



Fostering Sustainability Consciousness: The Role of Green Buildings in the United Kingdom

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Abstract

Climatic change has compelled constructors, workers and governments to look for new and innovative technologies to reduce the impact of human activities on Earth. Residential green buildings can offer an alternative to conventional green buildings. These buildings reduce the effect of the building industry on the environment by adopting features and measures that reduce GHGs as well as heat emissions. The current study is focused on evaluating the role of such residential buildings in increasing awareness regarding sustainability in the UK. This study adopted a survey-based approach that targeted the occupants of residential green buildings in the UK to achieve its objectives. This study determined the impact of green design features and sustainable building practices on occupants' awareness regarding sustainability. Encouragement to adopt an eco-friendly lifestyle was the most important impact. In terms of the perception of occupants about benefits and drawbacks, lower maintenance cost was the most prominent benefit while increased construction cost was the most important drawback. The current awareness status of occupants was also determined. Occupants were most well aware of energy-efficient lighting and BREEAM certification while they were least aware of workshops regarding the use of green technologies. Lastly, it was determined that organizing events like Earth Day and using digital displays were the most efficient modes of promotion while publishing sustainable reports was the least efficient. Hence, green buildings can effectively increase awareness regarding sustainability among their occupants while organizing events, which can be the most effective mode of promotion.

Subject Areas

Environmental Sciences

Keywords

Green Building, Climate Change, Greenhouse Gases, Sustainability Awareness, United Kingdom

1. Introduction

Climate change poses a serious threat to the world. Every part of the world is experiencing the adverse effects of climate change in various ways. The governing concern of this super-wicked problem has pushed researchers and institutions to start initiatives for sustainable development all around the globe. Recently, there has been a rapid technological advancement that has revolutionized all industries. The construction industry is said to be impacted by these innovations, specifically in the building construction process [1]. The process of building construction involves multiple variables and needs an array of collaborations. Eventually, construction management is vital for establishing a well-structured, coordinated and maintained work environment [2]. Recent studies are making progress in determining and suggesting that information technologies have become likely more important in systematically storing construction data and ensuring its proper and efficient utilization, especially for a sustainable tomorrow [3]. Green buildings are unique compared to ordinary buildings because they are designed to minimize their negative environmental impact and encourage their positive impact on the tenants' health and well-being as well as the ambiance surrounding them [1]. These buildings are constructed considering all the aspects of sustainability such as using sustainable materials, incorporating energy-efficient technologies, and optimizing resource utilization for the welfare of the environment. Green building entails constructing structures while using processes that are certified as environmentally friendly as well as resource-efficient at every step of the building and building's lifecycle, including the selection of site, building designing, construction of building, operation and maintenance as well as renovation, and deconstruction [4]. Green buildings are crucial not only for the environment but also for promoting the well-being and productivity of tenants by providing a healthy indoor environment, which ultimately helps spread awareness regarding sustainable development [1]. In the UK, green buildings have grabbed significant attention as a source of reducing greenhouse gas emissions and promoting sustainable living. The UK's regulatory framework emphasizes saving energy and has proved to be the key driver of the energy efficiency campaign, explicitly with regard to reducing carbon emissions and developing energy efficiency schemes for buildings [5]. This strategic framework is based on the EU's legislation policy, which implies that buildings play a significant role in achieving energy efficiency goals.

To comply with these laws, the UK has implemented two initiatives. The first initiative requires the display of certificates. These certificates include energy performance as well as the declaration of energy. The second one is known as zero-carbon building initiatives. Additionally, a carbon market has been established that focuses solely on building energy consumption. It is called the Carbon Reduction Commitment of 2010 [6].

Seeing the UK's determination toward sustainability through green buildings, it is evident that the occupants of green buildings are surely key stakeholders who can contribute to the awareness of the sustainability of the building and its surroundings by being part of the sustainability campaign themselves [7]. By adopting sustainable practices living in green buildings, tenants can minimize their carbon footprint and contribute to the building's overall sustainability goals. Green buildings can, therefore, act as an educational tool that promotes sustainability awareness and encourages occupants to adopt sustainable practices [5].

