certified low-cost urban housing projects would aim to ensure that quality and energy efficiency is maintained.

Table 7. KMO and Bartlet's test

KMO and Bartlet's test		
Kaiser-Meyer-Olkin measure of sampling adequacy		**0.735**
Bartlet's test of sphericity	Approx. Chi-square	2,317.218
	df	300
	Sig.	0.000

Data Analysis and Results

Respondents Opinion of BREEAM and LEED

As presented in Fig. 3, 31.6% of the 133 respondents stated that they deemed BREEAM and LEED to be inferior GBC systems and that others were more satisfactory.

Fig. 4 illustrates which alternative GBC system respondents chose to be more successful. Green Globe was shown to be the most chosen alternative with 52%, followed by CPD at 26%, and then WELL at 19%.

The data illustrate that the role of BREEAM and LEED may not be the optimum GBC to be applied in low-cost urban housing

Table 8. Factor component matrix

Component matrix[a]								
		Component						
Measure	Factor	1	2	3	4	5	6	7
High BREEAM rating being more likely to view the property	Climate change	**0.796**						−0.306
BREEAM as a quality brand	Quality	**0.778**			0.303			
LEED as a quality brand	Quality	**0.765**			0.337			
High BREEAM rating being more likely to view the property	Climate change	**0.740**						
Introduction of UNSDGs impact on public knowledge	Climate change	**0.633**	−0.334				−0.321	
Maintenance of LEED	Quality	**0.624**	−0.549					
Motivated by client	Cost	**0.607**		0.310	−0.325			
Energy efficiency and quality	Quality	**0.606**						
Price increase of environmentally friendly products	Cost	**0.596**	−0.344	0.388			0.305	
Organizations pursuing their own research projects	Technology and innovation	**0.585**		**0.551**				
Interest in tech and innovation	Technology and innovation	**0.580**			−0.489	0.305		
Knowledge of climate change increase	Climate change	**0.565**	0.339					−0.303
Further research and development is required	Technology and innovation	**0.508**				−0.394		
Motivated by climate	Climate change	0.466	0.385		−0.449			
BREEAM and maintenance	Quality	**0.588**	−0.633					
Time increase in BREEAM projects	Time	0.315	0.559	−0.386			0.414	
More optimum GBC	Quality	0.391	0.445		0.445			
Greater commitment from organizations	Climate change	0.493		0.522				
Type of home purchased	Quality	−0.336		0.491	0.483	−0.327		
LEED time increase	Time	0.380	0.403	−0.455		−0.310	0.435	
Motivation from international policies or personal views	Climate change		0.414		0.336	0.658	−0.310	
Technical risks are cause for concern	Technology and innovation	0.442					−0.364	0.659
Organizations ought to decline unsustainable projects	Cost	**0.512**		0.330				0.552

Note: Extraction Method: Principal Component Analysis.
[a]Seven components extracted.

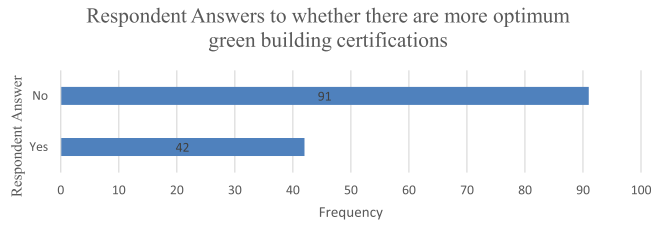

Fig. 3. Optimum green building certification.

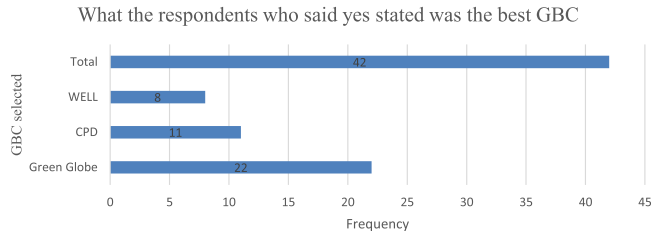

Fig. 4. Respondent answers.

projects. In relation to Research Question 2, the results lead to ambiguity surrounding whether BREEAM and LEED actually prove that they create energy-efficient low-cost urban housing projects.

