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Residents and Professionals' Perspectives on Energy and Water Consumption While Transiting from Conventional to Sustainable Housings in South Africa

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Abstract: The concept of sustainable construction is, unfortunately, not implemented in many developing countries, and even where it is, e.g., South Africa, the uptake is still slow. In the present study, we evaluate, based on residents and professionals' perspectives, the sustainability measures implemented at the Belhar Gardens Rental Estate (BGRE), a sustainable housing rated for its Excellence in Design for Greater Efficiencies (EDGE) in the Western Cape Province of South Africa. Data were collected through questionnaires administered to experienced professionals (n = 19) and residents (n = 106) of BGRE and analysed using descriptive statistics and a modelling approach. We found that 95% of professionals were aware of the concept of sustainable construction, and 74% were aware of the National Building Act 103 of 1977. However, some barriers to sustainable construction were raised: (i) it is expensive and (ii) there is a limited knowledge of how the sustainability concept can benefit the construction industry. Ecological design and procurement are the solutions proposed by professionals to mainstream sustainable construction in South Africa. Finally, 63% of the professionals indicated that the centralized heat pumps installed in BGRE lead to efficient energy use. Surprisingly, only 61% of residents are aware that energy-saving measures are implemented in BGRE, and only 40% of the residents agree that the energy-saving measures implemented are efficient. Interestingly, 65% of residents indicated that energy consumption in BGRE is less than what they consumed in conventional housings. Finally, none of the variables tested (age, gender and residence time) correlate with residents' satisfaction with sustainability measures in BGRE, making it difficult to predict what drives people's satisfaction in an EDGE-rated housing. By identifying the barriers and benefits of sustainable construction, we provide opportunities on which to press to improve the awareness, mainstreaming and uptake of the sustainable construction approach in South Africa.

Keywords: sustainable construction; construction industry; awareness; satisfaction-level; residents; developer

1. Introduction

Across the globe and particularly in the developing world, land cover is changing rapidly due to urbanisation [1]. This is because of a multitude of reasons, the most prominent of these being that cities experience rapid population growth due to immigration from rural areas as people search for better employment opportunities [2]. Consequently, more construction takes place in cities to respond to the unprecedented human population growth [3]. Unfortunately, the construction of this infrastructure may be a source of several environmental problems that may aggravate human conditions. In that regard, the increased need for construction has led to higher demands for natural resources used in the construction process. For example, recent studies have indicated that construction and the built environment consume 40% of global energy, 17% of freshwater, 40% of other materials and 25% of wood [4].

This increased use of natural resources often leads to the inherent risk of environmental degradation. As construction proceeds, in an era of pronounced climate change, developing countries that depend on built infrastructure to meet developmental goals should be mindful of the concept of sustainability in construction [4]. The traditional construction industry is accountable for a large proportion of the pollution that is generated around the world [5]. Buildings are one of the leading users of electricity, and they hence contribute to global warming and the depletion of natural resources [6]. Other examples of the negative impacts of construction on the environment include the loss of soil, agricultural land, wildlands and forests and the generation of air pollution, as well as the loss of energy sources and minerals [7]. Therefore, changes need to be applied as urgently as possible to transition from a conventional construction approach to green construction to minimise further environmental damage [8].

Furthermore, apart from ignoring the environmental impact of construction, traditional approaches also tend to largely focus on minimising costs while maximising profits at the expense of sustainability. The National Development Plan (NDP) for South Africa tries to address this by setting up several goals to be achieved before 2030 [9]. Among these lofty goals is the vision to change human settlements by “improving spatial economy to create energetic urban spaces.” Construction of social housing is the main component of the strategy [9]. Social housing refers to houses with rents pegged to low incomes (households earning between R1501–R15,000, or roughly US\$100–US\$1000) and offers a secure and affordable housing option for individuals across South Africa. Social houses are provided by housing associations, for example not-for-profit organisations or local municipalities [4]. Since the inception of social housing organisations and projects from 1997 to 2009, about 60 social housing institutions (SHIs) have delivered almost 30,332 residential properties in South Africa [9]. With the social housing niche within the construction industry, there is an opportunity to enhance sustainability through the implementation of sustainable construction requirements into specific, technical performance criteria for buildings, systems and materials. More critically, sustainability criteria should guide interventions at each stage of construction. The concept of sustainable construction has been proposed as an alternative to the conventional construction approach. According to Spišáková and Mačková [10], sustainable construction is a cross-cutting approach which can be defined as construction that ensures a better quality of life now and for future generations by achieving social, economic and environmental objectives at the same time. Aigbavboa et al. [11] further suggested that sustainable construction should be incorporated in construction enterprises as it forms part of corporate social responsibility. In the same vein, Agenda 21 on Sustainable Construction for Developing Countries expands the concept of sustainable construction to include the need to restore and maintain the relationship between the natural and built environments, whilst creating settlements that protect human dignity and encourage equity. The characteristics of a sustainable construction are therefore: less consumption of resources, i.e., less consumption of water; less energy consumption and low impacts on the environment, as well as low maintenance costs. We therefore expect the CO₂ footprint of sustainable constructions to be lower than those of conventional constructions.

According to Durdyev et al. [12], although the importance of implementing sustainable construction is unquestionable, there is evidence that the concept is not effectively implemented in many developing countries. Even in countries where the concept is acknowledged in the legislative framework (e.g., South Africa), the uptake of sustainable construction is still slow [12,13]. Specifically, in South Africa, 23% of carbon emissions are reported to be a result of the built environment and energy consumption [4]. In the face of these environmental problems linked to the conventional construction approach globally and locally, there is a need for a paradigm shift in construction methods [14].

In light of these problems (e.g., environmental issues linked to conventional construction, high cost attached to sustainable construction, limited awareness of sustainable construction principles), the present study aims to evaluate, based on residents and professionals’ perspectives, the sustainability measures implemented at the BGRE in the Western

Cape Province of South Africa. Specifically, we (i) determine the awareness level of the professionals of the Calgro M3 developments (used as a case study) of the concept of sustainable construction, (ii) determine the professionals' perceived barriers, opportunities and solutions to mainstreaming sustainability construction in South Africa, (iii) determine the awareness levels and feedback of the residents of Belhar Gardens Rental Estate on the various sustainability measures implemented in the estate, and (iv) identify the determinants of water-saving sustainability measures implemented in the Belhar Gardens Rental Estate.

