ANALYSIS OF THE BENEFITS OF GREEN BUILDING IN SOUTH AFRICA

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ABSTRACT

This paper investigates the perceptions of built environment professionals with respect to the benefits of green buildings and identifies the benefits regarded as the most important to promote the adoption of green building. The primary data was collected from 106 green building-accredited professionals in both the public and private sectors who are registered with the Green Building Council of South Africa (GBCSA). Response data was subjected to descriptive and inferential statistics, namely factor analysis (FA), ANOVA test, and the paired sample test. The benefits of green buildings emanating from the findings were categorised as socio-economic, financial, and health and community benefits. The paired sample test indicated a statistically significant difference between paired samples: financial benefits, health and community benefits, and socio-economic benefits. However, the test revealed no statistically significant difference between financial benefits and socio-economic benefits. There was no statistically significant difference with respect to the perceptions of respondents concerning financial benefits and health and community benefits. It is important to note that the benefits identified in this research may be limited to the time of the research, since the opinions of people relative to green building consciousness and conditions may change over time. It is anticipated that the most significant benefits identified by built environment stakeholders will create an enabling environment to enhance the adoption of green building. Therefore the findings emanating from this study can be used as a support tool for identifying the most significant benefits that enhance the decision of stakeholders to adopt green building and to provide continuous improvement that is essential for green building to gain competitive advantage over the traditional construction methods.

Keywords: Benefits, Built environment professionals, Green building, South Africa

1. INTRODUCTION

In South Africa there is pressure to deliver green building due to environmental issues such as climate changes, the energy crisis, as well as persistent water shortages. Although awareness and promotional efforts have increased drastically concerning the adoption of green buildings, the South African industry is still lagging behind owing to the slow rate of change in the construction industry. The slow rate of adoption of green building is further attributed to misconceptions regarding the benefits of green buildings and the lack of access to cost indications. For this reason, Hwang and Tan (2012) argue that inadequate information and ambiguity relative to the benefits are major obstacles to the development and adoption of green buildings. This notion is supported by Darko et al. (2013) who maintain that there are significant knowledge and data gaps such as lack of empirical information to enable comparisons to be made between conventional and green building costs as well as detailed data with respect to the energy, water and other resource savings arising from green building, and evidence to facilitate investment in financing packages for green building.

Although previous studies (Sundayi et al., 2015; Windapo, 2014; Cruywagen, 2013) have been conducted to analyse the cost benefits of green buildings, the majority limited themselves to direct financial or economic analysis, which assessed only the financial benefits and impact of green building development. Furthermore, the South African built environment has not extensively explored or categorised the benefits of green buildings or the interdependency of the benefits in relation to adoption. The lack of comprehensive information regarding the benefits of green building has been consistently reported by various authors (Naumann et al., 2011; Häkkinen & Belloni, 2011; Kats & Capital, 2003). The lack of evidence and inconsistencies, according to Milne (2012) and Sundayi et al. (2015), are because the South African green building market has not reached enough maturity or yet gained major support from the industry stakeholders. Empirical evidence in a study by Windapo (2014) indicated, on the one hand, that operational cost savings, along with marketing potential and the ability to charge higher rents, are all considered generally important benefits. On the other hand, healthy indoor air quality is almost unanimously considered as unimportant. It is worth noting that the designers and architects in particular pointed out that increased rent and property value are not important benefits of green building (Windapo, 2014). During another study conducted by Sundayi et al. (2015), reduction in operating costs and the cost premium for green implementation were identified as the benefits having the greatest influence regarding the decision to adopt green building projects in South African. The foregoing discussion provides a clear indication of a lack of a suitable classification system for categorising the various benefits of green building in South Africa.

Therefore, the study is aimed at investigating the benefits of green buildings and identifying the benefits regarded as the most important to promote the adoption of green building. The structure of this paper summarises and presents brief discussions with regard to the extant literature relative to the benefits of green building. It provides a brief theoretical underpinning with respect to the perceived attributes of green building, including its relative advantages or benefits. This is followed by the methodological approach adopted. It is in this context that the factor analysis-based method is used in categorising the benefits of green building, followed by a discussion of the findings. The final section addresses recommendations made, conclusions, and the critical implication and contribution of the paper to knowledge.

2. LITERATURE REVIEW

2.1 Overview of the benefits of green building

Several studies (Park et al., 2014; Castleton et al., 2010; Thatcher & Milner, 2014; Wiley et al., 2010; Ashuri & Durmus-Pedini, 2010) report that green buildings have an enormous advantage over non-green building. Thus green buildings are energy efficient, emit a lesser amount of greenhouse gases, produce less waste, and enhance occupants' productivity and health as well as ensuring higher satisfaction and a lower absenteeism rate. According to Ashuri and Durmus-Pedini (2010), green building is all about promoting well-being, usually as it relates to the environment, health, and community. In addition, there are also tangible economic benefits such as the reduction of energy and water use. Green building also provides other benefits, such as market and industry benefits (Ashuri & Durmus-Pedini, 2010). Nonetheless, Kim et al. (2017) contend that these ingenious benefits come with a high price tag. Empirical evidence is a study conducted by Chegut et al. (2014) to examine the supply, demand and the value of green buildings. The study revealed that tenants occupying green office buildings pay approximately 20% more on rental premiums compared with those who lease non-green buildings (Chegut et al., 2014). Therefore, improving the availability of reliable information and knowledge relative to the benefits of green building would better inform stakeholders and the general public and help to diminish misperceptions (Darko et al., 2013). According to Khoshbakht, Gou and Dupre (2017), the accumulation of diverse cost-benefit variables is imperative for a full package of economic evaluations, and it should be communicated to various stakeholders in the green building industry. Even though the benefits are categorised as environmental, health and community, financial and economic, market, and industry, most of the categories have secondary financial benefits as well (Ashuri & Durmus-Pedini, 2010).