Fig. 5 shows that despite some respondents not viewing BREEAM or LEED as the optimum GBC system, the majority of respondents (87%) would purchase a BREEAM- or LEED-accredited home. BREEAM is proven to be the most popular out of the respondents at 55% (74 out of 133) with LEED at 32% (43 out of 133). About 12% of respondents would buy a nonaccredited home for a selection of reasons, such as not wanting to live in a newbuild home or wanting to pursue an alternative accreditation.

Correlation Analysis

A correlation matrix was generated from the survey questionnaire to illustrate the links between the multiple variables discussed in the survey questionnaire. The Likert scale questions were selected and the Pearson measurement was applied as it is a parametric statistic that is most pertinent for determining the intensity of linear relation between two continuous variables (Forthofer et al. 2007). The correlation analysis table in Table 9 illustrates the correlations between the multiple motivations discussed across the survey.

There is a high correlation between respondents indicating their agreement with the statements that both BREEAM and LEED motivate contractors pursue energy-efficient options. The high correlation of 0.882 corresponds with the inherent motivation of BREEAM and LEED to decrease energy consumption and improve the sustainability of low-cost housing projects. The correlation also

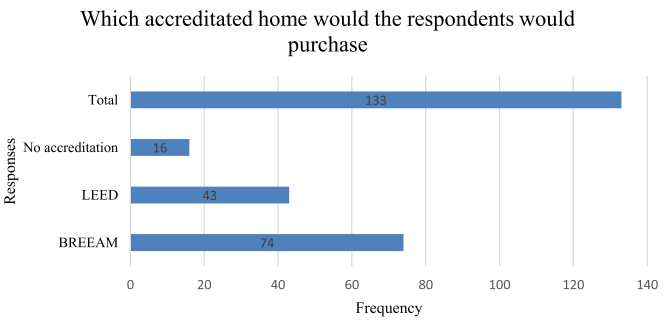

Fig. 5. What type of home respondents would purchase.

perhaps illustrates the successful reputation of BREEAM and LEED in developing energy-efficient projects.

In addition, there is strong agreement across the respondents that they are likely to purchase high-rated BREEAM or LEED homes. Similar to the correlation between the respondents stating that BREEAM and LEED motivate contractors to pursue energy-efficient options, the correlation illustrates how the respondents perhaps deem the quality of BREEAM and LEED to be comparable. However, there is a strong link between those who stated that their knowledge of the impact of climate change has increased in the past 5 years and so are more likely to buy a high-rated BREEAM property than a LEED property, with the correlations being 0.491 and 0.393, respectively. Therefore, it could be deduced that those whose knowledge has increased perceived BREEAM as being more successful at developing energy-efficient projects.

There was a strong correlation between the respondents who stated that their knowledge of the impact of climate change has increased and those who stated there ought to be more research and development as well as greater commitments from the construction industry to tackle climate change. The correlation rating was 0.451 and 0.452, respectively, and therefore it can be deduced that among the respondents there was an appetite for contractors to pursue research and development programs as well as stating a greater commitment to minimizing the effect of climate change.

Comparative of BREEAM and LEED Categories

The two tables in this section show the results of the two questions in the survey questionnaire that asked respondents to prioritize the different BREEAM and LEED categories.

Table 10 illustrates which category received the highest respondents within each ranking and the results are shown in bold. The most popular first ranking is Energy with 49.6% of respondents putting it at their highest priority. These results support the earlier deduction from the factor loading analysis that Climate Change and Quality are the two most important motivations within BREEAM's and LEED's application. The discussion surrounding climate change within the literature study helps explain the impetus placed on climate change among the respondents (Alawneh et al. 2019; Greer et al. 2019; Pelin and Arditi 2018). The increase in public knowledge of the impact of the construction industry has led to changes in the public's practice (Maqbool and Rashid 2017), hence the prioritization of reducing energy consumption. This also supports Hypothesis 2 on the importance of the climate change factor as a key motivation toward BREEAM and LEED.

