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A principal component analysis of regulatory environment features for sustainable building construction in South Africa

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ABSTRACT
Policies, legal frameworks, standards, and regulations referred to as the regulatory environment are linked to sustainable building construction (SBC) implementation. There have been contentions in the literature as to whether the regulatory environment features should be voluntary or mandatory for SBC adoption. Scholars also suggest that they should be tailored to suit the national context. This paper focuses on exploring the regulatory environment features for the effective implementation of SBC in South Africa. The primary research data was collected with a structured questionnaire from 281 built environment professionals, predominantly in the Gauteng Province of South Africa. The data was analysed with descriptive and inferential statistics. The Statistical Package for Social Sciences (SPSS) software version 29 was used to produce the results. Mean and standard deviation were used to rank the factors, while the data reduction technique was used to ascertain the principal regulatory environment features. Data suitability for factor analysis was assessed using the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity. Two constructs of RGE features, namely Compulsory enforcement and assessment, and National green building policies and standards, were developed from the PCA with factor loadings of the constituent variables ranging from 0.649 - 0.918. The Cronbach Alpha coefficient was used to assess the reliability of each construct, and the results were 0.904 and 0.818, respectively. The study showed that the significance of RGE features is widely acknowledged by professionals who participated in the study. The findings added to knowledge by confirming two fundamental factors for the regulatory environment. The study recommends that these factors be adequately considered for the effective implementation of SBC in South Africa.

Keywords: Regulatory environment, Sustainable building construction, Principal component analysis, South Africa

1. INTRODUCTION
Sustainability is one of the leading concepts in the 21st century, which influences and is influenced by the construction industry. The increasing global population and the expansion of urbanisation necessitate an increase in building construction. Similarly, the need to combat global warming and the climatic changes that the world is experiencing necessitates action toward sustainability (Shawkat et al., 2018). Despite the contributions of the construction industry, it still poses a significant threat and deleterious effects on the climate, environment, human health, and national economies (Zhang et al., 2011). Hence, sustainable building construction (SBC) provides an answer to mitigate the environmental negative impacts associated with building construction and ensure that social and economic objectives are met (Häkkinen et al., 2016; Krizmane et al., 2016).

According to Häkkinen et al. (2016:651), "sustainable building aims at the required building performance with minimum adverse environmental impact while encouraging improvements in economic, social, and cultural circumstances". Hence, the term "sustainable building construction" (SBC) can be defined as the construction of buildings in a sustainable and green way (Tabassi et al., 2016). Effective construction of sustainable buildings is linked with regulatory features such as policies, standards, regulations, legal frameworks etc (Wong et al., 2016; Wang et al., 2018). However, the regulatory environment associated with SBC is still lagging in many countries. Issues surrounding regulation/legislation have been recognised in various countries globally, especially in developing countries, by scholars who focused on barriers to SBC implementation. For instance, insufficient legislation was found in Malaysia by Samari et al. (2013), in Indonesia by Susanti et al. (2019), and in Brazil by De Souza Dutra et al. (2017). Besides, Aghimien et al. (2019) and Osuizugbo et al. (2020) identified a lack of legislation and policies as a critical barrier in Nigeria. It was also identified by Ametepey et al. (2015) as a critical roadblock to the effective implementation of SBC in Ghana. Although regulations regarding green building and adoption have improved in South Africa compared to other African countries, SBC is still not at an adequate level (Windapo and Goulding, 2015; Onuoha and Okeahialam, 2018; Owoha, 2019). There remain significant challenges associated with SBC.

Windapo and Goulding (2015), in their study to understand the gap between green building and legislation requirements in South Africa, found that non-compliance with policies is one of the critical problems. According to Windapo and Goulding (2015), the implementation of green practices (per se) has been "behind" legislation enacted to regulate the design and construction of green buildings. Similarly, Saad (2016), on the impediments to implementing green buildings in South Africa, found that the lack of effective enforcement, knowledge and awareness of sustainable principles and the high cost of implementing sustainable practices are prevalent. Marsh et al. (2021) also identified a lack of knowledge and awareness of sustainable construction principles and benefits and perceived high cost of implementation as critical barriers to adoption in South Africa among construction stakeholders. This suggests the need for a legislative mandate that will ensure effective enforcement, integrate environmental studies in construction, and issue financial incentives for companies that prioritise SBC (Otali and Oladokun, 2018; Windapo and Machaka, 2018). Also, Agyepong and Nhamo (2017), who focused on the perspective of legislative provisions for green procurement in South Africa, found that lack of legal mandate and non-compliance with policies were critical barriers. Noncompliance with policies was also identified by Naicker (2018) and Aigbavboa and Thwala (2019) as a critical barrier to SBC implementation in South Africa. Additionally, there has been a contention about whether legislation regarding SBC should be mandatory or voluntary for effective implementation (Yang and Zhang, 2012; Zhai, 2014). Considering the mentioned barriers associated with the regulatory environment globally and in South Africa, the current study seeks to explore the critical features that will curb these challenges to ensure that SBC is effectively implemented. Notably, no study has explored the principal factors associated with regulatory environment features in the South African construction industry. Hence, this study fills this gap by using the principal component analysis technique to reveal the principal regulatory environment features for the effective implementation of SBC in South Africa.