2. Materials and Methods

2.1. Study Area

The Western Cape, located on the south-western coast of South Africa, has an area of 129,449 km² and is the third most populated province in the country. Its capital, Cape Town, had 6.6 million residents in 2018 (Statistics South Africa [15]). The study was conducted in a residential estate in a Cape Town suburb called Belhar. This estate, called Belhar Gardens Rental Estate (BGRE) (Figure 1), is a development located at 33°56'24.7" S; 18°38'12.9" E. Figure 1 is a close-up aerial view of BGRE and the immediate surrounding areas of Belhar Suburb.



Figure 1. Aerial view of the locality of Belhar Gardens Rental Estate (the study site) in the Belhar suburb (Source: Google Maps, November 2021).

The driest month in Cape Town is February. There is 16 mm of precipitation in February. The rainfall pattern is unimodal: most of the precipitation here falls in April–September with the highest rainfall observed in June (112 mm). However, the temperature pattern is bimodal with February and December being the two modes (20 °C) and the lowest temperature is observed around July (12 °C).

The demographic profile of Belhar indicates that the coloured community forms 90.2% of the population whereas 4.9% of the population is African and only 1% is Asian. In term of education, some residents have never been to schools (between 0–5%), others have completed their primary education (up to 7%, coloured community) while up to 36% have completed their grade 12 (African community) and up to 38% have higher than grade 12 education level (White community). In term of income, 20% of the residents have no income while 15.5% of the White community earns between R51,000 (US\$3400) and above R100,000 (US\$6700) monthly.

2.2. Data Collection

2.2.1. Stakeholders of the Belhar Gardens Rental Estate Targeted for the Study

Two types of stakeholders were targeted for data collection: residents and developers. There are 630 units in BGRE, and all are inhabited by residents who are the beneficiaries of the sustainability initiatives conceptualised by architects and later implemented by Calgro M3 developments. Data collection was undertaken through questionnaires distributed to residents. Three hundred residents were available during the dissemination of the questionnaire (out of 630). Of the 300 residents, only 200 had access to internet and the electronic devices necessary to access the electronic survey questionnaires.

The developers, i.e., Calgro M3, were the company spearheading the Belhar social housing project, albeit with several smaller sub-contractors that were not part of this study's target. This study did not target any sub-contractors, since all their efforts on the Belhar social housing project were bound by and followed Calgro M3 specifications. It was therefore crucial to investigate the project source and converse with only the decision-making part of Calgro M3 developments, which was 35 individuals in senior managerial positions. Specifically, the study targeted project managers, town planners and architects. These professionals were identified as critical stakeholders since they were involved from the planning to execution stages of the project. Architects drew plans, designed the overall look, and ascertained how each part of BGRE was designed to ensure an overall sustainable structure. The architects were employees of Calgro M3; they were the main contractor of BGRE. There was a total of 35 people who worked as project managers, site supervisors and architects in the construction project of BGRE.

2.2.2. Sampling

Non-probability sampling, as a sampling method, was used with convenience sampling as a technique. The total sample is comprised of 35 BGRE contractors (20 Calgro M3 construction managers and site supervisors and 15 architects). Only 19 BGRE contractors responded and participated in the study whereas 106 residents of the estate responded, making it a total of 125 persons taking part in the study.

2.2.3. Data Collection Procedure

Initially, a survey questionnaire in hardcopy was designed (prior to the COVID-19 pandemic) and printed and the relevant authorities, i.e., management at Calgro M3 developments and management at BGRE, were approached to request their permission for the survey to be undertaken. Calgro M3 developments approved the questionnaire but approval by the board of the residential estate was also required. As such, the *Madulam-moho* Housing Association (MHA) had to be engaged to review the questionnaire. Only after MHA approved the content of the questionnaire did they allow the issuing of the questionnaires to their residents registered on the housing estate's database. Questionnaires were then shared with the Chief Operating Officer (COO) of BGRE. After their review, the COO returned the questionnaire for corrections.

However, the COVID-19 pandemic started before data collection took place, and physical face-to-face data collection was no longer possible. The questionnaire had then to be converted into an online questionnaire and the link sent to residents of the estate. The final, approved softcopy of the questionnaires was then shared with the COO, who then sent the link via their bulk communication channel (SMS and email) to residents. Only residents with access to email and smartphones therefore had the capability to access the online form on Google Forms and respond to the questionnaire. One hundred and six (106) residents returned completed and error-free questionnaires. Data collection for Objectives 1 and 2 occurred in October and November 2019 during the level 4 lockdown imposed by the South African government owing to the coronavirus (COVID-19) pandemic. The survey remained open for eight weeks to give ample opportunity for participation.

Two types of questionnaires were designed to answer the objectives of the study. The first questionnaire (Appendix S1) was directed to the 19 identified developers (contractors and architects). The specific sections of the questionnaire were:

- (i) Introductory statement and informed consent form
- (ii) Section A: Participants' demographic information
- (iii) Section B: Perceptions and knowledge of sustainable construction
- (iv) Section C: Sustainability measures implemented at Belhar Gardens Rental Estate.

Sections B and C asked questions on sustainability based on the most notable measures of sustainability being implemented across the world in the 21st century construction industry. These include (i) land use, (ii) water efficiency, (iii) energy and atmospheric considerations, (iv) legislation and (v) innovation and design process considerations.

The second questionnaire (Appendix S2) was sent to the residents. The purpose thereof was to solicit responses on awareness and satisfaction with sustainability measures implemented in the BGRE. The specific sections of the questionnaire involved:

- (i) Section A: Participants' demographic information
- (ii) Section B: Satisfaction level of residents regarding the following:
 - water management measures,
 - energy-saving technology,
 - cost saving due to the above sustainability measures.

The responses of residents were scaled as follows: 1 = not in agreement; 2 = somewhat in agreement; 3 = neutral; 4 = mostly in agreement and 5 = completely in agreement.

All data collected are in Table S1 (Supplemental Information).