The world's population is increasing with a robust momentum which has increased the demand for houses and commercial buildings. Currently, one of the largest and most rapidly developing industries is the construction industry. The UK government encourages efforts to improve power efficiency in the building sector and should prioritize by taking initiatives to reduce resource consumption throughout the whole lifecycle of buildings to achieve their full potential. A well-structured and coordinated approach to resource-efficient buildings can contribute to other goals, such as lowering the energy consumption of buildings and emissions, by prioritizing material and energy flows over the building's lifetime. Despite this mentioned knowledge, there is currently a lack of strong policies aimed at minimising resources in major EU legislation as well as a lack of awareness among the occupants already inhabiting green buildings [8]. End-use energy efficiency within the construction sector is better understood and considered to have the greatest potential due to a wide array of effective technologies and measures. EU legislation often only focuses on achieving energy efficiency levels, which may not precisely depict the measures taken by EU member states with comparable building standards to those of the UK [9].

This research paper aims to inspect the extent to which green buildings can increase sustainability awareness among occupants, especially in the UK. Therefore, this study aims to find the components that contribute to the increase of sustainability awareness among occupants of green buildings, along with an analysis of the effectiveness of diversified sustainability initiatives that are in action within these buildings in the UK. Lastly, this research would also aim at the promotional measures that can be adopted to increase awareness regarding sustainability in green building occupants.

2. Methodology

2.1. Rationale of Research

This research aims to add additional knowledge to already existing literature re-

garding green buildings and sustainability with special consideration of their location *i.e.*, United Kingdom (U.K.). In this study, the impact of green building features such as the material used, their energy efficiencies, water conservation, passive solar design, and green roofs and walls will be discussed in detail. Special attention would be given to their impact on occupant's awareness of sustainability. This study will also focus on sustainable building practices and their impact on occupant's awareness of sustainability.

The perception of occupants will be determined based on the benefits that green buildings and practices provide to them. Their thoughts regarding the drawbacks of green design features would also be considered. Both of these perceptions would be evaluated to determine the future feasibility of green buildings in the UK as both, the benefits and drawbacks of green design features, play a critical role in the formation of policy and inclination of interests of major construction companies.

Occupants' awareness level regarding sustainability in the UK is a key driving force of regulations and policy formation, and it develops the interests of construction companies and building owners towards green practices. Their current awareness level towards sustainability and the impacts of green building on the environment will be determined and analysed for future recommendations.

The promotion of sustainability awareness also determines the environmental effect. As occupants' awareness level regarding sustainability and the impact of green design features increases, they tend to shift their interests toward green buildings from conventional buildings. This would prompt, both construction companies and owners of buildings, to choose green design features rather than conventional ones. In addition to this, the public would demand that the government shift its focus towards green design features and provide incentives and other benefits to increase the number of green buildings.

2.2. Research Philosophy

Two prominent research philosophies exist in qualitative research. Positivism focuses on the collection of data and deduction of hypotheses, theories and/or law while ignoring the human interpretation and influence on data. On the other hand, interpretivism is based on the depth of data as well as the variables. It is argued that the method of collection of data, as well as the condition under which the data is collected, plays a major role in deducing the hypothesis [10] [11]. The current study would be more inclined toward positivism rather than interpretivism, as data would be collected and interpreted while ignoring the conditions of data collection such as culture, ethnicity and behavior.

2.3. Research Approach

In terms of qualitative research, two common research approaches exist. In the

deductive approach, already existing theories, laws, and/or principles are used to form a hypothesis. The observations are used to confirm those theories. In the inductive approach, data is obtained before the formation of a hypothesis. The obtained data is sorted into different categories and the interpretation of the data results in the formation of a hypothesis [12] [13]. The current study would be inductive in nature as data would be collected before variable formation.

2.4. Methodological Choice

Data can be collected via various methods. A mono-method involves using only one method, either qualitative or quantitative. In contrast, the mixed method involves both qualitative and quantitative methods [10]. The current study will be based on the mono-method and will only use qualitative data.