2. LITERATURE REVIEW

2.1 Regulatory environment for SBC

This can be referred to as requirements, legislations, standards, policies, and regulations (Ogunsanya, 2018) influencing the practice of sustainable building construction. Many authors believe that the regulatory environment is one of the most significant facilitators of the implementation of sustainable principles in construction (Diabat and Govindan, 2011;

Strandberg, 2012; Serpell et al., 2013; Wong et al., 2016; Wang et al., 2018). Therefore, adequate attention to the regulatory environment features is required, especially in developing countries and South Africa, to ensure that sustainable construction principles are rapidly implemented (Onuoha and Okeahialam, 2018). This is because the lack of instituting/adopting government policies, building codes, and regulations for the conscious promotion of sustainable construction is predominant in developing countries (Ayarkwa et al., 2017; Wang et al., 2018). Onuoha and Okeahialam (2018) assert that the government should participate in instituting policies and legislation that will encourage sustainable building construction practices. They also assert that the government should be the driver for sustainable development than any other sector (Onuoha and Okeahialam, 2018). Serpell et al. (2013) suggest that governmental policies, including company tax reduction incentives, should be initiated, especially in developing countries, to enhance their level of investment in sustainable construction. They further indicate that this initiative will help curb the perception of higher costs, a significant hindrance to sustainable building (Serpell et al., 2013). This position is also consistent with Wang et al. (2018), as they mentioned that the lack of legal framework for green specifications, governmental regulations, and incentives for green adoption are critical barriers to sustainable construction.

Manoliadis et al. (2006) posit that the legislative framework should be modified to include environmental studies, urban development in building construction and quality, and eco-labelling standards to help the entire cycle towards sustainability. Wang et al. (2018) avow that legislation regarding building green should be mandatory if green specifications and sustainable principles should be adhered to. This position is supported by many scholars (Diabat and Govindan, 2011; Yang and Zhang, 2012; Zhai, 2014) who contend that compulsory environmental policies and regulations are of most extreme significance to the fruitful implementation of green procurement. Other scholars also affirm that reliable methods to improve sustainable construction and green procurement include establishing standards, assessment measures and specifications (Diabat and Govindan, 2011; Strandberg, 2012; Wong et al., 2016).

DuBose, Bosch, and Pearce (2007) mentioned certifications and rating systems such as LEED or the equivalent for ensuring adequate implementation of sustainable principles. Arif et al. (2009) suggest that there should be a more unified regulatory framework between states and federal laws, as some states have more stringent regulations than others. Abidin and Powmya (2014) state that the rules regarding environmental protection and the green concept should be made compulsory at the municipal level. For instance, green belts or plantation areas should be provided for new construction works (Abidin and Powmya, 2014). Abiding and Powmya (2014) also enlisted tax breaks as measures the government needs to establish for building green.

Generally, the options regarding the efficacy of a policy rely on many components explicit to the context of implementation, for example, inter-alia, the degree of experiential knowledge and expertise regarding green building in that context, as well as the structure and culture of the company in which the programs are to be implemented (DuBose et al., 2007).

2.2 Sustainable building construction in South Africa

The South African construction industry is one of the leading contributors to the nation's GDP (Pillay and Mafini, 2017; Statistics South Africa, 2019). However, the construction sector activities in South Africa are not without an effect on the environment and natural resources. There is pressure to deliver green buildings in South Africa, considering the challenges such as climate change, the energy crisis, and ongoing water shortages (Simpeh and Smallwood, 2018). Building construction at least leads to 23% of greenhouse gas (GHG) emissions, while emissions from its material production account for 18mtCO2 annually, accounting for about 4% of the total CO2 emissions (Simpeh and Smallwood, 2020). Similarly, according to the Department of Science and Technology (DST) (2014), about 23% of the electricity in South Africa is consumed in buildings, while an additional 5% is used to manufacture construction products. Building construction operations also contribute to waste generation and landfill disposal (Aboginije et al., 2020). Solid waste production is estimated to be 42 million cubic meters yearly in South Africa, with most of this waste produced in Gauteng province (Simelane and Mohee, 2012; Nkosi and Muzenda, 2013; Aboginije et al., 2020).