2.3. Data Analysis

The percentage of developers who were aware and those not aware of the concept of sustainable construction was calculated (objective 1). Subsequently, developers expressed what they see as barriers, opportunities and solutions to mainstreaming sustainability construction in South Africa (objective 2) and the proportion (%) of developers expressing each of these factors (barriers, opportunities and solutions) was calculated. Next, for objective 3, the percentage of residents who were aware and those not aware of the various sustainability measures implemented in the residences of Belhar Gardens Rental Estate was calculated. Finally, to identify the determinants of water-saving sustainability measures implemented in the Belhar Gardens Rental Estate, satisfaction levels were defined as a rank variable with five levels: "not satisfied," "neutral," "somewhat satisfied," "highly satisfied" and "very highly satisfied." Following this, the cumulative link model was fitted using the R function *clm* implemented in the library Ordinal [16] using the rank variable as response and gender, age and residence time as predictors. The CLM model is preferred to the machine-learning methods based on a number of advantages that CLM provides [17]. In summary, CLM is a better approach as it does not require that the ranked categorical variable (used as response variables; here satisfaction levels) be converted into numerical values. In so doing, the CLM has the advantage of preserving the variance structure of the original ordinal ranks of the categorical response variables, and thus prevents the loss of information generally observed when categorical variables are either converted into numerical values or grouped into binomial classifications. The CLM also prevents an unnecessary elevated type I error generally observed when ranked variables are converted into numerical values in which differences between consecutive rank levels are assumed to be equal. The data analysed and the R script used are provided as Supplementary S1 and Supplementary S2 in Supplemental Information.

2.4. Ethical Considerations

We adhered to all the ethical principles of the University of Johannesburg, including obtaining written consent from respondents. The respondents were informed that they could withdraw from the study at any time if they wanted to. This was explained to them

at the outset of the investigation before data collection. We further obtained the university and relevant organisations' (Calgro M3 and BGRE) consent for the investigation before commencing with data collection. Moreover, the privacy of individuals was protected by rendering it unlikely that data could be connected to a specific individual. Anonymity and confidentiality, vital to principled practice in research, were also considered; thus, respondents' names and individual information were not revealed in the research process. All residential and contractor/developer participants were over the age of 18 and did not demonstrate impaired mental capacity. In the case of the contractor/developer participants, this was determined by their ability to perform in the positions that they hold in the workplace (i.e., Calgro M3 employees). Meeting these criteria qualified them as participants in this study.

3. Results

3.1. Awareness Levels and Perceptions of Developers of the Concept of Sustainability Construction

3.1.1. Demographic Structure of the Population of Developers

In total, 37% of the developers (referred to as professionals) were male while 63% were female. The majority is 26–33 years old (53%) followed by 34–41 (32%). The group of professionals above 42 years old represents 15%. The professionals were required to indicate their position within Calgro M3. As shown in Figure 2, the largest grouping of professionals was project managers (32%). Architectural technologist and contract manager comprised one individual each (5% of professionals, respectively). Sixteen percent of the professionals were environmental practitioners, while health and safety managers, procurements clerks, quantity surveyors and town planners were represented by 11% each. Furthermore, these professionals have various years of experience in the construction field. The highest number of them (37%) fell into the 7–9 years' experience range, followed by 32% having 4–6 years' experience. There were 21% professionals with more than ten years' experience, while only 11% had less than 3 years of experience.

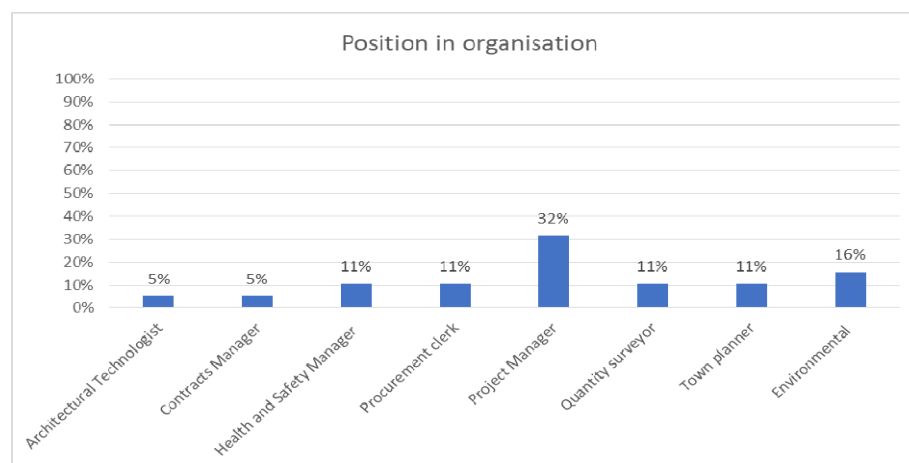


Figure 2. Work position of respondents in company (N = 19).

3.1.2. Level of Awareness of the Concept of Sustainable Construction among Developers

Two areas of awareness were assessed: (i) awareness of sustainability in construction and (ii) awareness of building standards and regulations. As shown in Figure 3, 95% of the participants are aware of the concept of sustainability in construction, whereas 5% are not aware of it. The participants further showed a high level of awareness of relevant legislation such as the National Building Regulations and Building Standards (as amended) Act 103 of 1977 (the Building Act). A total of 74% indicated that they were aware of building standards and regulations in construction and 26% were not (Figure 3).