The most popular 10th ranked category is Transport, with 39% of respondents voting it as their lowest priority. In relation to the literature study, Callaway et al. (2019) reiterated this argument as the transport links of BREEAM and LEED housing projects tend to not be prioritized, which could be the cause for the lack of public appetite.

Land Use and Ecology and Health and Wellbeing being ranked 2nd and 3rd, respectively, by respondents illustrates how quality of life is a high priority, as they deem how the surrounding land is used as well as their wellbeing as a prime concern. In relation to the prior literature and the factor loading analysis, this result links to how quality is deemed as one of the strongest motivations for BREEAM and LEED.

To correspond these results with the hypotheses being tested in this research study, the results of the BREEAM category ranking correspond with Hypothesis 1, that is, if the quality is not assured from the project, consumers will not purchase the housing.

The results of the LEED category ranking (Table 11) are similar to those of the BREEAM ranking (Table 10). The most popular

Table 9. Correlation matrix

Correlation matrix											
Measure	BREEAM motivates contractors to pursue energy-efficient options	LEED motivates contractors to pursue energy-efficient options	Motivated by client	Motivated by climate	Interest in technology and innovation	High BREEAM rating and buying property	High LEED rating and buying property	Knowledge of the impact of climate change increase	The introduction of UNSDGs and increase of knowledge	Further research and development is required	Greater Commitment from organizations for Climate Change
BREEAM motivates contractors to pursue energy-efficient options	1	0.882[a] 0.000	0.261[a] 0.002	0.212[b] 0.014	0.484[a] 0.000	0.479[a] 0.000	0.496[a] 0.000	0.304[a] 0.000	0.489[a] 0.000	0.374[a] 0.000	0.102 0.243
LEED motivates contractors to pursue energy-efficient options	0.882[a] 0.000	1	0.376[a] 0.000	0.419[a] 0.000	0.508[a] 0.000	0.524[a] 0.000	0.559[a] 0.000	0.374[a] 0.000	0.535[a] 0.000	0.342[a] 0.000	0.191[b] 0.028
Motivated by client	0.261[a] 0.002	0.376[a] 0.000	1	0.520[a] 0.000	0.351[a] 0.000	0.461[a] 0.000	0.515[a] 0.000	0.382[a] 0.000	0.351[a] 0.000	0.310[a] 0.000	0.368[a] 0.000
Motivated by climate	0.212[b] 0.014	0.419[a] 0.000	0.520[a] 0.000	1	0.425[a] 0.000	0.377[a] 0.000	0.274[a] 0.001	0.391[a] 0.000	0.293[a] 0.001	0.279[a] 0.001	0.252[a] 0.003
Interest in technology and innovation	0.484[a] 0.000	0.508[a] 0.000	0.351[a] 0.000	0.425[a] 0.000	1	0.580[a] 0.000	0.330[a] 0.000	0.373[a] 0.000	0.207[b] 0.017	0.247[a] 0.004	0.199[b] 0.022
High BREEAM rating and buying property	0.479[a] 0.000	0.524[a] 0.000	0.461[a] 0.000	0.377[a] 0.000	0.580[a] 0.000	1	0.769[a] 0.000	0.491[a] 0.000	0.443[a] 0.000	0.180[b] 0.038	0.363[a] 0.000
High LEED rating and buying property	0.496[a] 0.000	0.559[a] 0.000	0.515[a] 0.000	0.274[a] 0.001	0.330[a] 0.000	0.769[a] 0.000	1	0.393[a] 0.000	0.528[a] 0.000	0.337[a] 0.000	0.433[a] 0.000
Knowledge of the impact of climate change increase	0.304[a] 0.000	0.374[a] 0.000	0.382[a] 0.000	0.391[a] 0.000	0.373[a] 0.000	0.491[a] 0.000	0.393[a] 0.000	1	0.367[a] 0.000	0.451[a] 0.000	0.452[a] 0.000
The introduction of UNSDGs and increase of knowledge	0.489[a] 0.000	0.535[a] 0.000	0.351[a] 0.000	0.293[a] 0.001	0.207[b] 0.017	0.443[a] 0.000	0.528[a] 0.000	0.367[a] 0.000	1	0.261[a] 0.002	0.315[a] 0.000
Further research and development is required	0.374[a] 0.000	0.342[a] 0.000	0.310[a] 0.000	0.279[a] 0.001	0.247[a] 0.004	0.180[b] 0.038	0.337[a] 0.000	0.451[a] 0.000	0.261[a] 0.002	1	0.258[a] 0.003
Greater mommitment from organizations for climate change	0.102 0.243	0.191[b] 0.028	0.368[a] 0.000	0.252[a] 0.003	0.199[b] 0.022	0.363[a] 0.000	0.433[a] 0.000	0.452[a] 0.000	0.315[a] 0.000	0.258[a] 0.003	1