Although there is a great need to adopt sustainable building construction in South Africa, it has not received sufficient attention in practice compared to developed countries like the USA, UK, Singapore, Australia etc. (Simpeh and Smallwood, 2020). The South African construction industry is still slow in adopting green and sustainable building principles (Simpeh and Smallwood, 2020). Also, adoption is still in the infancy stage among property developers and clients compared to developed countries (Masia et al., 2020). Nevertheless, there has been an improvement in awareness creation and the embrace of green building guidelines compared to other developing African countries.

South Africa is currently the only country in Africa with a green building council that is a fully certified member of the World Green Building Council and has fully adopted a sustainable building assessment tool (GBCSA, 2017a). The Green Building Council of South Africa (GBCSA) was established in 2007 to work with its membership community to transform the built environment for people and the planet to thrive (Nurick and Cattell, 2013; GBCSA, 2017). The goal is to ensure that buildings and homes are designed, built and operated environmentally sustainably (GBCSA, 2017a). To achieve this, the council adopted the Green Star assessment tool launched in 2002 by the Green Building Council of Australia (GBCA). However, the GBCSA adopted it in 2009 and named it Green Star SA (Hoffman et al., 2020). The Green Star assessment is based on nine distinct areas, each with a range of credits that address environmental and sustainability issues related to building design, construction, and use (GBCSA, 2017b; Green Star SA, 2022). The rating tools assess the building performance of new buildings and major refurbishments, existing buildings, interiors, etc. (GBCSA, 2017). Other rating tools certified by the GBCSA associated with Green Star SA include Net Zero, Energy Water Performance (EWP), Excellence in Design for Greater Efficiencies (EDGE), and EDGE Residential (GBCSA, 2017c).

Similarly, other regulatory environment features apart from the GBCSA standards/rating systems can directly/indirectly add to SBC implementation in South Africa. A typical example is the Department of Public Works' green building policy. The Department of Public Works (DPW) provides leadership and practice concerning green buildings in the public and private sectors (DPW Green Building Policy, n.d.). DPW is the custodian of all immovable assets vested in the national government, which are not otherwise vested in the custodianship of other departments through legislation (DPW Green Building Policy, n.d:4). Hence, DPW through its green building unit (established in 2015) launched the Green Building Policy in 2018 in Cape town (DPW, 2023). The policy aims to provide leadership in the sustainable buildings sector, primarily green buildings (DPW Green Building Policy, n.d.; DPW, 2023). "The principles of the green building policy include Leadership; Energy, water and waste management; Indoor environmental quality and comfort; Product and materials management; Promotion of indigenous knowledge systems; Acceptable horticulture and landscaping construction practices; Green procurement; Monitoring and reporting." (DPW, n.d:5). By implementing the Green Building Policy, "DPW will support sustainable development within South Africa; job creation and the development of green jobs; the development of improved working and living conditions; and the development of cost-effective solutions and the efficient use of resources during the life of buildings" (DPW Green Building Policy, n.d:19).

The DPW green building policy is not isolated but also works together with other regulations and standards that promote, support, or implement green building practices, such as GBCSA (Green Star), National Building Regulations and Buildings Standards Act 103 of

1977, National Environmental Management Act (NEMA) 107 of 1998 etc. (Windapo and Goulding, 2015; Aboginije et al., 2020).

3. RESEARCH METHODOLOGY

The study adopted a quantitative research approach to assess the regulatory environment features to implement sustainable building construction in South Africa effectively. Hence, the research paradigm centred on positivist philosophy. The assumption was that certain regulatory environment features influence SBC implementation. Literature was reviewed from journals, published conference papers, and internet sources, which served as secondary data. Similarly, primary data was collected with a structured questionnaire.

The questionnaire was categorised into two sections. Section A comprised demographic data like educational qualification, professional background, project role, and industrial experience. Section B comprised the regulatory environment (RGE) features for SBC implementation. Respondents were asked to indicate the extent to which the RGE features influence sustainable building construction (SBC) implementation in South Africa. A 5-point Likert scale ranging from 1 to 5 (No extent to Very high extent) was used to elicit their responses.