2.2 Environmental benefits

Various authors (Shabrin & Kashem, 2017; Darko et al., 2013; Nurick & Cattell, 2013) were of the view that green buildings' environmental benefit is well recognised. According to Darko et al. (2013), the environmental benefits associated with green building include improved air and water quality; reduced waste; conservation and restoration of natural resources, and protected biodiversity and ecosystems. Similarly, a report compiled by the US Environmental Protection Agency also revealed that green buildings enhance and protect ecosystems, improve air and water quality, decrease waste streams to air and land, and preserve and restore natural and renewable resources (USEPA, 2009). Research conducted by Shabrin and Kashem (2017) also revealed that the environmental aspect of green building is to reduce heat gain, particularly when buildings are designed and oriented to optimise the utilisation of daylight.

2.3 Financial / Economic benefits

Shabrin and Kashem (2017) report that green buildings have numerous economic benefits. The benefits range from the direct to the indirect. Firstly, the direct economic benefits comprise better a payback period for green buildings due to a low consumption of energy, water, and health cost; providing a quick return on investment, and an increase in revenue. Secondly, there is a reduction in operating costs as green building saves money through reduced energy usage, water usage and lower maintenance costs of the building. Thirdly, green buildings have higher building value as it owners and developers can earn higher rents, and enjoy higher occupancy rates than non-green buildings. On the other hand, indirect benefits are firstly, improved internal building conditions which contribute to higher productivity for occupants due to good indoor air quality and thermal comfort of the workplace; and secondly, branding and prestige since green building is a divergent product which is technologically and environmentally advanced and socially liable. Similarly, Darko et al. (2013) opine that the economic benefits of green building include reduced operating costs; the creation, expansion and shaping of markets for green products and services; enhanced productivity of occupants, and optimised economic performance over the building's lifetime. Srinivas (2009) found that green building may significantly contribute to the reduction of power consumption by 20% - 40 % and the reduction of potable water consumption by between 30% - 40%.

2.4 Social benefits

Enhanced comfort and health for occupants and being aesthetically pleasing have been identified as some of the social benefits associated with green building (Darko et al., 2013). According to Khoshbakht et al. (2017), benefits include differing savings and financial gains during building construction and after construction phases such as higher property market value, higher rents, fewer vacancies, marketing opportunities resulting from social benefits, lower carbon taxes, higher energy savings, less sick leave, and higher productivity. Shabrin and Kashem (2017) postulate that the social and community aspects of green building provide more opportunities in terms of job creation for the locals. For example, many jobs will be offered for the reason that green building is a new venture since new generations can undertake research and explore this industry.

2.5 Market and industry benefits

According to Ashuri and Durmus-Pedini (2010), green building tends to bring its own demand to the marketplace; hence, as the numbers of workers occupying green buildings surge, their greater levels of satisfaction with their work environment will prompt a demand for similar surroundings from industry peers. Consequently, this will create a positive feedback loop within the marketplace that will complement the financial, environmental and health benefits (Ashuri & Durmus-Pedini, 2010). The benefits with respect to market aspects include the creation of value within the compatible market, higher occupancy rates, fewer vacancy periods, meeting of growing demands by tenants, company recognition, and lower advertising costs (Ashuri & Durmus-Pedini, 2010). Moreover, Ashuri and Durmus-Pedini (2010) opine that the industry benefits associated with green building include creating a positive impact on the construction industry; allowing technology to become part of the green building process; improving the outcome of projects; professionals becoming more qualified, educated, and integrated; allowing openings for other countries and selling green building know-how; other industries benefitting from new opportunities apart from the building sector benefit; helping to create and increase job opportunities, and enabling eligibility for grant money.

2.6 Other benefits

It is important to note that in addition to the specific benefits, there are other benefits of green building. These benefits include opportunities for research and development in the green building field, more tax revenue for the government (Shabrin & Kashem 2017), and climate change-related benefits (USEPA, 2014). With respect to research and development, Shabrin and Kashem (2017) state that researchers will always find a way to make the necessary improvement for the building. In addition, researchers will focus on the greenhouse effect as this will cause harm to the environment in the long term. Relative to the government aspect, the job opportunities that have been offered by the green building will increase the number of employees within a particular area. The government can earn more tax revenue from the employees and corporates (Shabrin & Kashem, 2017). Regarding climate change-related benefits, green infrastructure vegetation assists in the reduction of the amount of atmospheric CO_2 through direct carbon sequestration, reductions in water and wastewater pumping and treatment and the associated energy demands, and reductions in building energy use (USEPA, 2014).

3. THEORETICAL UNDERPINNINGS: PERCEIVED ATTRIBUTES OF GREEN BUILDING

Construction innovation researchers have often noted the importance of the diffusion of innovation frameworks and models (Larsen, 2005; Koebel, 2007; Sargent et al., 2012). Innovation diffusion theory examines how the perceived attributes of the innovation, type of innovation decisions, communication channels, time, and social systems interact for the adoption of a new idea, concept or technology in a given adopter market (Mollaoglu et al., 2016). In the context of the study, the green building sector can be seen as a new adopter market. The attributes of the innovation that influence the adoption decision have been well documented in the literature. According to Dearing (2009), an attribute is a perceived characteristic of an innovation. Rogers' (1995) work suggests five central factors, namely observability, trialability, relative advantage, complexity, and compatibility. Together these attributes relate to the adopters' ability to see, touch, try, compare, and understand the innovation in their market context. An array of literature confirms the role each attribute plays in the adoption decision (Greenhalgh et al., 2004). Rogers (2003) postulates that in particular, relative advantage, simplicity, and an innovation's compatibility with a potential adopter's or organisation's norms and procedures account for considerable variance in explaining adoption decisions. The other two attributes, namely observability and trialability, are not as consistently important across innovation types for producing adoption. It is reasonable to assume that for high risk, expensive, and obtrusive innovations, trialability should be especially important whereas for complex innovations which entail many process steps and those innovations that embed high degrees of ambiguity or tacit knowledge in their operation, visibility of the innovation in process and observability of outcomes should be especially important.