[a]Correlation is significant at the 0.01 level (2-tailed).
[b]Correlation is significant at the 0.05 level (2-tailed).

Table 10. BREEAM category ranking

BREEAM category ranking										
Frequencies										
Rank	Management	Health and wellbeing	Energy	Transport	Water	Waste	Land use and ecology	Pollution	Innovation	Materials
1st	8	16	**66**	4	11	13	10	20	8	12
2nd	8	18	22	8	15	15	**34**	10	8	10
3rd	15	**40**	13	8	18	14	14	29	6	7
4th	2	8	15	10	20	**30**	19	16	8	10
5th	8	10	0	10	18	**32**	10	16	10	10
6th	4	13	6	2	**22**	14	12	16	15	12
7th	6	5	2	18	13	4	11	7	19	**36**
8th	12	6	7	9	6	7	13	11	**24**	23
9th	**50**	6	0	12	8	2	6	6	22	7
10th	20	11	2	**52**	2	2	4	2	13	6
Total	133	133	133	133	133	133	133	133	133	133

Table 11. LEED category ranking

LEED category ranking										
Frequencies										
Rank	Integrative process	Indoor environment	Water efficiency	Material and resources	Sustainable sites	Regional priority	Innovation	Quality	Energy and atmosphere	Location and transportation
1st	8	14	8	6	17	3	11	25	**66**	10
2nd	6	**27**	10	26	23	6	8	15	24	4
3rd	6	24	14	22	**31**	8	4	13	9	8
4th	8	27	**30**	18	17	8	2	18	12	8
5th	18	12	**25**	18	11	7	4	10	4	13
6th	15	5	18	11	10	**26**	11	6	7	13
7th	20	9	12	12	10	**24**	19	3	4	10
8th	18	8	6	6	8	18	**24**	17	0	7
9th	20	7	6	3	2	18	**26**	24	2	14
10th	14	0	4	11	4	15	24	2	5	**46**
Total	133	133	133	133	133	133	133	133	133	133

vote was Energy and Atmosphere, which in comparison to other research illustrated in the literature study comes as little surprise as contractors tend to prioritize this category in order to gain maximum points (Table 11). In addition, as discussed in the BREEAM analysis, the emphasis placed on the reduction of energy consumption as well as sustainability of housing projects translates onto the LEED category results. Similarly, the results link to the correlations discussed in Table 9. The results show how a high LEED rating makes consumers more likely to purchase a LEED-accredited property if organizations place greater commitments on minimizing their impact on climate change (0.433 Pearson score), so, it supports Hypothesis 3 as well.

Indoor environment and sustainable sites are 2nd and 3rd, respectively, in the LEED category ranking (Table 11), which also links back to the discussion in the literature study. Altomente et al. (2017) highlights that greater emphasis ought to be placed on the quality of both the external and the internal surroundings by focusing on temperature control, air quality, noise, natural and artificial lighting, visuals, and sound privacy of LEED projects. Thus it ought to be deduced that LEED ought to be utilized as a method to ensure high-quality indoor and outdoor environments.

Respondents Actions to Diminish Their Energy Consumption

Table 12 presents the collation of the answers for the respondents actions they undertake to decrease their energy consumption. The results were coded into SPSS and then decoded for presentation in the research study. As shown in Table 12, the most common actions were minimizing unnecessary lighting and heating, switching off unused appliances as well as purchasing energy-efficient technology, with 18% of respondents selecting these actions.