The questionnaire was distributed to the built environment professionals with a background in project management, construction management, architecture, quantity surveying, engineering and town and regional/urban planning who are knowledgeable and can provide information to address the research topic. Before questionnaire circulation, necessary checks for sample size determination were done (Pallant, 2020). Ideally, a minimum of 150 respondents is sufficient for the factor analysis (Pallant, 2020). However, 400 questionnaires were circulated. This was because the authors intended to model the features in subsequent studies. For structural equation modelling (SEM), several authors proposed a sample size of at least 200 (Kline, 2010; Bagozzi and Yi, 2012; Oke et al., 2012) and a maximum of 400 for a population of 5000 or more (Neuman, 2014; Leedy and Ormrod, 2016; Ametepey, 2019). According to Statista (2023), the total number of construction practitioners in the Gauteng province of South Africa is approximately 333,000. Considering that the study population is more than 5,000 (Statista, 2023), 400 questionnaires were circulated with 281 valid responses. Therefore, the sample size met the criteria for the analysis and was less susceptible to generating negative results.

The convenience sampling technique was adopted to ensure that the sampling size effectively represented the study population. Considerations included the nature of the research, time frame, and availability of the relevant respondents whose characteristics, knowledge and experience were required and willing to participate (Creswell and Clark, 2011; Etikan et al., 2016).

The Statistical Package for Social Sciences (SPSS) version 29 software was used to produce the results. Descriptive statistics with mean and standard deviation were utilised as outputs to rank the factors. Likewise, exploratory factor analysis (EFA) was employed to collect data or explore the correlations between variables. An empirical summary of the data set from the exploratory factor analysis (EFA) was provided using PCA. PCA was crucial in reducing many correlated variables and resizing the variables into a set of components (Tabachnick and Fidell, 2013; Pallant, 2020). Varimax method rotation and eigenvalue over one were used to extract the regulatory environment principal factors influencing the SBC implementation in South Africa. Additionally, the extracted factors were validated using a parallel analysis test. Hence, only the "actual eigenvalues" that are greater than the "random eigenvalues" are to be chosen (Pallant, 2020). Scree plots were also employed to support the decision to extract the factors.

Furthermore, other measures were used to ensure the reliability and validity of the findings. Cronbach's alpha test was employed to assess the reliability and internal consistency of the collected data. The variables' average value was 0.917, which exceeded the threshold value of 0.70, indicating the collected data's excellent reliability and internal consistency (Pallant, 2020). Similarly, the principal factors were separately assessed with Cronbach's alpha test, contributing to the collected data's discriminative validity. Besides, the questionnaire was developed with insights/synthesis from the reviewed literature, including repeated questionnaire reviews by the researcher's supervisors. These helped to improve the questionnaire's content and face validity (Olson, 2010).

4. FINDINGS

4.1 Demographic data

Table 1 shows that respondents with Honours/Btech degrees were predominant and ranked first. They were followed by those with master's degrees, bachelor's degrees, national diploma, and doctorate in descending order. Regarding professional background in Table 1, most respondents were from construction management (1st), followed by engineering, quantity surveying, project management, architecture, and town/urban and regional planning in descending order. The sample accommodated the various backgrounds within the South African built environment (Council for the Built Environment (CBE), 2018). This contributed to authenticating the collected data. Regarding industrial experience, in Table 1, the top-ranked were those between 6 to 10 years, seconded by 1 to 5 years. The third was 11 to 15 years, and the fourth was 16 to 20. Those between 21 to 25 and 26 to 30 years were the fifth and sixthly ranked, respectively, while those above 30 years were the lowest ranked group. Likewise, regarding project roles, many respondents participated as project managers and were seconded by construction managers. Those who participated as quantity surveyors, project managers and principal agents were ranked third, fourth and fifth, respectively. Town planners and other project roles were the least ranked. Generally, the demographic data results implied that respondents had enough knowledge and experience and were in a great position to participate in the study.