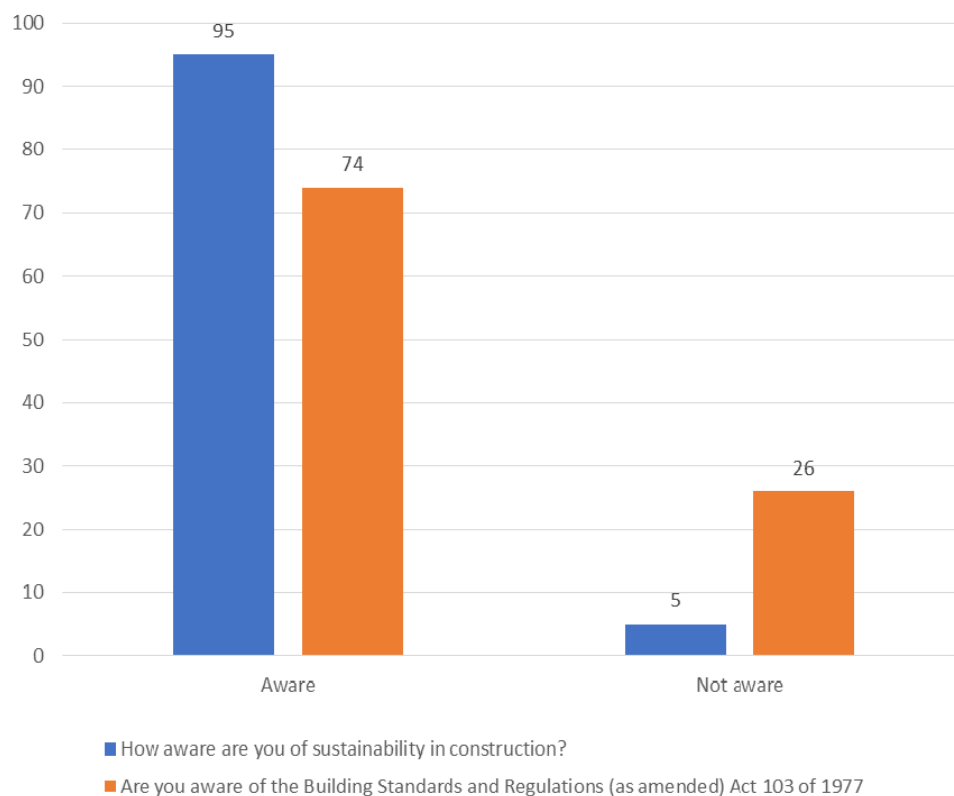


Figure 3. Awareness level of sustainability in construction and the National Building Regulations and Building Standards Act 103 of 1977 (N = 19).

3.2. Mainstreaming Sustainable Construction in South Africa: Barriers, Opportunities and Solutions According to the Developers

Developers of Calgro M3 were requested to share their perceptions of various aspects of sustainable construction (Figure 4A). They were requested to answer the following questions: (i) Are the environment and sustainability concept more important than saving costs on constructions? (ii) Is sustainable construction a way to reducing global warming? Will future technological development assist in reducing the costs of sustainable construction? To these questions, around 85% of the developers responded ‘yes’. However, 52% of developers believe that the implementation of sustainable measures in construction is costly and this does not encourage the mainstreaming of sustainable construction, although 63% of them agree that ecological design and procurement are the solutions to sustainable construction barriers. In addition, 95% of the respondents believe that government should do more to promote sustainable construction within the construction industry (Figure 4A).

Furthermore, in term of solutions to speed up the mainstreaming process (Figure 4B), 68% of the developers admit there is, in the industry, a limited knowledge and understanding of how the concept of sustainability can benefit the construction industry while 16% believe there is enough knowledge in the industry to move the concept forward. Along the same line, 74% agree that the knowledge of the concept will not only contribute to reducing the cost of construction but also to meeting the Green Building Council South Africa’s requirements for sustainability. At the same time, 11% remain sceptical of this. Interestingly, 100% agree that the government should make the shift toward sustainable construction compulsory in the country while 68% of those aware of the building Act acknowledge that the Act is actually in use in their organization, while 16% disagree. Finally, as a case study, 63% of the developers indicated that centralized heat pumps are a solution to creating sustainable housing in terms of efficient energy use, while 11% disagree.

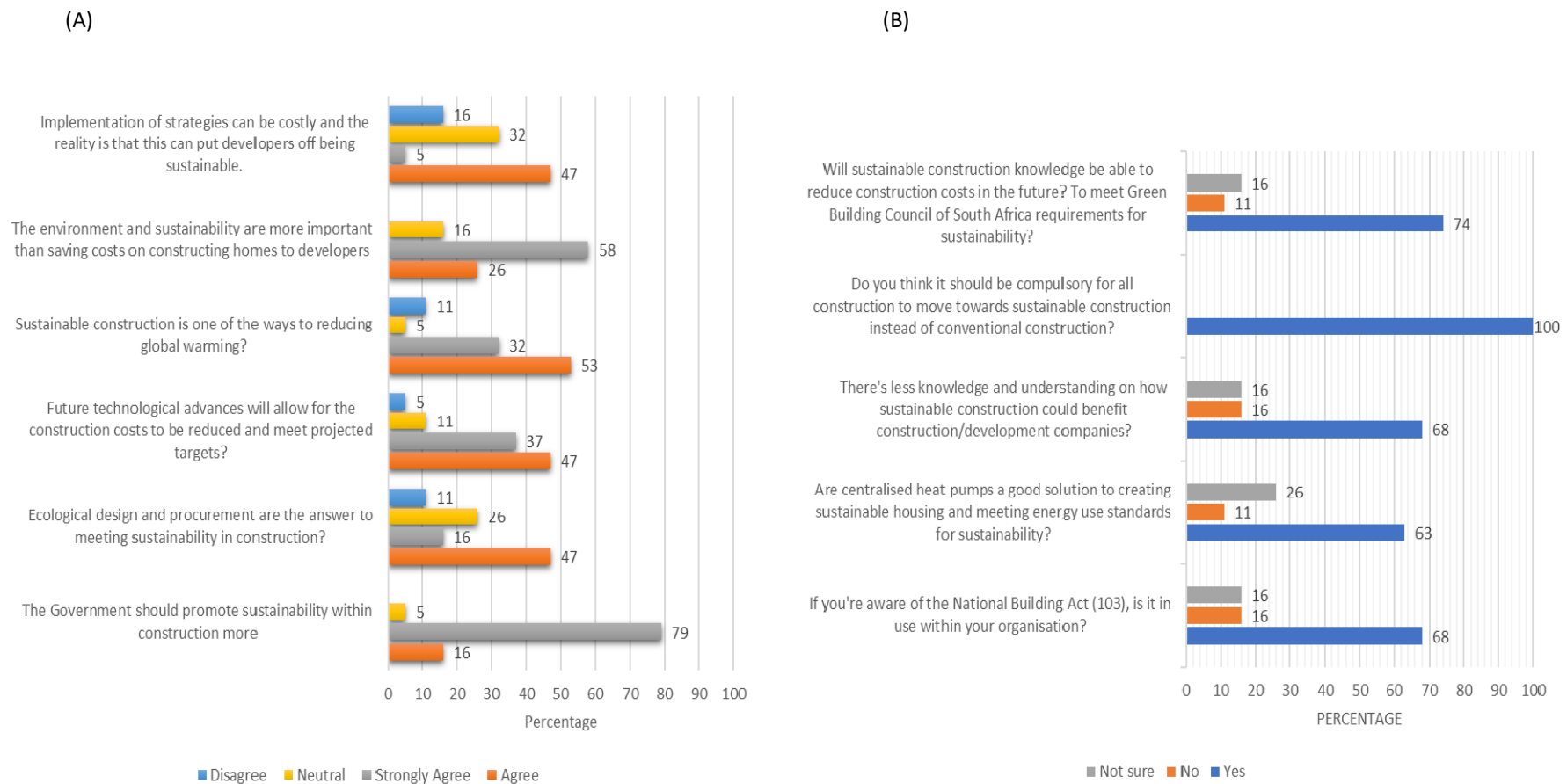


Figure 4. Mainstreaming sustainable construction in South Africa: (A) barriers and opportunities and (B) solutions according to the professionals.