2.5. Research Strategy

Multiple research strategies are available for qualitative research. The strategy can be based on surveys, archival research, case studies, narrative inquiries, ethnography, and/or interviews [14]. The current study would be based on a questionnaire/survey.

2.6. Questionnaire Design

The questionnaire was designed based on previous studies as well as the various features that are included in green building design features and sustainable building practices. Educational knowledge of the general population of the UK was considered while designing. Lastly, the objectives of this study played a vital role in designing the questionnaire.

2.7. Target Population

This research target population included occupants of green buildings only. Non-green buildings or conventional buildings' occupants were not included. The buildings will be residential.

2.8. Sample Frame

There are over 600,000 BREEAM-certified buildings in 93 countries. According to an estimate, in 2020, 4000 such buildings exist in the UK alone [15]. This study will target occupants of at least 2 BREEAM Certified residential buildings for data collection and survey.

2.9. Sample Population

The population in this study would be the occupants of the BREEAM-certified buildings. These occupants can be the residents, and/or workers. They can also include the building's owners as well as the security officials. The current study was based on a short survey.

3. Results and Interpretation

3.1. Questionnaire's Response

Three BREEAM-certified residential green buildings were selected for this survey. More than 150 occupants were handed the questionnaire. Among them, only 100 occupants returned the completed questionnaire.

3.2. Respondents' Demography

The respondents' demography included age, gender, and qualification. It also included the number of green buildings the respondent has lived in as well as the number of years as an occupant of green buildings. The gender distribution of respondents is provided in **Table 1**. Half of the participants were male while almost half were female.

Table 1. Summary of gender of respondents.

Gender	Frequency	Percentage
Male	53	53%
Female	46	46%
Prefer not to say	1	1%

Table 2. Summary of age groups of respondents.

Age Group	Frequency	Percentage
18 - 20 years	2	2%
21 - 25 years	5	5%
26 - 30 years	9	9%
31 - 35 years	20	20%
36 - 40 years	17	17%
41 - 45 years	16	16%
46 - 50 years	8	8%
Older than 50 years	9	9%
Prefer not to say	15	15%

Table 3. Summary of qualification of respondents.

Qualification	Frequency	Percentage
Diploma	44	44%
Bachelor's/B. tech degree	31	31%
Master's degree	7	7%
Doctorate	5	5%
Prefer not to say	13	13%

Table 2 represents the summary of the age groups of the respondents. The

highest frequency (20) was recorded for 31 - 35 years of age while the lowest (2) was recorded for the 18 - 20 years age group. 15% of respondents did not feel comfortable mentioning their age. Similarly, **Table 3** provides a summary of the educational background of respondents. The majority of occupants (44%) were diploma holders while most of them had at least 14 years of education (31%). 13% of respondents were reluctant to provide their educational background.

The years of experience as an occupant of residential BREEAM-certified buildings and the number of green buildings are shown in **Table 4** and **Table 5**, respectively. Most of the occupants (25%) have been occupants for 21 - 25 years while the 16 - 20 years' experience group was 2nd most common (24% frequency). In terms of building numbers, 27% of occupants have lived in 3 - 4 buildings while 21% have lived in 5 - 6 buildings.

Table 4. Summary of experience in poultry industry of respondents.

Experience as an occupant of green building	Frequency	Percentage
1 - 5 years	5	5%
6 - 10 years	8	8%
11 - 15 years	12	12%
16 - 20 years	24	24%
21 - 25 years	25	25%
26 - 30 years	19	19%
More than 30 years	7	7%

Table 5. Summary of association of respondents with poultry farms and/or projects.

Number of green building occupants have lived in	Frequency	Percentage
None	2	2%
1 - 2	11	11%
3 - 4	27	27%
5 - 6	21	21%
7 - 8	17	17%
9 - 10	15	15%
More than 10	6	6%

The impact of green building design features and sustainable building practices was based on multiple factors. **Table 6** represents the summary of all the features that were considered during this study. These features were given code from ISB01 to ISB11. The highest mean score was achieved by ISB07 (3.77) and ISB09 (3.54). Both these features are present to a large extent. The lowest mean scores were 2.89 and 2.86, which were achieved by ISB10 and ISB11, respectively. Based on their mean scores, both these features fall under the small extent category of impact.