Table 1: Demographic data of respondents

Demographic		Percentage	Rank
Educational Qualification	National Diploma	10.7	4th
	Bachelor's Degree	14.6	3rd
	Honours/Btech	44.8	1st
	Master's Degree	24.2	2nd
	Doctorate	5.7	5th
Professional Background	Project Management	17.1	4th
	Architecture	14.6	5th
	Engineering	20.6	2nd
	Quantity Surveying	19.6	3rd
	Construction Management	21.4	1st
	Town and Regional Planning	6.0	6th
	Other	0.4	7th
Project Role	Project Manager	33.1	1st
	Construction Manager	17.1	2nd
	Project Engineer	14.9	4th
	Principal Agent	8.9	5th
	Quantity Surveyor	16.4	3rd
	Town Planner	5.7	6th
	Other	3.9	7th
Industrial Experience	Less than 12 months	6.8	7th
	1-5 years	18.1	2nd
	6-10 years	19.6	1st
	11-15 years	15.7	3rd
	16-20 years	14.6	4th

	21-25 years	11.4	5th
	26-30 years	8.1	6th
	More than 30 years	5.7	8th

Table 2: Regulatory environment features influencing sustainable building construction for project delivery in South Africa

Code	Measure	PM	CM	PE	PA	QS	TP	O	Overall Mean	SD	Overall Rank
RGE2	Green Building Council of South Africa standards	4.16 4th	4.29 1st	4.14 4th	4.32 1st	4.41 1st	4.44 1st	3.91 2nd	4.22	0.73	1
RGE4	National Environmental Management regulations	4.23 2nd	4.06 4th	4.10 6th	4.12 4th	4.17 3rd	4.19 9th	4.00 1st	4.15	0.80	2
RGE3	Department of Public Works' green building policy	4.11 6th	4.02 5th	4.29 1st	4.24 2nd	4.20 2nd	4.25 7th	3.73 4th	4.14	0.73	3
RGE11	Compulsory sustainable building certification	4.14 5th	4.25 2nd	4.14 4th	4.00 9th	4.00 6th	4.31 4th	3.73 4th	4.12	0.90	4
RGE10	Compulsory enforcement of sustainable construction laws	4.17 3rd	4.00 6th	4.26 2nd	4.04 6th	3.96 7th	4.31 4th	3.73 4th	4.10	0.80	5
RGE9	Compulsory sustainable building assessment	3.85 9th	4.08 3rd	4.21 3rd	4.04 6th	3.96 7th	4.38 2nd	3.45 10th	4.08	0.79	6
RGE8	Integrating environmental studies in construction	3.99 7th	3.98 7th	4.00 10th	4.20 3rd	3.89 9th	4.25 5th	3.36 11th	4.00	0.80	7
RGE1	National Building Standards Act	4.28 1st	3.98 7th	3.86 11th	3.80 11th	4.02 5th	3.63 10th	3.73 4th	4.00	0.75	8
RGE5	Laws ensuring the sustainability of resources	3.93 8th	3.98 7th	4.05 9th	3.92 10th	4.17 3rd	4.25 7th	3.73 4th	3.98	0.75	9
RGE6	Government-a-driving force more than the market	3.82 11th	3.85 10th	4.10 6th	4.04 6th	3.76 10th	4.38 2nd	3.91 2nd	3.93	0.77	10
RGE7	Incentives for the companies that are building sustainably	3.84 10th	3.81 11th	4.07 8th	4.08 5th	3.76 10th	4.31 4th	3.46 9th	3.86	0.91	11
Cronbach Alpha		0.916									

4.2 Assessing regulatory environment features

Table 2 presents the regulatory environment factors influencing sustainable building construction implementation for project delivery in South Africa. The built environment respondents were asked to rate the extent of influence of the measuring variables on a 5-point Likert scale ranging from 1 (no extent) to 5 (very high extent). The mean score (MS) and standard deviation (SD) were used as outputs to rank the measuring variables. Table 2 shows that all the variables achieved an average/overall MS value $\geq 3.86 \leq 4.22$, which indicates a significant influence. However, some variables were more notable than orders. The first ranked was the Green Building Council of South Africa standards. Second and third were the National Environmental Management Regulations and the Department of Public Works green building policy, respectively. However, government-a-driving force more than the market and incentives for the companies building sustainably were ranked tenth and eleventh, respectively. Nevertheless, the MS values showed a general indication of the significant influence of the variables. Furthermore, the measuring variables' internal consistency and reliability were excellent, with Cronbach's alpha value of 0.916 above the threshold of 0.70 (Pallant, 2020).