The explanation behind the most popular actions could be rooted in the literature outlined in the literature study section. The benefits of minimizing the use of lighting and heating and purchasing energy-efficient technology is twofold, as it both limits energy consumption as well as decreases energy costs. As outlined in the literature study by Mills and Schleich (2012), it is more likely for younger respondents to utilize cost-saving methods, and as the respondents demographics table (Table 4) shows, the largest age group across the respondents is 18–25, thus supporting the results shown in Table 12.

Discussion

Conceptual Findings

The aim of this research study is to illustrate the role of BREEAM and LEED within low-cost urban housing projects through the analysis of multiple factors and motivations impacting the outcome of construction projects. The literature study outlined previous research and instigated debate surrounding how contractors, designers, and consumers have an impact on the role of BREEAM and

Table 12. Respondents actions to decrease their energy consumption

Item	Frequency	Percent
Lighting	12	9.0
Heating	8	6.0
Purchasing energy-efficient technology	6	4.5
Water use	2	1.5
Lighting and heating	12	9.0
Lighting and purchasing energy-efficient technology	2	1.5
Heating and purchasing energy-efficient technology	2	1.5
Heating and water use	2	1.5
Heating and other	2	1.5
Lighting, heating, and appliances	12	9.0
Lighting, heating, and purchasing energy-efficient technology	8	6.0
Lighting, heating, and water use	2	1.5
Lighting, appliances, and purchasing energy-efficient technology	2	1.5
Lighting, purchasing energy-efficient technology, and water use	2	1.5
Lighting, heating, appliances, and purchasing energy-efficient technology	**24**	**18.0**
Lighting, heating, appliances, and water use	19	14.3
Lighting, heating, appliances, purchasing energy-efficient technology and water use	16	12.0
Total	133	100

LEED within low-cost urban housing projects. Consequently, the literature study framed the questions for the survey questionnaire to deduce conclusions about how multiple motivations (e.g., climate change, quality, cost, technology and innovation, duration time) are weighted by contractors, designers, and consumers. The survey data were taken from UK construction professionals based on the snowball-sampling technique to target only the relevant people who have the right information.

The following subsection illustrates the links found within the research projects and how the different factors impact the role of BREEAM and LEED.

Climate Change

From the factor analysis, correlation matrix, and the analysis of the other survey questionnaire responses, it was found that climate change was the primary factor that influenced the role of BREEAM and LEED in low-cost urban housing projects. In addition, the respondents ranked the LEED energy and atmosphere and BREEAM energy categories as the highest priority. In order for contractors to harness the primary factor to influence success, there needs to be a holistic bond between the consumers, designers, and contractors in order to develop projects that will meet the expectations of the customers while minimizing the environmental impact of the construction industry.

Technology and Innovation

The results of the survey questionnaire illustrate the demand for increased research and development across organizations within the construction industry to help minimize its impact on climate change. There was a strong correlation between the emphasis placed on climate change, with respondents advocating for greater research and development from organizations within the construction industry. This comes from the perception that organizations ought to show a public commitment to decreasing their energy consumption (Ospina et al. 2016). Previously research and development was underfunded by government bodies; however, government grants are now available due to the introduction of national policies. The study undertaken highlighted that organizations could benefit from funding their own research and development projects in order to improve public perception of the organization as well as improve practices in BREEAM and LEED low-cost urban housing projects.

Cost Dimension

The context being low-cost housing projects is paradoxical for different factors, as motivations incur high costs despite the aim of the context to produce low-cost developments (Gurgun and Arditi 2018). There are two sections of the cost dimension that is most important to both the organizations involved and the market demographic. For the organizations, the costs involved in implementing practices that minimize their impact on climate change, such as high-quality products, technology and innovation, as well as the increased time period, create difficulties. The largest cost is the upfront cost involved with technology and innovation, as recent technologies for energy efficiency are considered to be the major issue in sustainable energy installations (Gurgun and Arditi 2018), whereas for the market demographic, it is important to consider the ability of the residents to be able to save money on energy bills as well as the cost of the property itself.

The results from the research project illustrate that organizations within the construction industry ought to develop policies and a practical framework in order to improve the cost efficiency of low-cost urban housing projects.