3.3. Awareness Levels and Perceptions of the Residents of BGRE

3.3.1. Residents' Population Structure of BGRE

The majority (66%) of residents at BGRE who participated in the study were female and 34% were male. BGRE has relatively more youths, with 51% being in the age bracket of 26–33 years. The smallest grouping (5%) was those in the 18–25 years age group. Additionally, 84% of the residents had lived in BGRE for at least 3 years, 13% had been residents for less than 2 years and only 3% of had been there for less than a year.

3.3.2. Residents' Level of Awareness of Sustainability Measures Implemented in the BGRE

More residents of the BGRE are aware of the various sustainability measures implemented in their Estate than not, but the proportions of residents who are aware are not strongly different from those who are not (Figure 5). For example, 55% of residents are aware that BGRE is EDGE rated for water and energy efficiency while 45% are not even aware of that status of BGRE. Additionally, 53% and 59% of residents are aware of the EDGE rated initiatives for energy and water consumption efficiencies, respectively, implemented in BGRE against 47% and 41% who are not aware of both energy and water efficiencies, respectively. Overall, 61% of residents are aware that energy-saving measures are implemented in BGRE.

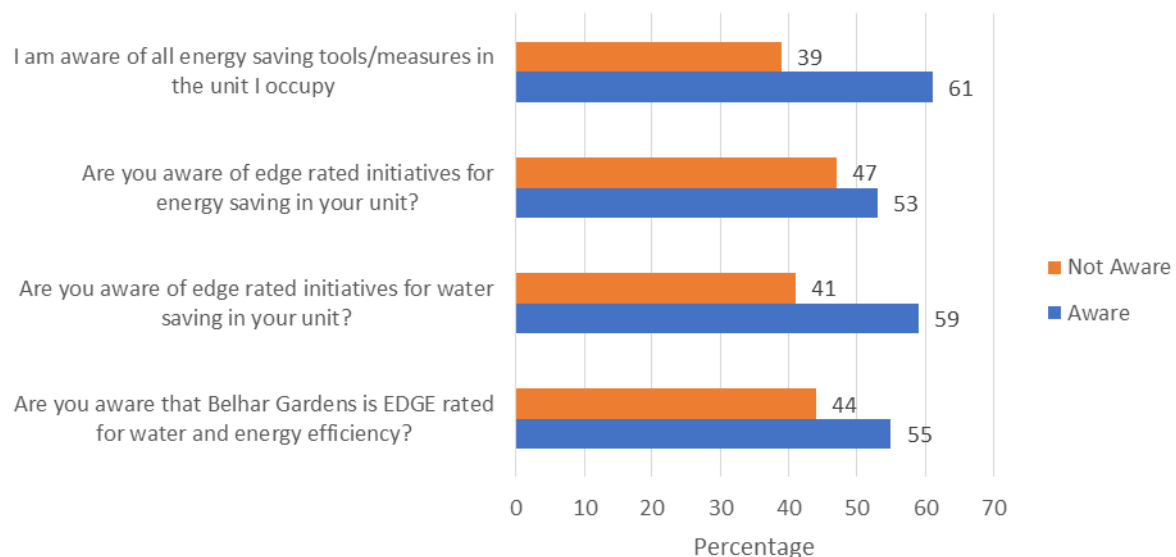


Figure 5. Awareness level of residents on EDGE rating, energy- and water-saving initiatives (N = 106).

3.3.3. Residents' Assessment of on Sustainability Measures Implemented in Belhar Gardens Rental Estate

Various sustainability measures were implemented in the BGRE. On energy measures, the vast majority, i.e., 50% of residents showed a neutral attitude towards the measures implemented. However, 10% of residents were clearly in disagreement that the implemented measures are efficient, while only 12% were completely in agreement. When all variants of agreement were combined, i.e., mostly in agreement (18%), completely in agreement (12%) and somewhat in agreement (10%), this amounted to only 40% of agreement towards the efficacy of the energy-saving measures implemented (Figure 6A).

On the usefulness of the information carried by energy meters in reducing energy consumption, 46% show neutral attitude towards the usefulness of those information. However, 15% did not find the information useful for the purpose of reducing energy consumption. When all variants of agreement were combined, i.e., mostly in agreement (15%), completely in agreement (12%) and somewhat in agreement (12%), this amounted to only 42% of agreement on the usefulness of information on energy meters to residents (Figure 6B).