4.3 Principal component analysis for RGE features

This process started with exploratory factor analysis (EFA). Eleven (11) RGE measuring variables were analysed with EFA. Principal component analysis (PCA) and the varimax method were used for extraction and rotation, respectively. Tables 3 to 7 and Figure 1 present the results of the EFA for regulatory environment factors influencing sustainable building construction for project delivery in South Africa. Table 3 indicates the results of the Kaiser-Meyer-Olkin (KMO) sampling adequacy test and Bartlett's test of sphericity. KMO value was 0.889, surpassing the minimum acceptable threshold of 0.6 to continue with factor analysis (Tabachnick and Fidell, 2013; Pallant, 2020). Additionally, factorability was permitted as Bartlett's sphericity test showed a statistical significance value of 0.001 (<0.05).

Table 3: KMO and Bartlett's test for RGE features

Kaiser-Meyer-Olkin Measure Sampling Adequacy		0.889
Bartlett's Test of Sphericity	Approx. Chi-Square	2134.112
	df	55
	Sig.	<0.001

Table 4 presents the total variance explained and the individual eigenvalues of the measuring variables. Considering Kaiser's criterion, two principal component factors achieved values greater than one and were extracted with a cumulative percentage variance of 67.57, surpassing the recommended minimum threshold of 50% (Tengan, 2018). The principal component one (1) accounted for 55.08% of the total variance explained, while the other accounted for 12.49%.

Table 5 presents the rotated component matrix results showing the factor loadings of the regulatory environment measuring variables categorised according to the principal components. The varimax rotated component matrix helped achieve a simple, robust structure and results that were more straightforward to identify and interpret (Tengan, 2018). The variables loading in each principal component extracted were vital, recording values above 0.5. Similarly, the principal components extracted had more than one variable, suggesting reasonable results devoid of complicated structures (Pallant, 2020).

Table 4: Total variance explained for RGE features

Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	% Of Variance	Cumulative %	Total	% Of Variance	Cumulative %
1	6.059	55.082	55.082	6.059	55.082	55.082
2	1.374	12.488	67.570	1.374	12.488	67.570
3	0.844	7.670	75.240			
4	0.639	5.805	81.045			
5	0.491	4.461	85.506			
6	0.412	3.749	89.255			
7	0.378	3.440	92.694			
8	0.331	3.006	95.701			
9	0.177	1.607	97.308			
10	0.168	1.524	98.832			
11	0.128	1.168	100.000			
Extraction Method: Principal Component Analysis.						

Table 5: Rotated component matrix for RGE

Code	Variable	Component	
		1	**2**
RGE9	Compulsory sustainable building assessment	0.918	
RGE10	Compulsory enforcement of sustainable construction laws	0.896	
RGE11	Compulsory sustainable building certification	0.874	
RGE7	Incentives for the companies that are building sustainably	0.649	
RGE8	Integrating environmental studies in construction	0.552	0.535
RGE1	National Building Standards Act		0.743
RGE4	National Environmental Management regulations		0.738
RGE3	Department of Public Works green building policy		0.729
RGE6	Government-a driving force more than the market		0.679
RGE5	Laws ensuring the sustainability of resources		0.640
RGE2	Green Building Council of South Africa standards		0.617

The scree plot in Figure 1 showed a reasonable break after the initial two component factors before the gradual meandering off displays of the inconsequential remaining factors with eigenvalues less than one. Likewise, Table 6 shows a parallel analysis test to crosscheck the suitability of the factors extracted. According to the parallel analysis table, all the actual Eigenvalues are greater than the random Eigenvalues. Hence, this validates the decision to use the two extracted components. Additionally, Cronbach's alpha reliability and internal consistency test were assessed to ascertain the suitability of the items in each of the principal components. However, variables with cross-loadings were not considered. Table 7 presents Cronbach's alpha values of components one (1) and two (2), recording 0.904 and 0.818, respectively, above the 0.7 threshold.