Quality Factor

Quality was deemed the secondary factor that impacts the role of BREEAM and LEED, as those surveyed stated that the sustainability of the developments is paramount. Therefore, the project requirements for energy, water, indoor environmental quality, and durability are met for potential residents (Gurgun and Arditi 2018). Contractors and designers ought to utilize the quality factor illustrated in this research study as it will allow for policy and stakeholder frameworks to be developed. The framework and policies will be able to focus on the stakeholder demands and requirements to improve the application and success rate of BREEAM and LEED projects.

Owing to the research project focusing on low-cost urban housing projects, the quality of the completed projects has strong links with the cost dimension. It is necessary to find a balance between the demanded quality and maintaining a low cost for the market demographic. Within the wider debate, the improved practices in BREEAM and LEED will have a ripple effect on the perception of the quality of BREEAM and LEED.

Time Factor

Time factor was not deemed a primary factor by the survey respondents but was a more tertiary factor that impacts upon the cost dimension. Industrial and public attitudes to the increased time duration tends to be unchanged by the duration required in BREEAM and LEED projects. The importance placed on the benefits of minimizing the impact on climate change as well as quality of life positions time factor below others. The time increase involved in BREEAM and LEED energy projects leads to increased completion time, which incurs additional costs due to the longer labor time and plant hire period as well as the hiring of consultants and subconsultants. Therefore, within low-cost urban housing projects, organizations ought to implement practices that minimize the time and thus decrease the costs incurred.

Practical Application of the Study

The multiple factors and motivations within BREEAM and LEED construction projects mean that their role is not consistent across construction projects. The inconsistency of the success of BREEAM and LEED projects prevents wider application across the sector; however, the expansion of public knowledge of the impact of the construction industry on climate change increases public appetite for energy-efficient housing projects (Callaway et al. 2019). Previously, the application of BREEAM and LEED within housing projects has not necessarily created energy-efficient, high-quality projects despite the high costs involved.

Limitations

This study was created using respondents from mainly UK residents due to the publication of the survey questionnaire mainly being within UK-based students and architectural organizations. Despite the study successfully illustrating the multiple factors and motivations involved in BREEAM and LEED projects, there are still a few limitations that ought to be highlighted. First, the study was mainly completed within the UK, therefore the public perceptions of BREEAM and LEED within other countries was not discovered. Future research would benefit from the expansion of the study across multiple countries so there can be more nuanced frameworks for the different projects. Second, the research would have been improved by a larger number of respondents, as the total of 133 does not allow for generalizations to be made across the public. In addition, the demographics of the study would have benefitted from a larger number of respondents with more construction industry experience. Therefore, it is necessary to compare the results with proceeding or forgoing research to curtail these limitations.

Conclusion and Recommendations

The research project aimed to illustrate the role of BREEAM and LEED in low-cost urban housing projects through the discussion of the multiple factors and motivations that frame the success of the construction projects. The discussion within previous literature developed three hypotheses, which were then tested through data analysis in SPSS. A factor analysis and correlation matrix was then applied to the responses where it was concluded that climate change and quality are the two most important factors despite tenuous links to other motivations such as cost and quality.

In relation to the research questions and hypotheses, the results stated that the role of BREEAM and LEED is predominantly undermined when value for money is not developed. The certification systems alone do not necessarily improve the energy efficiency and sustainability of urban housing projects if the quality of materials and resources is not utilized. Thus moving forward, contractors and designers ought to develop strong communication frameworks that will allow for the expectations of consumers to be matched within low-cost urban housing projects. It is necessary for the two to strike a balance between investment on research and development while also keeping the costs low for the market demographic.

Organizations ought to create and develop their own practical framework to allow them to create a balance between the costs involved in research and developing these into the design and build of low-cost urban housing projects, while also maintaining a low price for market demographics. Considering the recent economic recession, cost of living is a major challenge that is further catalyzed with the energy prices shooting up more than double in a year. Owing to this catastrophic situation, low-cost energy houses are a big concern for consumers. In this case, contractors and designers can benefit from the findings of this research regarding low-cost and energy-efficient housing projects through LEED and BREEAM.