Yudelson (2005) contends that of these five attributes, relative economic advantage is considered as the major driver of response to innovation such as green building. The extent of relative advantage is often expressed as economic profitability, social prestige, or other benefits (Rogers, 1995). If adoption of innovation is to be realised, then innovation typically has to make economic sense or have a business advantage over existing ones (Yudelson, 2005). However, the relative advantage of green buildings has yet to be shown in either of these markets, given the demonstrably higher investment costs and certainly higher certification costs, as well as the risks of unforeseen costs compared with conventional building (Häkkinen & Belloni, 2011). Edwards (2003) found that green buildings do pay in the long term. The benefits seem greater for long-term owner-occupants of buildings: however, it is worth noting that many of the reported and putative benefits such as increased employee productivity, reduced absenteeism, improved morale, and health and safety of the building's occupants are soft costs that are difficult to measure or evaluate (Srinivas, 2009; Furr, 2009). In similar vein, Yudelson (2005) states that anecdotal evidence of benefits is strongly in favour of green buildings, but it has not yet filtered through sufficiently to the general marketplace to overcome perceived cost hurdles. Since the green building market is project-based, it may take some time for perceived benefits to find appropriate projects for a fuller implementation. Hence the benefits of green building currently have relatively little acceptance among building owners, developers, and project financiers. In view of the current state of the market, building owners' and developers' requirements for more independent cost and performance appraisals of green buildings are important for building credibility and overcoming perceived barriers. According to "Yudelson's Law" for new products, the anticipated real benefits of the innovation must exceed the likelihood of increased costs by 25% or more to change most decisions in favour of new technologies or methods (Yudelson, 2005: 3).

4. RESEARCH METHODOLOGY

The research method for this study is explained in terms of the research measurement instrument, sampling procedure and size, data collection and analysis techniques. The aim is to investigate the benefits of green buildings and identify the benefits regarded as the most important to promote the adoption of green building in South Africa.

The study hypothesises that:

H1: There is no statistically significant difference between the mean rankings of construction and consultant team members' perceptions on the importance of benefits of green building that enhance the adoption of green building, and

H2: There is no statistically significant difference in agreement of respondents according to their professions and for all identified benefits of green building that *enhances the adoption of green building.*

4.1 Measurement instrument

The questionnaire was divided into three sections as follows:
General demographics of the respondents;
Respondents' involvement with green building, and
Respondents' opinions concerning the benefits associated with green building.

The respondents were asked to rate the benefits they perceived as important in enhancing the adoption of green building on a five-point Likert-scale (1 = minor extent, 2 = a near minor extent, 3 = to some extent, 4 = near to a major extent, and 5 = a major extent)

4.2 Sampling procedure and size

The technique of probability (simple random sampling) sampling was employed for this study. The population of the survey was limited to the green building council database for accredited green building professionals in both public and private sectors. The professionals included architects and designers, consulting engineers (electrical, civil, mechanical and structural), developers, environmental and sustainable consultants, facility managers, quantity surveyors, green building consultants, project managers, and general contractors (GCs). The sampling frame for the research was limited to four provinces given that most (99%) of the GBCSA accredited professionals were from the four provinces as indicated in Table 1.

Table 1: Sample frame of accredited GBCSA professionals from the four provinces

Province	No.	Percentage
Eastern Cape	40	3.2
Gauteng	758	60.8
KwaZulu-Natal	88	7.1
Western Cape	360	28.9
Total	1 246	100.0

Following the research population in Table 1, it would have been impossible to obtain data from all the targeted populations owing to time and cost constraints; hence, sampling is essential for the questionnaire survey to have a size that will be representative of the population being studied. To determine a suitable representative sample, the formula from Czaja and Blair (2005) was applied:

$$ss = \frac{z^2 \times p(1-p)}{c^2}$$

where:
ss = sample size
z = standardised variable
p = percentage picking a choice, expressed as a decimal
c = confidence interval, expressed as a decimal

From the above formula, the survey sample was determined to be approximately 445 built environment professionals. Based on the calculated sample size, a random selection of professionals was made from the GBCSA database to provide a list of 445 participants for the survey.

4.3 Survey administration and data collection

The targeted GBCSA professionals in the selected four provinces were invited via email to take part in the study. A web-based survey was adopted owing to the geographical spread of the professionals and firms involved in the study (Saunders et al., 2009). The survey instrument with a supplementary personalised, signed cover letter was sent to the 445 survey participants through e-mail. It is important to note that out of 445 sent e-mails, 419 (94%) were delivered and 26 (6%) were not delivered. Out of the 419 e-mails delivered to respondents, 106 were duly completed and returned using a web survey, hence an overall response rate of 25% was achieved.

4.4 Data analysis techniques

The data analysis technique comprised both descriptive and inferential statistical methods. Descriptive statistics were used to measure the central tendency such as mode, median and mean, and the dispersion (standard deviation) of the data. Inferential statistics were used to validate the data collected through the paired sample t-test and analysis of variance (ANOVA), as well as factor analysis. The Statistical Package for Social Scientists (SPSS) and Microsoft Excel for Windows were used for capturing and computing relevant analyses of the data.