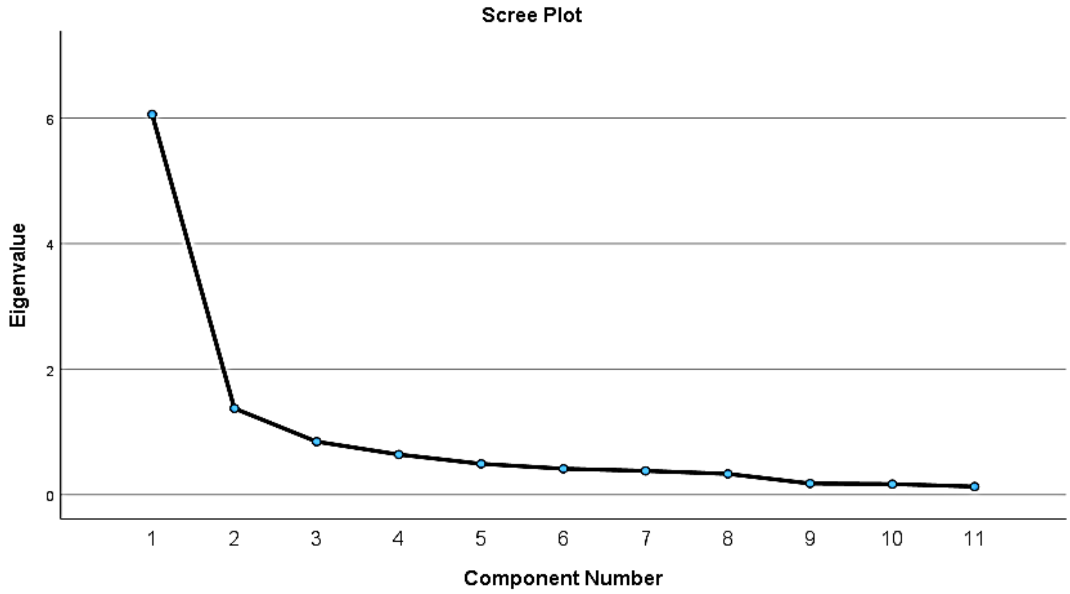

Figure 1: Scree plot for RGE features

Table 6: Parallel analysis test

Principal Component	Random Eigenvalue	Actual Eigenvalue	Accept/Reject
1	1.329	6.075	Accept
2	1.235	1.376	Accept

Table 7: Cronbach's alpha for RGE principal components

Principal Component	Cronbach's Alpha	Number of items
1	0.904	4
2	0.818	5

4.3.1 Naming of Components

The two principal components extracted were named considering the interrelationships and loadings of the variables/items between them. Component one (1) was named Compulsory Regulatory Enforcement and Assessment, while component two (2) was named National Green Building Policies and Standards.

Component 1 - Compulsory Regulatory Enforcement and Assessment

This comprised four variables with their loadings, namely, Compulsory sustainable building assessment (0.918), Compulsory enforcement of sustainable construction laws (0.896), Compulsory sustainable building certification (0.874), and Incentives for companies that are building sustainably (0.649).

Component 2 - National Green Building Policies and Standards

This comprised five variables with their loadings, namely, National Building Standards Act (0.743), National Environmental Management regulations (0.738), Department of Public Works' green building policy (0.729), and Government-a-driving force more than the market (0.679), and Green Building Council of South Africa standards (0.617). The loadings explain the influence of variables on the extracted principal components/factors.

5. DISCUSSION

Results from descriptive statistics in Table 2 showed that the predominant regulatory environment (RGE) features defining the effective implementation of sustainable building construction (SBC) for project delivery in South Africa included the Green Building Council of South Africa (GBCSA) standards, National Environmental Management regulations, Department of Public Works' green building policy, Compulsory sustainable building certification, and Compulsory enforcement of sustainable construction laws. Respectively, they were the top five ranked in descending order out of eleven variables.

The finding on GBCSA standards being the top-ranked suggests that the built environment professionals in South Africa highly appreciate the council's initiatives in ensuring sustainable building construction implementation (GBCSA, 2017a; Hoffman et al., 2020). Notably, it was explicitly ranked first by construction managers, principal agents, quantity surveyors, and town planners. The findings on National Environmental Management regulations and the Department of Public Works green building policy ranked second and third, respectively, are consistent with Abonginije et al. (2020), who affirmed that the two are among the prime factors for implementing green building practices in South Africa. It was also quite revealing that the Department of Public Work's green building policy was ranked first by project engineers and second by quantity surveyors and principal agents. This confirms its importance. Additionally, the findings on compulsory sustainable building certification and compulsory enforcement of sustainable construction laws are consistent with Wang et al. (2018), avowing that legislation regarding building green should be mandatory if green specifications should be adopted.