Table 6. Summary of impact of green building design features and sustainable building practices on occupant's awareness of sustainability in the UK.

Code	Sustainable building practices and green building design features	Mean score	Rank
ISB07	To what extent have they encouraged you to adopt an eco-friendly living style?	3.77	1
ISB09	To what extent would you say that your building has a positive impact on the environment?	3.54	2
ISB04	To what extent do they promote social sustainability?	3.44	3
ISB06	To what extent do they improve indoor air quality?	3.43	4
ISB03	To what extent do they increase your knowledge about sustainability?	3.28	5
ISB01	To what extent do they achieve environmental goals?	3.25	6
ISB08	To what extent would you recommend conventional building occupants move into green buildings?	3.23	7
ISB05	To what extent can they influence investors to invest in green buildings?	3.15	8
ISB02	To what extent do they reduce electricity bills?	3.03	9
ISB10	To what extent would you say renewable energy source is a necessary green building feature?	2.89	10
ISB11	To what extent are you knowledgeable regarding green building certification?	2.86	11

The perception of occupants regarding the advantages and disadvantages of green building design features and sustainable building practices was determined using multiple variables. **Table 7** represents the summary of all the features that were considered during this study. These features were given code from OPB01 to OPB11. The lowest mean scores were 2.91 and 2.78, which were achieved by OPB12 and OPB10, respectively. Based on their mean scores, both these features are considered minor drawbacks. The highest mean score was achieved by OPB05 (4.24) and OPB79 (4.17). Both these features are considered major benefits.

Table 7. Summary of perception of occupants regarding the benefits and drawbacks of sustainable practices and design features.

Code	Green building design features and sustainable building practices features	Mean score	Rank
OPB05	Lower maintenance cost	4.24	1
OPB07	Increase in thermal comfort	4.17	2
OPB06	Mitigation of climatic change	4.14	3
OPB03	Improved energy efficacy	4.12	4
OPB02	Improved water efficacy	4.06	5
OPB16	Low flow toilet	4.02	6
OPB04	Lower electricity and water bills	4.01	7

Continued

OPB01	Increased natural ventilation	3.89	8
OPB08	Reduction in noise disturbance	3.89	8
OPB09	Increase in natural lighting	3.89	8
OPB11	Requires more maintenance	3.58	11
OPB14	Daylight saving	3.3	12
OPB13	Climatic variability can affect the passive heating and cooling system	3.08	13
OPB15	Each building cannot have every green design feature	3.06	14
OPB12	Require more planning because of the complexity	2.91	15
OPB10	Increase in cost of construction	2.78	16

The current awareness status among occupants regarding sustainability and the impact of resident green buildings on the environment was determined on the basis of multiple. **Table 8** represents the summary of all the attributes that were considered during this study. These features were given code from ART01 to ART11. The highest mean scores were 3.79 and 3.75, which were achieved by ART07 and ART08, respectively. Based on their mean scores, both these features fall under the large extent category of awareness level. The lowest mean score was achieved by ART02 (2.83) and ART06 (2.44). Both these features are present to a small extent.

Table 8. Summary of current status of awareness among occupants in the UK about sustainability and the impact of residential green buildings on the environment.

Code	Attributes	Mean score	Rank
ART07	Energy-efficient lighting	3.79	1
ART08	BREEAM certification	3.75	2
ART11	Buildings have a positive impact on the environment	3.47	3
ART05	Presence of HVAC system	3.45	4
ART10	Positive effect on your productivity	3.4	5
ART04	Energy Storage System	2.98	6
ART09	LEED certification	2.89	7
ART01	Solar and/or wind power	2.84	8
ART03	Green roofs and walls	2.84	8
ART02	Rainwater harvesting	2.83	10
ART06	Workshop on using green technologies	2.44	11