5. FINDINGS AND DISCUSSION

5.1 Demographic data

This section presents an overview of the demographical data received, namely (1) qualification; (2) occupation or profession; (3) experience of respondents (4) age; (5) gender; and (6) number of green projects executed.

Highest formal qualification

Table 2 indicates the various academic qualifications within the population response group. It is important to note that approximately 83% of respondents had tertiary learning qualifications, including national diplomas (19.8%) BTech or bachelors' degrees (23.6%), BSc (Hons) degrees (21.7%), masters' degrees (17.0%), and doctoral degrees (0.9%). This suggests respondents had the relevant educational background to understand and respond appropriately to the survey. Moreover, a large portion of the sample consisted of holders of bachelors' degrees, followed by BSc (Hons) degrees and national diploma holders.

Table 2: Highest formal education achieved by respondents

Qualification	Frequency	Percentage
Matric certificate	2	1.9
National diploma	21	19.8
BTech / BSc	25	23.6
BSc (Hons)	23	21.7
MSc / MTech	18	17.0
PhD / DTech	1	0.9
Other	16	15.1
Total	106	100.0

Occupation / profession

Table 3 depicts the occupations of the respondents. The survey population included construction professionals and other stakeholders within the South African built environment. More or less equal portions of the sample consist of architects and designers (23.8%), followed by consulting engineers (22.9%) and environmental, sustainability or green building consultants (21.0%). This result has shown that the respondents surveyed represent a broad spectrum of different professions across the built environment.

Table 3: Occupation of the respondents

Occupation	Frequency	Percentage
Architects / designers	25	23.8
Consulting engineering (civil, mechanical, electrical, structural)	24	22.9
Developer / client / owners	2	1.9
Environmental / sustainable / green building consultants	22	21.0
Facility manager	7	6.7
Quantity surveyor / cost consultant	8	7.6
Project manager	17	16.2
Total	105	100.0

Experience, age and gender of respondents

Results as depicted in Table 4 indicate that the majority of respondents (41.5%) have between two to five years of experience in their current position. Most of the respondents in the construction industry have experience of over five years distributed as between six to ten years (26.4%) and over 10 years (37.7%). Regarding the age group, the majority of the respondents (32.4%) were aged between 31 and 40 years, 27.6% were aged between 25 and 30 years, and 21.0% were aged between 41 and 50 years: this suggests that the respondents were mature. With regard to gender, 64% (68) of the respondents were males and 36% (38) were females, and this suggests both genders participated in the study but were not equally represented. In addition, the descriptive analysis revealed that the majority of respondents (53.8%) have executed between two to five green building projects, and the rest as indicated by respondents are fairly evenly distributed across the groups. The results are presented in Table 4.

Table 4: Age, experience and gender of respondents

Variable	Frequency	Percentage
Experience in current position		
0 – 1 years	21	19.8
2 – 5 years	44	41.5
6 – 10 years	24	22.6
Over 10 years	17	16.1
Total	**106**	**100.0**
Experience in the construction industry		
0 – 1 years	16	15.1
2 – 5 years	22	20.8
6 – 10 years	28	26.4
Over 10 years	40	37.7
Total	**106**	**100.0**
Age group of respondent		
Under 25 years	7	6.7
25-30 years	29	27.6
31-40 years	34	32.4
41-50 years	22	21.0
51-60 years	10	9.5
Over 60 years	3	2.9
Total	**105**	**100.0**
Gender		
Male	68	64.0
Female	38	36.0
Total	**106**	**100.0**
Number of green building projects performed		
0 – 1 projects	13	16.7
2 – 5 projects	42	53.8
6 – 10 projects	11	14.1
Over 10 projects	12	15.4
Total	**78**	**100.0**

In the past have you worked or are you currently working on a green building project?

The descriptive analysis revealed that most of the respondents (78.3%) have been or are currently involved in green build projects, 20.8% answered in the negative, while 0.9% were unsure. This suggests that the majority of the respondents have hands-on experience with regard to green building.

5.3 Benefits of green building that enhance the adoption of green building

The results as shown in Table 5 indicate the extent to which the benefits associated with green buildings enhance the decision to adopt green building in terms of percentage responses in a range of 1 (minor) to 5 (major), and a MS with a minimum value of 1.00 and a maximum value of 5.00. It is evident that 27 of the 30 (90%) MSs are above the midpoint score of 3.00, which indicates that in general the respondents can be deemed to perceive that the 27 benefits associated with green buildings could influence stakeholders' decisions to a major extent as opposed to a minor extent in terms of adopting green building in the South African market. The top four out of 30 (13.3%) MSs are > 4.20 ≤ 5.00, which indicates that these benefits could influence stakeholders'decisions from a near major extent to a major extent. The hierarchy further indicates that 'green building reduces energy and water consumption' is ranked first, followed by 'reduces operational costs', 'enhances the value and profitability of assets' is ranked third, and 'reduces life cycle energy costs' is ranked fourth, which are imperative in terms of building a sound business case for the adoption of green building.