Similarly, the PCA results showed that "Compulsory Regulatory Enforcement and Assessment", the first principal component, is critical in defining the SBC implementation in South Africa. This component included features like compulsory sustainable building assessment, compulsory enforcement of sustainable construction laws, compulsory sustainable building certification, and incentives for companies that are building sustainably. These findings align with Wang et al. (2018) and several authors who avow that regulations, standards, and legislation regarding building green should be mandatory for adequate adherence to green specifications and sustainable principles (Diabat and Govindan, 2011; Yang and Zhang, 2012; Zhai, 2014). According to Saad (2016), ineffective enforcement is a crucial hindrance to SBC in South Africa. The findings on incentives concurred with Serpell et al. (2013), who suggested enforcement of governmental policies such as company tax reduction, especially in developing countries, to enhance their level of investment in sustainable construction. Additionally, Oguntona et al. (2019) found that providing economic incentives is one of the critical drivers for green building implementation. Many scholars also affirmed this position (Udawatta et al., 2015; Yas and Jaafer, 2020; Chen et al., 2022).

Furthermore, the PCA results revealed that "National Green Building Policies and Standards" was another principal factor in defining SBC implementation in South Africa. This component included the National Building Standards Act, National Environmental Management regulations, the Department of Public Works' green building policy, government-a-driving force more than the market, and Green Building Council of South Africa standards. The National Building Regulation/Standards Act promotes uniformity in the law relating to the erection of buildings in the areas of jurisdiction of local authorities. Its importance in this study concurs with Abonginije et al. (2020), who confirmed that it was enlisted as one of the Acts that unites with the Department of Public Works (DPW) green building policy to implement green building practices in South Africa. It was the most prioritised regulatory environment feature by project managers, according to the findings. Similarly, the National Environmental Management regulations provide for cooperative environmental governance by establishing principles for decision-making on environmental matters (Government of South Africa, 2023). It was also enlisted as one of the Acts that united with the DPW green building policy to implement green building practices in South Africa (Windapo and Goulding, 2015; Aboginije et al., 2020). Besides, it was the second prioritised regulatory environment feature by the project managers indicating its significance. Similarly, the findings on DPW policy confirm its goal of providing leadership in the sustainable buildings sector in South Africa (DPW Green Building Policy, n.d.; DPW, 2023). The findings on government being a driving force align with Mashwama et al., 2020), who enlisted the lack of limited government involvement as one of the critical barriers to the effective implementation of green building and sustainable construction in South Africa. Town/urban planners mostly appreciated this finding. Furthermore, the findings regarding Green Building Council of South Africa standards correspond with Windapo (2014), who identified legislation and the Green Star rating systems as key green building drivers in the South African construction industry.

5.1 Implications and recommendations of the study

The current study contributed to theory, methodology, policy and practice. Theoretically, no study in South Africa has explored the regulatory environment features for sustainable building construction (SBC) implementation. Methodologically, no study has utilised the principal component analysis technique to identify the principal regulatory environment features for SBC implementation in South Africa. Therefore, the findings added to knowledge by confirming two fundamental factors for the regulatory environment. The study recommends adequately considering these factors to implement SBC in South Africa effectively. The findings on the Green Building Council of South African standards and the Department of Public Works' green building policy solidify their importance in propagating SBC. They should be prioritised by policymakers and stakeholders for improvement initiatives and practice. Also, findings on compulsory enforcement of laws, standards, and assessments suggest that practical SBC needs a grave corporation/mandate by all stakeholders to achieve sustainable development goals. Similarly, the general findings can serve as a support tool for identifying the most significant regulatory environment features to enhance the decision of built environment professionals and stakeholders to adopt SBC.

6. CONCLUSION

The study established the principal regulatory environment (RGE) features for sustainable building construction in South Africa. The theoretical review is consistent with the empirical findings of this study. The respondents indicated that the discussed RGE features influence SBC implementation. Knowledge of these principal features will enable decision-makers within construction organisations to direct improvement initiatives appropriately. This also implies that they must be prioritised to achieve high efficiency and effectiveness in implementing sustainable building construction. Compulsory enforcement of laws, standards, and assessments regarding SBC was appreciated instead of voluntary for effective implementation. Similarly, the SBC-related regulations in South Africa were found adequate to drive the implementation forward.

Arguably, the identified factors in this study should serve as minimum RGE features for SBC implementation. The findings also spark debate among academics and professionals on effectively motivating SBC implementation. The study comes with some limitations. This paper focused on exploring the principal factors. Future studies should confirm the impact of RGE features on SBC implementation using multiple regression or structural equation modelling techniques. Nevertheless, the authors aim to bring this to light in subsequent studies. Geographically, the study was conducted predominantly in the Gauteng province of South Africa. Further studies can broaden the geographical scope and sample to see if there is a significant difference in viewpoints. Although these limitations do not annul the findings, any improvement in the study will contribute to a more holistic view of SBC implementation in South Africa.

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