The last objective was to determine effective ways to adopt sustainability awareness among occupants of green buildings in the UK. Multiple modes of promotion were selected so that occupants could choose the best among them. **Table 9**

represents the summary of all the attributes that were considered during this study. These features were given code from MPA01 to MPA11. The highest mean score was achieved by MPA04 (3.58) and MPA03 (3.41). Both these modes are effective to a large extent. The lowest mean scores were 3.01 and 2.99, which were achieved by MPA07 and MPA06, respectively. Based on their mean scores, both these features can be considered moderately effective modes of promotion

Table 9. Summary of current status of awareness among occupants in the UK about sustainability and the impact of residential green buildings on the environment.

Code	Modes of promotion	Mean score	Rank
MPA04	Organize events like earth day	3.58	1
MPA03	Using displays such as touchscreen	3.41	2
MPA01	Organizing workshops	3.33	3
MPA05	Social media	3.31	4
MPA02	Using newsletters	3.05	5
MPA07	Digital media	3.01	6
MPA06	Publish sustainability reports	2.99	7

4. Discussion

The data was gathered in the form of a questionnaire with the first objective being to determine the extent to which these features and practices can achieve environmental goals (ISB01). Its mean score was 3.25 which put its impact in the large extent category. A study in Canada reported a reduction in GHG emissions from 271 kg CO₂eq/m² to 37.0 kg CO₂eq/m² if sustainable building practices are adopted [16]. The second important feature was the reduction in electricity bill (ISB02). Its impact was moderate according to its mean score of 3.03. It has been reported that shifting to LEED-certified lighting systems can reduce up to 42% of the electricity bills of residential buildings [17].

Increase in knowledge (ISB03) and promotion of social sustainability (ISB04) had mean scores of 3.28 and 3.44, respectively and had a large extent impact on the awareness of respondents. It has been reported that social benefits and sustainability are key aspects of green buildings and their design features [18]. In terms of influence on investors (ISB05), the mean score (3.15) determines its impact as a moderate one. Green buildings have higher rents and occupancy rates than conventional buildings, making them a good investment for investors [5]. Furthermore, they have lower maintenance costs which further increases investors' interest in these buildings [19]. Improvement of indoor air quality (ISB06) is an important green design feature. It has a large impact on the awareness of occupants (mean score = 3.43). It has been reported that green design features can reduce low-VOC emissions by 90%, airborne pollutants by 20 - 30% and other pollutants by 80% [20] [21].

Green building design can also influence the adoption of an eco-friendly lifestyle

(ISB07). The extent of impact can be large (mean score = 3.77). It is the most impactful feature of green building designs (rank = 1). It has been reported that green building design features influence its occupants to adopt an eco-friendly lifestyle [22]. It has been observed that green building owners are more aware of general as well as specific sustainability awareness and would recommend people to shift to their buildings [23]. In terms of positive impact on the environment (ISB09), the awareness among occupants was present to a large extent (mean score = 3.54). It was the 2nd most influential feature (rank = 2). Green design features have a significant effect on GHG emission as they can reduce the emission by 9 times (271 to 37 kg/CO₂eq). Similarly, they also reduce landfill waste by 27% [16] [24]. The last two features were the necessity of renewable energy as a green building feature (ISB10) and knowledge about green building certification design (ISB11). Both these features had the lowest mean score, 2.89 and 2.86, respectively. The impact on awareness was only to a moderate extent. It has been reported that renewable energy sources are present in most green buildings. However, they are not necessarily present in every building [25]. Similarly, it has been reported that a significant percentage of occupants (70% - 80%) are aware of green building certification and would like to live in buildings that have that certification [26]. One of the good impacts was increased ventilation (OPB01). It had a mean score of 3.89, making it a minor benefit. Similarly, for water efficacy (OPB02) and increased energy efficacy (OPB03), their mean score of 4.06 and 4.12, respectively, made them major benefits. It has been reported that green buildings increase the ventilation of fresh air. This results in an increase in IAQ which ultimately increases the ANSI/ASHRAE Standards rating [23]. Green buildings tend to have water conservation, such as innovative taps, shower nozzles and auto sensors for flushing as well as rainwater harvesting systems that improve water efficacy [27]. Lastly, it has been reported that shifting to green design features can save 42% of electricity in residential buildings [17]. Lowering electricity and water bills (OPB04) is considered a major benefit (mean score = 4.01). Using innovative water taps and nozzles, as well as rainwater harvesting systems, can result in a decrease in water bills. Similarly, improving energy efficiency can also decrease electricity bills. Switching to green building lighting can conserve energy by 42% [27] [17]. Lower maintenance cost (OPB05) can also be considered a major benefit based on its mean score (4.24). Green buildings have HVAC systems as well as water fixture systems which reduces the cost of maintenance [28]. Mitigation of climatic change (OPB06) is one of the most important features of green buildings. Occupants believe that it can be considered as a major benefit (mean score = 4.14). Green roofs and walls can reduce CO₂ concentration while increasing oxygen concentration. Similarly, their construction can reduce GHG emissions from 271 kg/CO₂eq to only 37 kg/CO₂eq [16] [20] (see **Figure 1**).