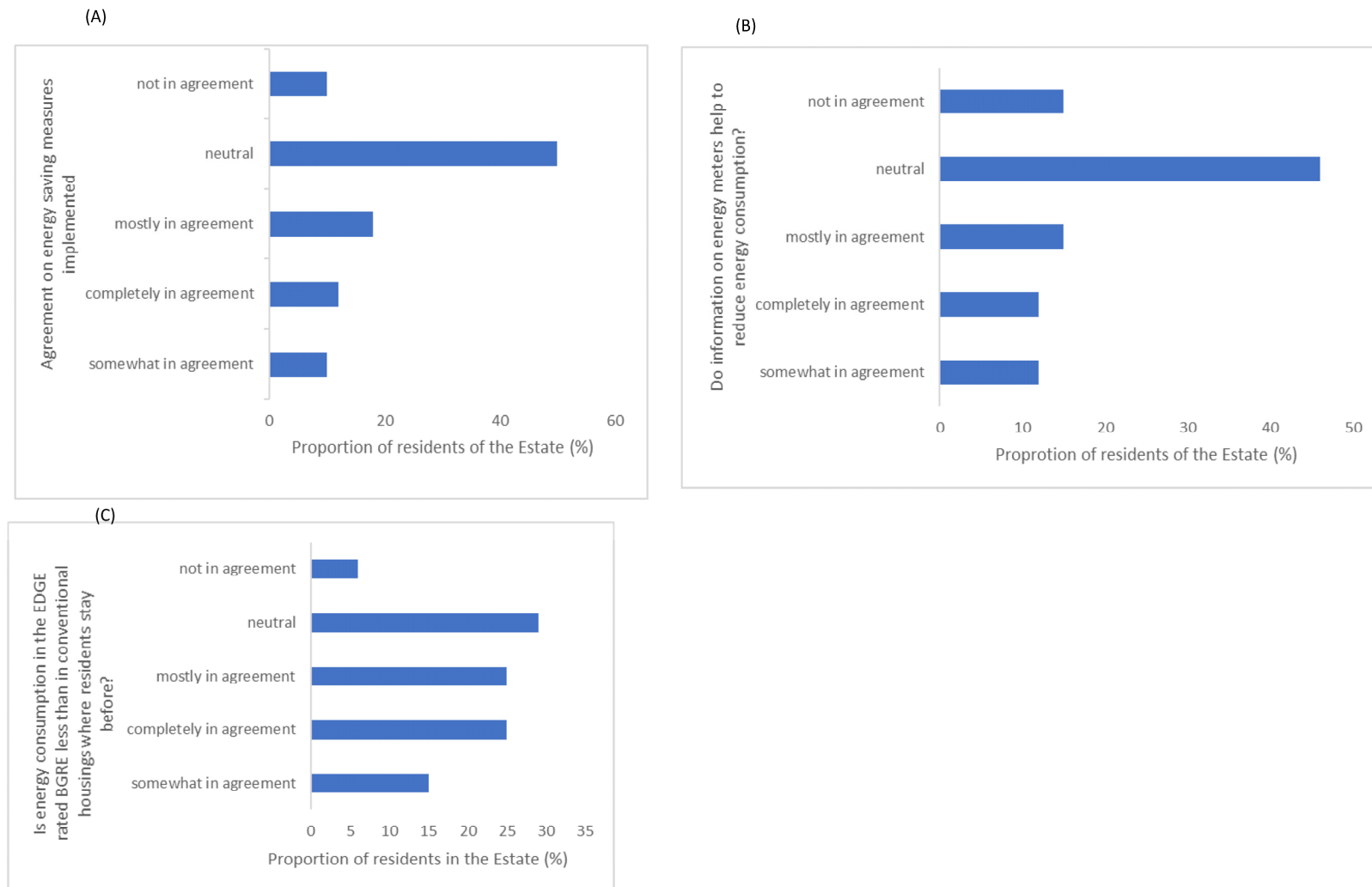


Figure 6. Residents' feedback on sustainability measures implemented in Belhar Gardens Rental Estate. (A) efficacy of energy-saving measures, (B) usefulness of information on energy meters and (C) efficacy of energy consumption in BGRE in comparison with conventional consumption.

Interestingly, on the question of the efficiency of energy consumption in BGRE in comparison with consumption in conventional housing where residents lived in the past, 65% indicated that the consumption in BGRE is less than in conventional construction: mostly in agreement (25%), completely in agreement (25%) and somewhat in agreement (15%). Only 29% remain neutral on the question and only 6% did not find consumption lower in BGRE than in conventional construction (Figure 6C).

3.4. Determinants of Satisfaction Levels of Residents towards Water-saving Measures

Finally, among all variables tested, none correlated with residents' satisfaction with water-saving measures implemented and even towards water-flow restrictor measures (Table 1): gender ($p = 0.26$), Age ($p = 0.92$) and residence time ($p = 0.06$). On the satisfaction of residents towards water flow restrictors, none of the variables tested correlated with resident satisfaction: gender ($p = 0.23$), age ($p = 0.72$) and residence time ($p = 0.12$). However, only gender correlated significantly with satisfactions toward information displayed on water meters, with males being the less satisfied ($p = 0.02$; Table 1).

Table 1. Coefficients of the cumulative link model of the satisfaction level of residents.

Response Variable	Predictors	Estimate	Std Error	Z Value	p Value
Satisfaction of residents <i>vis-a-vis</i> water-saving measures	Gender	−0.41	0.37	−1.11	0.26
	Age	0.002	0.02	0.09	0.92
	Residence time	−0.70	0.38	−1.84	0.06
Satisfaction of residents <i>vis-a-vis</i> water flow restrictors	Gender	−0.43	0.37	−1.17	0.23
	Age	0.009	0.02	0.34	0.72
	Residence time	−0.62	0.40	−1.53	0.12
Satisfaction of residents <i>vis-a-vis</i> information displayed on water meters	Gender	−0.84	0.38	−2.18	0.02
	Age	0.04	0.02	1.72	0.08
	Residence time	−0.75	0.39	−1.88	0.05

4. Discussion

4.1. Socio-Educational Profile of the Respondents from Calgro M3 Development

The representation of women among the Calgro M3 employees is noteworthy: more female developers (63%) than males participated in the study. This is encouraging, considering that the average representation of women in the South African construction industry is 13% [18] and 16% in the UK [19]. There has been a historical issue of women being underrepresented in the construction sector, and [19] surmises that more needs to be done to ensure the opportunities and benefits of working in construction jobs for women. In line with [19], governments have established programmes to encourage science, technology, engineering and mathematics (STEM) subjects in high school which can lead to an increase in the number of women working in the industry [20,21]. However, the proportion of women reported in the present study is for only one development organization, i.e., Calgro M3 development. This is perhaps a call for South Africa's other development organizations to do more to attract women in the construction industry.

Additionally, 53% of the Calgro M3 professionals are young, and interestingly, the vast majority of the respondents from the Calgro M3 (74%) have a university degree or diploma. Indeed, education within the construction industry is important to ensure that construction personnel are competent to carry out their jobs [22]. That most respondents are university graduates is not surprising, since this seems to be a requirement in the field of construction as reported elsewhere [23]. Additionally, the value of experience in construction cannot be

discounted. According to [24], the success of a construction firm relies on skilled labour. In the M3 Calgro, professionals at various positions and experience levels were found and they all shared their knowledge and insight on sustainable construction: project managers, architectural technologists and contract managers, environmental practitioners, health and safety managers, procurements clerks, quantity surveyors and town planners, all with more than 10 years of experience in the field. The question was: Are they aware of the benefits of sustainable construction, and if so, what are their own perspectives about it?

4.2. Mainstreaming Sustainability into Construction: Perspectives of the Professionals

Most of the respondents (95%) are aware of the concept of sustainable construction, including the Building Act (74%). This is in line with what [25] has already reported, that built environment professionals are generally aware of sustainability principles. Several authors highlighted the importance of awareness and knowledge of sustainability options and regulations in construction and the need for the concept to be filtered across various organisational levels in order for it to be incorporated in projects [26]. Such a high level of awareness of professionals in Calgro M3 is perhaps an assurance that the future of green building in South Africa is bright. However, these professionals also raised some doubts that need to be addressed.