The descriptive analysis further indicates that 16 out of 30 (53.3%) MSs are > 3.40 ≤ 4.20, which indicates that the contribution of these benefits to enhancing the adoption of green building can be deemed to be between some extent to a near major extent. 'Company recognition', 'higher occupancy rate', 'creating value within the compactible market', and 'meeting growing demands by tenants' ranked fifth, ninth, twelfth, and fourteenth respectively: all are market-related benefits that can influence the adoption of green building. 'Optimises life cycle economic performance', 'higher rental growth', and 'longer economic life of the facility' ranked sixth, sixteenth, and nineteenth respectively: all are financial-related benefits that augment the adoption of green building. The benefits 'enhances occupant comfort and health', 'improves water and indoor air quality', and 'improves employee productivity and satisfaction', are ranked seventh, eighth, and tenth respectively. In addition, 'lowers greenhouse gas emissions', 'contributes to the overall quality of life', and 'improves thermal, daylight and acoustic environments', ranked eleventh, thirteenth, and fifteenth respectively. Furthermore, 'conserves natural resources', 'enhances and protects the eco-system' and 'reduces solid waste' are ranked seventeenth, eighteenth, and twentieth respectively, and are all environmental-related benefits that promote the adoption of green building. 'Longer economic life of the facility', which is ranked nineteenth, is primarily a financial-related benefit.

Table 5: Relative advantages / benefits of green buildings

Benefit	Unsure	Response (%) Minor...				...Major	MS	SD	Rank
		1	2	3	4	5			
Reduces energy and water consumption	1.9	0.0	0.0	4.7	23.6	69.8	4.58	0.85	1
Reduces operational costs	1.9	0.0	3.8	8.5	22.6	63.2	4.40	1.01	2
Enhances the value and profitability of assets	2.8	0.0	0.9	10.4	31.1	54.7	4.31	1.03	3
Reduces life cycle energy costs	4.7	0.9	2.8	11.3	20.8	59.4	4.21	1.28	4

Company recognition	1.9	0.9	0.9	13.2	37.7	45.3	4.20	0.99	5
Optimises life cycle economic performance	1.9	1.9	4.7	16.0	33.0	42.5	4.04	1.12	6
Enhances occupant comfort and health	1.9	0.0	9.4	14.2	34.9	39.6	3.99	1.11	7
Improves water and indoor air quality	1.9	0.9	5.7	18.9	34.9	37.7	3.97	1.09	8
Higher occupancy rate	4.7	0.0	2.8	19.8	33.0	39.6	3.95	1.21	9
Improves employee productivity and satisfaction	2.8	0.0	6.6	18.9	34.0	37.7	3.94	1.14	10
Lowers greenhouse gas emissions	1.9	2.8	9.4	17.0	30.2	38.7	3.87	1.22	11
Creates value within the compactible market	6.6	0.0	2.8	17.0	39.6	34.0	3.85	1.29	12
Contributes to the overall quality of life	1.9	0.0	10.4	18.9	40.6	28.3	3.81	1.08	13
Meets growing demands by tenants	4.7	0.0	6.6	20.8	34.0	34.0	3.81	1.24	14
Improves thermal, daylight and acoustic environments	2.8	1.9	7.5	23.6	28.3	35.8	3.80	1.22	15
Higher rental growth	10.4	1.9	5.7	5.7	32.1	44.3	3.80	1.59	16
Conserves natural resources	0.9	5.7	9.4	23.6	25.5	34.9	3.72	1.25	17
Enhances and protects the eco-system	1.9	3.8	11.3	24.5	23.6	34.9	3.69	1.27	18
Longer economic life of the facility	4.7	4.7	8.5	18.9	30.2	33.0	3.64	1.39	19
Reduces solid waste	4.7	4.7	11.3	27.4	17.0	34.9	3.52	1.43	20
Positive impact on the construction industry	2.8	7.5	17.0	23.6	28.3	20.8	3.29	1.33	21
Reduction in the cost of refurbishment	10.4	6.6	13.2	18.9	21.7	29.2	3.23	1.64	22
Allows professionals to become more qualified, educated, and integrated	4.7	9.4	14.2	26.4	23.6	21.7	3.20	1.42	23
Lowers health-related costs such as insurance premiums	7.5	7.5	17.0	26.4	15.1	26.4	3.13	1.54	24
Reduction in property taxes and insurance rates	14.2	9.40	11.3	17.0	17.0	31.1	3.07	1.79	25
Helps to create job opportunities in the construction industry	7.5	10.4	14.2	27.4	21.7	18.9	3.02	1.49	26
Helps other industries to benefit from new opportunities	5.7	12.3	15.1	26.4	24.5	16.0	3.00	1.43	27
Creates collaboration between other countries and selling green building know-how	5.7	12.3	19.8	19.8	27.4	15.1	2.96	1.45	28
Lowers litigation risks because of improved indoor air quality	12.3	19.8	13.2	17.0	13.2	24.5	2.73	1.76	29
Lowers advertising costs	13.2	13.2	17.9	22.6	19.8	13.2	2.62	1.58	30

The remaining 10 out of 30 (33.3%) MSs are > 2.60 ≤ 3.40, indicating that respondents' agreement can be deemed to be between a near minor extent to some extent and some extent for the following benefits: 'positive impact on the construction industry'; 'reduction in the cost of refurbishment'; 'allows professionals to become more qualified, educated, and integrated'; 'lowers health-related costs such as insurance premiums'; 'reduction in property taxes and insurance rates'; 'helps to create job opportunities in the construction industry'; 'helps other industries to benefit from new opportunities'; 'creates collaboration between other countries and selling green building know-how'; 'lowers litigation risks because of improved indoor air quality', and 'lowers advertising costs'.