In terms of the positive effect on productivity (ART10), occupants report a large extent of awareness (mean score = 3.4). It has been reported that green building design features maximize productivity [4]. Another study reported an increase of

13 - 15% in productivity [23]. The last attribute was the positive impact on the environment (ART11). Its mean score was 3.47 which places the awareness extent at large. Various positive impacts of green buildings have been discussed. They reduce GHG emissions from 271 kg/CO₂eq to only 37 kg/CO₂eq [16]. Similarly, they reduce landfill waste by 27% [24]. It has also been reported that green design features can reduce airborne pollutants by 20 - 30% and other pollutants by 80% [20] [21]



Figure 1. Illustrates the role and impact of green building in creating overall knowledge and awareness about green energy in the population of the United Kingdom; according to our study cohort, their mean values are provided as well.

5. Conclusions and Recommendations

In the present study, it was observed that ISB07 had the highest mean score, followed by ISB09 and ISB04. All of these features had a large impact on occupants' awareness of sustainability. Their least impact features were ISB10 and ISB11. Both of them have a moderate level impact. Except for ISB 10 and ISB11, all other features had a large impact on awareness. In addition, the current research explored that the biggest benefit was the lower maintenance cost, followed by an increase in thermal comfort and mitigation of climatic change. All of these benefits were major ones. Minor benefits included improved water efficacy and low-flow toilets. In terms of drawbacks, all of them were minors. An increase in construction cost had the lowest mean score, followed by planning complexity and

the absence of some features in every building. Climatic variability and daylight savings had neutral status. Furthermore, energy-efficient lighting had the highest mean score, followed by BREEAM certification, positive impact on the environment and presence of an HVAC system. Occupants had a large extent of awareness of all the above-mentioned attributes. The lowest mean score was for workshops, rainwater harvesting, solar and/or wind power and LEED certification. All of their mean score puts them under the moderate awareness category. Lastly, the most effective mode was organizing events, followed by displays and workshops. All of these features were effective to a large extent. Social media, newsletters, and digital media also fall under the same category. Publishing of sustainability reports had the lowest mean score.

Based on the current study, it can be recommended that green building design features and sustainable building practices have a significant impact on occupants' awareness levels. These features help achieve environmental goals set by designers and owners. The current study was limited to only BREEAM-certified residential green buildings; hence, it would be recommended that future studies include LEED-certified residential buildings as well as non-residential green buildings. Secondly, there is a need to compare green buildings with non-green buildings. Thirdly, future studies should expand the locality under study and try to include multiple countries. Lastly, it is recommended that statistical analysis is also included in research.

Author Contribution

Hamza Khaliq—Extracting the literature, manuscript writing, concept of the data, re-evaluation.

Ahmed Abdullah Baerom—Manuscript writing, result Analysis.

Faiza Shahzad—Manuscript writing, survey.

Asad Ullah—Re-evaluation, survey.

Muhammad Aziz Abid—collection of data.

Farah Saif—Finalising the manuscript.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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