To mainstream sustainability in the construction industry in South Africa, the professionals identified several barriers, opportunities and solutions. Two main barriers were identified by the professionals: they estimated that sustainable construction is expensive (52%) and that there is a limited knowledge in the industry (68%). Such barriers were also reported in some early studies [27]. Green buildings are estimated to be 6.7–9.3% more costly than traditional constructions. Despite this, it was encouraging that the professionals of Calgro M3 (85%) believed that future technological advances would help minimizing construction costs.

Interestingly, they also indicated that sustainable construction is an important opportunity toward reducing global warming. Similar opportunities have been reported for sustainable constructions such as lower operational costs; lower energy, waste and water costs; lower maintenance costs and increased productivity and health [28–30]. Others have even suggested that the use of new technologies together with digitization and atomization should be included for the development of the construction industry [31]. In the specific context of South Africa, the professionals suggested that (i) ecological design and procurement, (ii) improvement and dissemination of knowledge of the concept and (iii) government interventions are the way forwards towards mainstreaming the concept in the construction industry. They specifically suggested that the government should make it compulsory for all to shift towards sustainable construction. Such suggestions were also made in other studies [30,32].

4.3. Perspectives of Residents of a Green Building on Implemented Sustainability Measures

The results have shown that more females than males participated in the study at the Belhar Gardens Rental Estate (BGRE)—66%. In terms of age, the majority of respondents are young (26–33 years old). If more young people go to Belhar Estate, which is an EDGE-rated housing, it is perhaps because young people are more likely to adopt green technologies and alternative ways of construction. For example, in the Western Cape, the South African province where the present study took place, there is a societal movement of the youth who want hemp in the form of hempcrete to be industrialised and used in the construction sector because hempcrete meets all the conditions of being an eco-friendly building material [33]. There are multiple metrics to rate sustainable constructions from country to country. One of them is EDGE. The estate used in our study is EDGE rated for water and energy efficiency. Countries where EDGE rating approach is adopted use similar criteria for their rating of building. The BGRE residents who took part in the study have been living in the estate for more up to 10 years, suggesting that they have enough experience with the sustainability measures implemented in the estate. What are their perspectives on these measures?

Only 55% of the residents were aware of the EDGE-rated status of the estate, i.e., 45% of residents ignored the sustainability status of the building they were living in. Similar proportions even ignored the sustainability initiatives implemented in the estate for energy and water consumption efficiency. All these points may mean that there is no handover pack or formal handover presentation given to residents to highlight the EDGE status and sustainability initiatives implemented in the residential units they occupy. Green technology makes buildings more energy efficient, water efficient and sustainable, and it is therefore critical that residents are aware of the benefits of the sustainable building. This is an important marketing point for the concept of sustainability.

Interestingly, 65% of residents admitted that the energy consumption is lower than the consumption in conventional constructions. Additionally, among those who are aware of the measures implemented, the efficacy of the measures implemented for energy consumption can be estimated at 40% (proportion of residents who find the measures effective) whilst a similar proportion (42%) estimated that the information on energy meters is effective. This means roughly 60% do not find implemented measures as effective, mirroring perhaps a lack of buy-in from residents. This is a serious concern for the future of sustainability. Sustainably constructed buildings use natural resources efficiently and reduce wastage during construction; this leads to lower utility bills and reduced impacts on the environment. Raising the awareness of residents of the promise of sustainability in construction is a critical step towards mainstreaming the concept in the country.

4.4. Residents' Satisfaction towards Implemented Sustainability Measures

One technology used in sustainable construction of houses that has low impact on the environment is dual flush toilet mechanisms, mixer taps, centralised water heat areas and stabilised soil blocks (SSBs). These technologies were also implemented in BGRE. The SSBs were utilised in the construction of the housing structure. The blocks are low-cost as their main component, the soil, is sourced locally, often directly from the site of construction. Further, these blocks can be produced on site, thus leading to some savings in transportation costs [34]. It emerges then that to achieve sustainable construction, technology should be included as an integrated element to maximize the social, environmental and economic benefits of sustainable construction [31].

These measures or technologies have important benefits since sustainable construction contributes to the reduction in global warming [35]. High-performing green buildings, particularly LEED-certified buildings, provide the means to reduce the climate impacts of buildings [24]. Green buildings work to slow down the effects of climate change in two main ways. First, they are more energy efficient. Energy efficiency can be accomplished by conducting retrofits, optimizing operations, adding solar or renewable energy on-site or taking advantage of existing landscape features like shade [25]. Green communities take into account the many facets of the built environment and try to lessen their impact on the environment. This includes increasing access to cleaner transportation or walking/cycling, reducing water usage, enhancing green spaces and carefully planning cities and communities to minimise disruption to the environment [36]. The authors of [37] suggest that housing should enable residents to have positive experiences which lead to physical and mental happiness whilst enabling healthy living. The authors of [38] indicated that to assess the end-user's satisfaction, more post-occupancy evaluation (POE) of the technologies in green buildings should be provided.

Water being a particularly important natural resource, which is shrinking day by day [39], there should be a proper or optimum use of water during construction [40]. For satisfaction with water-saving measures, none of the three predictors (age, gender and residence time) tested was significant. This could be because the residents interviewed are still living in the estate, and they may eventually realize the benefits of living in a green building only after they have left the building [38]. Some suggested that POE is rather preferable to determine the satisfaction of occupants [41]. POE allows for a post certification evaluation to assess whether certified buildings and the inherent sustainability initiatives

are deemed valuable by the occupants. Such POE evaluation is necessary for the estate involved in the present study, and future studies may focus on that aspect. Furthermore, ref. [40] indicates that the POE can include indoor air quality, acoustics, comfort and/or lighting as factors that might influence satisfaction during a POE. The scope of this study was energy and water efficiency as these are the two elements that BGRE is EDGE-rated for.

5. Conclusions and Recommendations

Climate change is one of the major challenges of our time. To address the changing climate, the concept of sustainability in all sectors is proposed. Conventional construction is known to contribute in various ways to the effects of the changing climate, and this calls for more sustainable construction to be mainstreamed in our governance system. In practice, the uptake of the concept in the construction industry is still low particularly in the developing world. To address this, there is a need to first understand the people and professionals' perspectives on sustainable construction.