5.4 Identifying the underlying structure of benefits of green building using factor analysis

In total, 30 benefits of green building were evaluated in the study. To condense the number of variables to enable subsequent analyses, and also to test the factor structure of the 30 benefits associated with green building, factor analysis was undertaken. It was also an opportunity to assess the convergent and discriminant validity of the benefits. A principal component analysis (PCA) was adopted as the method of extraction. To extract the underlying components, all thirty items pertaining to benefits of green building loaded together on this factor and Kaiser's criterion using eigenvalues was adopted. Oblimin rotation was used to extract the variables that load on each identifiable component. Prior to performing PCA, the Kaiser-Meyer-Olkin test and Bartlett's test of sphericity were conducted to assess the suitability of data for factor analysis. These two statistical measures provide the minimum standard that the data should meet to be considered adequate for factor analysis. Pallant (2012) and Tabachnick and Fidell (2012) maintain that the value of the KMO ranges between 0 and 1, with 0.60 suggested as the minimum value for good factor analysis. The Bartlett test indicates the strength of the relationship among variables and a significant level of Bartlett's test is a requirement for the data to be considered suitable for analysis. The level of significance for Bartlett's test should be $p<0.05$ for FA to be considered appropriate (Field, 2013). The dataset was suitable as the KMO value was 0.899, exceeding the recommended value of 0.6 and Bartlett's test of sphericity was statistically significant at $p=0.000$ ($p<0.05$). The PCA uncovered five components under this category with eigenvalues greater than 1, and the five factors accounted for 73.45% of the total variance of the thirty benefit criteria. A careful assessment of the scree plot revealed a clear break after the fifth component. The Monte Carlo PCA for parallel analysis was performed to ascertain which components to retain. The result of the parallel analysis is presented in Table 7. The criterion eigenvalues of the first five components are 12.868, 3.698, 2.472, 1.679 and 1.319. On the other hand, the corresponding random eigenvalues obtained from the parallel analysis are 2.1578, 1.9792, 1.8439, 1.7296 and 1.6350 for components 1,2,3,4 and component 5 respectively. It is apparent in Table 6 that only three components could be retained since their eigenvalues are greater than the parallel analysis randomly generated eigenvalues. However, it should be noted that the fourth and fifth components are rejected, given that their eigenvalues are less than the random eigenvalues of the parallel analysis.

Table 6: Comparison of PCA eigenvalue with parallel analysis eigenvalue

Component number	Actual eigenvalue from PCA	Random eigenvalue from parallel analysis	Decision
1	12.868	2.1578	accept
2	3.698	1.9792	accept
3	2.472	1.8439	accept
4	1.679	1.7296	Reject
5	1.319	1.6350	Reject

Hence three components were retained based on the results of the parallel analysis. For this reason, the three-component solution was accepted and the analysis was re-run extracting three components. These three components extracted accounted for 63.458 % of the total variance in the 30 dimensions of benefits associated with green building. The Oblimin rotation was adopted to aid in the interpretation of these three components. The results as depicted in Table 7 revealed the three components showing a number of loadings above 0.3 on both pattern matrix and structure matrix on the three components. The communalities values as shown in Table 7 also indicate that the variables fit well into the component with all the variables having above 0.3, which indicates that there was a positive correlation between the three components. Considering the loading pattern of benefits of green building, the variables that converge on component 1 represent 'socio-economic benefits', on component 2 represent 'financial benefits' and component 3 was named 'health and community benefits'.

Table 7: Pattern and structure matrix for benefits of green building

Variables	Pattern Matrix Coefficient Component			Structure Matrix Coefficient & Component			Communalities
	1	2	3	1	2	3	
MB8 - Creates collaboration between other countries & selling green building know-how	.816			.830		.372	.663
MB6 - Positive impact on the construction industry	.812			.830	.392	.301	.671
EB6 - Conserves natural resources	.810			.823		.357	.702
EB1 - Enhances and protects the eco-system	.800			.819			.609
MB9 - Helps other industries to benefit from new opportunities	.791			.801			.722
MB7 - Allows professionals to become more qualified, educated, and integrated	.787			.778			.686
EB4 - Lowers greenhouse gas emissions	.706			.768	.420	.409	.560
MB10 - Helps to create job opportunities in the construction industry	.688	.301		.750	.466		.642
EB5 - Reduces solid waste	.675			.741		.701	.650

EB2 - Improves water and indoor air quality	.618		.385	.737		.364	.648
EB9 -Contributes to the overall quality of life	.589		.538	.725		.568	.788
FB7 - Reduction in property taxes and insurance rates		.872		.302	.871		.770
FB8 - Higher rental growth		.829			.828	.333	.711
FB10 - Lowers litigation risks because of improved indoor air quality	.468	.690		.602	.770		.779
FB6- Longer economic life of the facility		.671		.495	.768	.396	.654
FB5- Lowers health-related costs such as insurance premiums		.665		.344	.767	.474	.687
MB2 - Higher occupancy rate		.635	.360		.718	.519	.622
FB9 -Reduction in the cost of refurbishment	.312	.613		.479	.700	.320	.584
MB5 - Lowers advertising costs	.486	.534		.582	.621		.588
MB3 - Meets growing demands by tenants		.489	.351		.601	.506	.472
FB1 - Reduces operational costs		.338	.720		.525	.772	.705
EB3 - Reduces energy & water consumption			.714	.689		.762	.504
FB3 - Enhances the value and profitability of assets		.465	.653	.363	.544	.757	.747
FB4 - Optimises life cycle economic performance		.327	.632		.629	.743	.678
EB8 - Enhances occupant comfort & health	.507		.630	.586		.714	.802
EB10 - Improves employee productivity and satisfaction	.336		.623	.518		.698	.588
EB7 - Improves thermal, daylight and acoustic environments	.404		.610			.688	.651
FB2 - Reduces life cycle energy costs			.568	.325	.483	.678	.541
MB1 - Creates value within the compactible market			.521			.547	.313
MB4 - Company recognition			.425		.348	.508	.300

Factor 1 - Socio-economic benefits: Based on the inter-correlation, eleven benefits related to socio-economic benefits should be consolidated into an underlying factor. These include 'creates collaboration between other countries and selling green building know-how'; 'positive impact on the construction industry'; 'conserves natural resources'; 'enhances and protects the eco-system'; 'helps other industries to benefit from new opportunities'; 'allows professionals to become more qualified, educated, and integrated'; 'lowers greenhouse gas emissions'; 'help to create job opportunities in the construction industry'; 'reduces solid waste'; 'improves water and indoor air quality', and 'contributes to the overall quality of life'. These findings are related to the normative literature reported by Darko et al. (2013), Khoshbakht et al. (2017) and Shabrin and Kashem (2017).