The results of this paper illustrated the public demand for organizations to provide greater commitments for minimizing their impact on climate change. Therefore, the construction industry ought to seek research projects to improve practices within the industry as a whole while improving the public perception of its organization. In addition, this research provides the base for meeting the targets of the construction 2025 strategy related to energy-efficient housing and low-cost energy projects.

To develop the results illustrated in this research study, the study will benefit from increased data being collected by other countries as well as gaining more respondents from within the construction industry. As a result, more holistic conclusions could be developed.

Appendix. Survey Questionnaire Questions

No.	Questionnaire section	Style of question
Background		
1	What is your age group?	Age group selection split every five years from 18 to 55+
2	What is your gender?	Male/Female/Other
3	What is your occupation?	Professional Engineer, Project Manager, Project Architect, Architectural Technologist, Project Coordinator, Researcher, University Lecturer/ Professor, Other
4	What is your experience of working on construction projects?	1–5 years, 5–10 years, 10–15 years, 15–20 years, 20–25 years, 25 years plus
5	What is the level of your education?	Secondary, Higher Secondary, Bachelors, Masters, Ph.D., other
6	Are you a homeowner?	Y/N
7	What type of area do you live in?	City Central, Urban Area, Village, Countryside
8	Do you live in an energy-efficient home?	Y/N
Motivations for BREEAM/LEED		
1	BREEAM motivates contractors to pursue energy-efficient options	Likert
2	LEED motivates contractors to pursue energy-efficient options	Likert
3	The use of energy-efficient options ought to be motivated by client	Likert
4	The use of energy-efficient options ought to be motivated by climate	Likert
5	Are you interested in the potential for improved technology and innovation in the construction sector as a result if an increased focus on green building certifications?	Likert

(*Continued*.)

No.	Questionnaire section	Style of question
6	A high BREEAM rating system makes me more likely to buy the property	Likert
7	A high LEED rating system makes me more likely to buy the property	Likert
8	My knowledge of the impact of climate change has increased in the past 5 years	Likert
9	The introduction of UNSDGs increased my education on the impact of climate change	Likert
10	Further research and development is required to decrease the impact of the construction industry on the environment	Likert
11	There ought to be greater commitments from organizations in the construction industry to minimize their impact on climate change	Likert
12	Do you believe there are more optimum green building certifications?	Y/N
13	Are you motivated by international and national policies to decrease the construction industry's impact on the environment, your personal views, or both?	
Cost of implementation		
1	You ought to purchase more environmentally friendly products even if there is a price increase	Likert
2	Contractor and design companies ought to pursue their own research projects to improve the technology and materials they design with and use	Likert
3	Architects and contractors ought to decline construction projects that are not pursuing energy-efficient methods if they are in the financial position to do so	Likert
4	The technical risks involved in the new technologies are cause for concern	Likert
5	You ought to still purchase a BREEAM-rated home even if it requires greater maintenance	Likert
6	You ought to still purchase a LEED-rated home even if it requires greater maintenance	Likert
7	Would you still purchase a home with BREEAM or LEED rating if it required greater maintenance?	Likert
Quality of BREEAM and LEED GBCs		
1	Energy efficiency is directly associated with quality	Likert
2	BREEAM is recognized as a quality brand	Likert
3	LEED is recognized as a quality brand	Likert
Time/Scheduling		
1	The application of LEED on average increases the time until completion by 0.3, would this demotivate you from purchasing a LEED accredited home?	Y/N
2	The application of BREEAM on average increases the time until completion by 0.2, would this demotivate you from purchasing a LEED accredited home?	Y/N
3	Knowing the aforementioned statistics about the incurred time increases, which type of home would you purchase?	BREEAM/LEED/no accreditation
BREEAM and LEED categories		
1	Please rank the 10 main BREEAM categories 1st (highest priority) to 10th (lowest priority)	Ranking 1–10
2	Please rank the 10 main LEED categories 1st (highest priority) to 10th (lowest priority)	Ranking 1–10
3	Please select which areas of your home you try and minimize energy consumption	Lighting/Heating/Appliances/Purchasing energy-efficient technology/ Water Use/Other

Data Availability Statement

Data generated or analyzed during the study are available from the corresponding author by request.

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