Our objectives were to:

- To determine the awareness level of the developers (i.e., construction professionals of Calgro M3 developments) of the concept of sustainable construction;
- To determine the professionals' perceived barriers, opportunities and solutions to mainstreaming sustainability construction in South Africa;
- To determine the awareness levels and feedback of the residents of Belhar Gardens Rental Estate of the various sustainability measures implemented in the estate;
- To identify the determinants of water-saving sustainability measures implemented in the Belhar Gardens Rental Estate.

The major findings of the present study can be summarized as follows:

On the professionals' side:

- 95% of the construction professionals are aware of the concept of sustainable construction;
- 74% of them are aware of the Building Act.

To mainstream sustainable construction in South Africa, the following perspectives were shared by the professionals:

- 52% of the professionals reported two barriers to mainstreaming the concept: (i) green construction is expensive and (ii) there is limited knowledge of the concept;
- 85% of the professionals indicated that (i) environment and sustainability concept is key and can offset the cost inherent to sustainable construction, (ii) sustainable constructions contribute to reducing global warming and (iii) technological development will contribute to reducing the high price of sustainable construction in the future.

The following are the proposed ways forwards:

- Ecological design and sustainable procurement in the project lifecycle;
- The government must intervene and make sustainable construction compulsory;
- The knowledge of the concept must be disseminated actively within the construction industry.

Such knowledge will help meet the criteria set by Green Building South Africa.

On the residents' side:

- 55% of the residents of the Belhar Estate are aware of the EDGE-rated status of the estate for water and energy.
- 53% and 59% of the residents are aware of EDGE rated initiatives implemented, respectively, for energy and water consumption efficiency.
- 61% of residents are aware of the energy-saving measures implemented.
- 40% of residents find the implemented energy-saving measures effective.
- 42% reported the information on energy meters to be useful in reducing energy consumption.
- 65% of residents indicated that the energy consumption in the estate is lower than in a conventional construction.

- None of the variables tested (age, gender and residence time) correlates significantly with residents' satisfaction level of the implemented measures.
- Male residents are less satisfied with information displayed on water meters.

An evaluation of the sustainability measures implemented at the BGRE in the Western Cape Province of South Africa was the focus of the present study. Sustainable construction has immense value for the environment, people and the economy. The findings indicate that the key stakeholders are knowledgeable of the concept of sustainable construction in South Africa, and residents are aware to some extent of the efficiency level of sustainability measures implemented in the BGRE. Strong empirical evidence exists to show that sustainability measures are implemented in construction [41].

Potential limitations of the study include the focus on only one case study and the online data collection strategy. Similar studies must be conducted on different case studies so that general patterns can be identified to inform interventions. Online data collection was adopted due to COVID-19 restrictions. This prevented us from visiting the estate in person for further observations on site.

The following recommendations are provided based on the findings reported in the present study.

- **Increasing awareness of the building Act amongst construction professionals.**

Individuals and construction organizations should be equipped by government and institutions of higher learning with knowledge of the Building Act, sustainable construction benefits and areas of perceived improvement. An understanding of sustainability measures implemented in construction will help practitioners to better understand the different views and methods of sustainable construction and to produce interventions that would normalize sustainability practices in their construction processes [42,43]. Sustainable construction could be better understood if it is aligned to the different phases of the project lifecycle.

Based on the present investigation, it may be useful to conduct a future study that evaluates the sustainability measures implemented in several EDGE-rated rental estates and make comparisons among these. The benefit of comparisons can yield many learning opportunities and enhancements of sustainability measures for future rental green buildings in the residential construction markets of South Africa. Several studies would be an excellent basis for such comparisons [44–46].

- **Funding green building and educating all professionals involved in construction about how sustainable construction inclusive of ecological design can help in the reduction in global warming.**

It would be beneficial for government to incentivize or partially fund developers and construction professionals who implement green building principles in their projects [42]. There should be an intensive drive to dispel the perception that green building is costly by rewarding those that implement sustainable construction principles in their construction work. Cost should be assessed on a long- and short-term basis to highlight the cost savings and wellness of those who are involved in green building projects.

- **Establishing boards responsible for increasing knowledge on environment and sustainability concepts within the construction industry.**

The Construction Industry Development Board (CIDB) may be best suited for this task as the chief regulator of the construction industry. Advisers and experts should help such boards to deal with the challenges faced during sustainability implementation. As far as the construction of sustainability measures are concerned, relevant organizations and institutions need to introduce/extend training courses, sustainability workshops and to identify advisers to improve sustainability implementation in construction; as well as mitigate the constraints (awareness, cost, lack of enforcement, etc.) to achieving sustainability implementation.

- **Develop handover packs for residents that include sustainability information, i.e., energy-saving and water-saving measures.**

Sustainability measures within residential areas are a competitive edge for the developers responsible for building sustainable homes; as such, it would be prudent to develop handover packs with details of the EDGE status of EDGE-rated residential areas. Furthermore, the packs can have additional tips on how best to monitor water and energy savings so that implemented measures can be of tangible benefit to residents. A handover pack would ensure that residents' awareness is ignited even prior to the occupation of the residential units. Moreover, a post construction evaluation of sustainability efficiency should be encouraged to ensure residents reap and understand sustainability benefits. In conclusion, this will close the knowledge gap (general awareness, strategies of sustainable construction, post-occupancy satisfaction) in the South African construction industry.

Furthermore, as an exploratory avenue for future research, it would be interesting to conduct a study that evaluates the integration of sustainability principles in the full life cycle of the construction process in South Africa and in other parts of the world so that data on global perspectives can be collected to inform improvement strategies of uptake of the sustainable construction approach [46,47]. Future studies should also aim to quantify, using appropriate metrics, sustainability measures in construction [47].

The recommendations provided in the present study will be shared with professionals and residents of the estate, as well as the policy makers in the field of construction. A summary of the findings and recommendations will be sent via email to professionals and residents. However, for policy makers, we will request for an oral presentation during which the first author will share the key findings and recommendations.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su14084498/s1>, Table S1: Raw data collected from professionals and residents by means of questionnaires; Supplementary S1: Data analysed in the study. Supplementary S2: R script used for data analysed. Appendix S1: Questionnaires to professionals. Appendix S2: Questionnaires to Residents of the Belhar Estate.

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