Factor 2 - Financial benefits: The financial benefits include nine factors: ‘Reduction in property taxes and insurance rates’; ‘higher rental growth’; ‘lowers litigation risks because of improved indoor air quality’; ‘longer economic life of the facility’; ‘lowers health-related costs such as insurance premiums’; ‘higher occupancy rate’; ‘reduction in the cost of refurbishment’; ‘lowers advertising costs’, and ‘meets growing demands by tenants’. These findings are supported by those of Shabrin and Kashem (2017), Srinivas (2009) and Darko et al. (2013).

Factor 3 - Health and community benefits: ‘Reduces operational costs’, ‘reduces energy and water consumption’, ‘enhances the value and profitability of assets’, ‘optimises life-cycle economic performance’, ‘enhances occupant comfort and health’, ‘improves employee productivity and satisfaction’, ‘improves thermal, daylight and acoustic environments’, ‘reduces life cycle energy costs’, ‘creates value within the compatible market’, and ‘company recognition’ were grouped under the aforementioned factor based on the analysis. These findings are consistent with the findings of previous studies related to health and community benefits (Yudelson, 2008).

5.5 Perception with respect to the importance of the benefits of green building

H1: Ranking the importance of the benefits of green building

A paired sample test was performed to test the following hypothesis:
H1: There is no statistically significant difference between the mean rankings of construction and consultant team members’ perceptions on the importance of benefits of green building that enhance the adoption of green building.
Prior to performing the paired T-test, the test of reliability of scale of benefits of green building was undertaken. Table 8 presents the results of the test of reliability for benefits of green building that enhance the adoption of green building. It is worthy to note that the study produced highly reliable measures ranging from 0.89 to 0.941.

Table 8: Test of reliability of benefits of green building

Factors	Number of items	Cronbach’s alpha coefficient	Comments
Socio-economic benefits	11	0.941	Highly reliable
Financial benefits	9	0.916	Highly reliable
Health and community benefits	10	0.890	Highly reliable

Test of mean ranking and paired sample test on benefits of green building

Table 9 depicts the hierarchical ranking of the importance of the benefits of green building that enhance the adoption of green building. It is evident that 'health and community benefits' had the highest mean score of 4.13. In addition, a paired sample statistic test was performed to assess the statistical significance difference between the perceived benefits of green building and the effect of size. It is evident from Table 10 that a statistically significant difference between the following paired samples was revealed: financial benefits and health and community benefits, and health and community benefits and socio-economic benefits since p= 0.000. On the other hand, the analysis revealed no statistically significant difference between financial benefits and socio-economic benefits. The eta squared ranged from small (0.01) to large size effect (0.42). The significance difference between financial benefits and health and community benefits, and health and community benefits and socio-economic benefits is a signal that something is operating below the surface of the statistic and merits further attention and investigation (Leedy & Ormrod, 2010). Therefore, the null hypothesis stating that there is no significant difference between the mean rankings of built environment professional's perception regarding the benefits of green building can either be accepted or rejected.

Table 9: Benefits of green building

Benefits of green building	No	Mean	SD	Rank
Health and community benefits	106	4.1311	0.78708	1
Socio-economic benefits	106	3.4588	1.04796	2
Financial benefits	106	3.3312	1.19069	3

Table 10: Paired sample test on attributes of adopters

		Paired Differences								
					95% CI of the Difference					Eta squared
		Mean	Std. Dev.	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)	
Pair 1	FB - HCB	-0.800	0.946	0.092	-0.982	-0.618	-8.707	105	.000	0.42
Pair 2	FB - SEB	-0.128	1.065	0.103	-0.333	0.077	-1.234	105	.220	0.01
Pair 3	HCB - SEB	0.672	0.851	0.083	0.508	0.836	8.137	105	.000	0.39

Keys: FB: Financial benefit; HCB: Health and community benefits; SEB: Socio-economic benefit

H2: Discussions with regard to agreement of built environment professionals and benefits of green building

The one-way between-groups ANOVA was carried out to examine the following hypothesis:

H2: There is no statistically significant difference in agreement of respondents according to their professions and for all identified benefits of green building that enhance the adoption of green building.

Table 11 presents a summary of the ANOVA test relative to the agreement of respondents according to their professions and the benefits of green building. It is imperative to note that there is a statistically significant difference across the different built environment professionals regarding socio-economic benefits. A post-hoc test was deemed necessary to establish the difference in perceptions amongst the different built environment professionals concerning the social-economic benefits of green building. In the results presented in Table 12, post-hoc comparisons using the Tamhane test indicate that only consulting engineers and facility managers are statistically significantly different from each another. In effect, consulting engineers' and facility managers' perceptions in terms of the socio-economic benefits differ significantly. However, there was no statistically significant difference in the agreement of respondents according to their professions and financial and health and community benefits since the significance level is $p>0.05$. Therefore, the null hypothesis stating that there is no statistically significant difference in the agreement of respondents according to their professions and for all identified benefits of green building that enhance the adoption of green building is partially supported.

Table 11: ANOVA on Built environment professionals and benefit of green building

	Due to different professional backgrounds				
Benefits	Sum of Squares	df	Mean Square	F	Sig.
Socio-economic benefits					
Between groups	15.108	6	2.518	2.509	0.027
Within groups	98.339	98	1.003		
Total	113.447	104			
Financial benefits					
Between groups	16.340	6	2.723	2.021	0.070
Within groups	132.072	98	1.348		
Total	148.412	104			
Health and community benefits					
Between groups	7.399	6	1.233	2.101	0.060
Within groups	57.511	98	.587		
Total	64.910	104			

Table 12: Tamhane post-hoc test on built environment professionals' perceptions and socio-economic benefits

(I) To which category do you belong?	(J) To which category do you belong?	Mean Diff. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Consulting engineering (mechanical, electrical, civil, structural)	Architects / designers	-0.310	0.300	1.000	-1.275	0.655
	Developer / client / owners	-1.712	0.287	0.279	-5.366	1.941
	Environmental / sustainable / green building consultants	-0.348	0.265	0.990	-1.203	0.506
	Facility manager	-1.225*	0.302	0.030	-2.364	-0.087
	quantity surveyor / cost consultant	-0.064	0.528	1.000	-2.281	2.152
	project manager	-0.736	0.267	0.176	-1.608	0.136
	project manager	0.976	0.304	0.638	-1.829	3.780
Facility manager	Architects / designers	.915	0.346	0.290	-0.296	2.125
	Consulting engineering (mechanical, electrical, civil, structural)	1.225*	0.302	0.030	0.087	2.364
	Developer / client / owners	-0.487	0.335	0.995	-2.857	1.883
	Environmental / sustainable / green building consultants	.877	0.317	0.267	-0.282	2.035
	Quantity surveyor / cost consultant	1.161	0.556	0.745	-1.064	3.386
	Project manager	0.489	0.318	0.964	-0.679	1.658

*. The mean difference is significant at the 0.05 level.

6. PRACTICAL IMPLICATIONS AND CONTRIBUTION TO THE BODY OF KNOWLEDGE

Green building represents a different kind of construction practice, hence in addressing the changes in built environment, stakeholders require new techniques to understand and promote its adoption. The adoption of green building projects not only involves a change in mind-set and the kinds of practices employed but also involves changes for built environment stakeholders. It is important to note that if green building remains a niche area, the detrimental environmental effects of building construction will not be sufficiently reduced. Compared to previous empirical studies in the South African context, the knowledge gap included the lack of evidence in terms of a suitable system for categorising the benefits of green building. Furthermore, the statistically significant differences concerning the perceptions of built environment professionals regarding the mean rankings of the benefits that enhance the adoption of green building are not evident.

Thus, this research has contributed to existing knowledge by developing a suitable system for categorising the benefits of green building which can be valuable in bringing green building into the mainstream as the non-availability of such a system is a major barrier in the growth of the green building movement. Therefore, the findings emanating from this study can be used as a support tool for identifying the most significant benefits that enhance the decision of stakeholders to adopt green building and to provide continuous improvement that is essential for green building to gain competitive advantage over the traditional construction methods. The categorisation system for the benefits of green building has considerable potential to broaden the understanding of stakeholders who engage in green building and to accelerate the implementation of the green building concept in construction. Moreover, clients or developers and other built environment stakeholders should not overlook the relative advantages of green building such as health and community benefits, socio-economic benefits and most importantly, financial benefits in terms of adopting green building.

7. CONCLUSION AND RECOMMENDATION

The aim of the study was to investigate the benefits of green buildings and identify which benefit is regarded as the most important to promote the adoption of green building. In total, 30 benefits were evaluated in the study. The descriptive statistic revealed that out the 30 factors identified, 27 had mean scores above the midpoint score of 3.00. This implies that these factors will contribute to more of a major as opposed to a minor extent in influencing stakeholders' decision to adopt green building. Further analysis of the results was conducted using PCA. Based on the PCA results, the benefits were categorised as 'socio-economic', 'financial', and 'health and community benefits'. A paired sample test was performed to ascertain whether there is any statistically significant difference between the mean rankings of construction and consultant team members' perceptions with respect to the importance of the benefits of green building. The paired sample test indicated a statistically significant difference between paired samples: financial benefits and health and community benefits, and health and community benefits and socio-economic benefits. On the other hand, the analysis revealed no statistically significant difference between financial benefits and socio-economic benefits. As such, the hypothesis stating that there is no significant difference between the mean rankings of built environment professional's perception regarding the benefits of green building can either be accepted or rejected.

The one-way between-groups ANOVA was carried out to examine whether there is any statistically significant difference in the agreement of respondents according to their professions and for all identified benefits of green building. There are no statistically significant differences in the perception of financial benefits and health and community benefits necessary to enhance the adoption of green building among the different groups. This implies that construction professionals within the South African built environment, irrespective of the sector (clients, consultants or contractors) where they work, generally have similar opinions regarding the financial, and health and community benefits influencing the adoption of green building. But the statistical analysis revealed a statistically significant difference across the different built environment professionals regarding the socio-economic benefits. As such, the hypothesis that there is no statistically significant difference in agreement of respondents according to their professions and for all identified benefits of green building is partially supported.

Based on the findings of this study discussed in the aforementioned sections, it is recommended that further studies should focus on the following:

To investigate and identify professionals' perception of the importance of performance indicators for assessing or measuring the benefits of green building;

To test the statistically significant difference between groups based on adopter categories and the benefits of green building; and

To evaluate the actual post-occupancy performance of the buildings with the purpose of comparing actual operating data of green-rated buildings to the other buildings (e.g. 4 star versus 5 star) as well as non-green buildings.

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