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Enhancing sustainable construction in the building sector in Uganda

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ABSTRACT

To further the sustainability agenda of the building sector, recent research and practice suggest that integrating embodied carbon (EC) in the sustainability assessment of buildings is necessary. This paper presents an investigation to assess whether the consideration of EC in the development approval process (DAP) could enhance sustainable construction (SC). A recent proposal for integrating the assessment of EC in the DAP of building projects in Uganda was used. Structured interviews were used to collect data from construction professionals. Findings show that construction professionals were highly aware of SC, suggesting that initiatives of enhancing SC could be easily appreciated. However, the concept of SC was found to be largely interpreted in terms of environmental sustainability, implying that measures that highly promote environmental sustainability could be adopted. A hypothesis test confirmed that integrating the assessment of EC in the DAP of building projects in Uganda could enhance SC. This provided new evidence to corroborate the assertion that assessment of carbon emissions associated with buildings can enhance sustainable construction. Having further found that social sustainability could be enhanced the most, this study provides new evidence linking the assessment of EC to promoting social sustainability. Recommendations on introducing the assessment of EC in the DAP of buildings in Uganda are also provided. These include taking necessary steps to increase awareness of SC, implementation of a pilot program in a selected area of Uganda, and further research to capture more opinions from stakeholders, other than construction professionals. Overall, this study shows that transition to sustainable low carbon development in developing countries is possible and a potential way of achieving this could be through implementing measures that bring carbon emissions to bear on the environmental impact assessment of prospective buildings.

1. Introduction

Scientific reports suggest that increased concentration of carbon emissions in the atmosphere causes climate change (Hergerl et al., 2007), which is now recognised as a foremost challenge of the 21st century (de Wilde & Coley, 2012). Annually, the building sector accounts for one-third of the carbon emissions worldwide (UNEP, 2009; WBCSD, 2012). With rapid urbanisation happening in the developing world, concomitant with increased construction activities (Shi, Ye, Lu, & Hu, 2014), carbon emissions from the building sector are envisaged to increase (UNEP, 2009). For the developing countries to follow a low carbon path to development, the case for tackling carbon emissions associated with the construction of buildings becomes persuasive. Moreover, unlike in the developed world where emission reduction opportunities are limited by the fact that most buildings that will be operating in decades to come are already built, in the developing world, such buildings are either being built or yet to be built (UNEP, 2009). If developing countries are to avoid some of the mistakes the developed countries made, integrating the assessment of carbon emissions in the prevailing construction practices is necessary to foster sustainable construction.

Unfortunately, in the developing world, the consideration of carbon emissions in the sustainability assessment of proposed buildings is yet to gain recognition. For instance, in the African continent, where most of the developing countries are found (UNCTAD, 2011), recent reviews (Cabeza, Rincón, Vilariño, Pérez, & Castell, 2014) show that environmental assessment of buildings in terms of their energy consumption and carbon emissions is a rarity. Since enhancement of sustainable construction is increasingly linked with addressing carbon emissions (BSI, 2011; RICS, 2012), it is clear that there is a gap in knowledge about the potential of enhancing sustainable construction in developing countries

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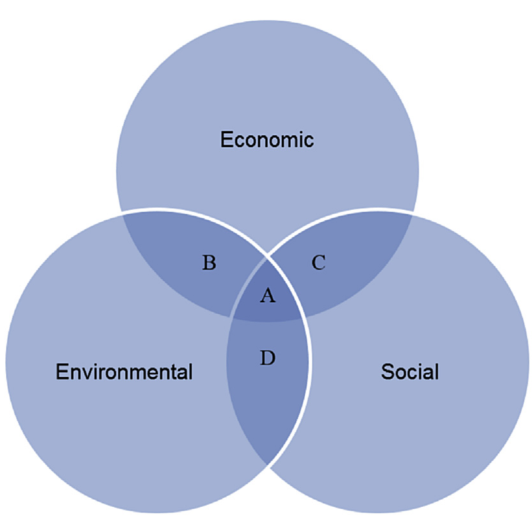
through assessment of carbon emissions. The research presented in this paper contributes to filling this gap by investigating the perceived implications of integrating the assessment of embodied carbon emissions in the development approval process of buildings in Uganda with regard to enhancing sustainable construction.

2. Sustainable construction

Sustainable construction can be interpreted as the application of the principles of sustainable development to construction. Acknowledgment of sustainable construction manifested in 1994 during the first international conference on sustainable construction which was held in Tampa, Florida, United States of America (Kibert, 1994). In that conference, sustainable construction was defined as "… creating and operating a healthy built environment based on resource efficiency and ecological design" (Hill & Bowen, 1997). Other commentators suggest that sustainable construction should be viewed as the responsibility of the construction industry towards sustainability (Bourdeau, 1999; Hill & Bowen, 1997). However, Kibert further suggested that sustainable construction should be construed as a subset of sustainable development (Kibert, 2008). This concurs with the assertion that sustainable construction is the means through which the construction industry contributes to achieving sustainable development (CIB, 1999).

Since sustainable construction is related to sustainable development, sustainable construction practices should therefore address the three pillars of sustainable development. According to a widely quoted definition, sustainable development is development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland et al., 1987). Achieving sustainable development requires balancing economic, social, and environmental pillars of sustainability (Edum-Fotwe & Price, 2009; Parkin, Sommer & Uren, 2003). It is argued in Edum-Fotwe and Price (2009) that consideration of one pillar only, two pillars only, and all the three pillars relates to first order, second order, and third order states of sustainability, respectively (see Fig. 1). Therefore, sustainable construction can be interpreted to manifest in first, second, and third order states of sustainability.



'A' stands for sustainable development (3rd order sustainability); 'B', 'C' and 'D' stand for 2nd orders of sustainability. Adapted from Edum-Fotwe and Price (2009)

Fig. 1. Pillars of sustainable development.

Literature suggests that the drivers for sustainable construction can be structured into environmental, economic, and social drivers (see Table 1). As such, strategies that aim to enhance sustainable construction should facilitate at least one of such drivers of sustainable construction. However, for a given project, optimising all the possible available drivers of sustainable construction is often impossible; compromises are inevitable (Hill & Bowen, 1997). Therefore, a strategy that facilitates the largest number of the drivers for sustainable construction would greatly contribute to enhancing sustainable construction practices. In the building sector, a bulk of strategies (e.g. EU's *European Performance of Buildings Directive* (CA EPBD, 2014)) hitherto focus on energy efficiency, which relates to driver number 2 in Table 1. However, the increasing focus on energy efficiency in the operational phases of buildings has made embodied energy, and consequently embodied carbon (EC) emissions, prominent in the lifecycle of buildings (Ibn-Mohammed, Greenough, Taylor, Ozawa-Meida & Acquaye, 2013). Therefore, for holistic enhancement of sustainable construction, strategies that focus on energy efficiency need to consider EC emissions as well.

EC are emissions that are largely attributed to activities like material manufacture, transportation, and on-site construction, during the creation of buildings (Cole, 1998; Hacker, De Saulles, Minson, & Holmes, 2008; Hammond & Jones, 2008). Recent research suggests that EC should be integrated in the environmental assessment of buildings, so as to enhance sustainable construction (Häkkinen, Kuittinen, Ruuska, & Jung, 2015; Kibwami & Tutesigensi, 2016; Knight & Addis, 2011; Teh, Wiedmann, Schinabeck, Rowley, & Moore, 2015; Yuan & Ng, 2015). For some recent practices like in the UK, local planning authorities started requiring infrastructure developers to demonstrate how they use "materials that are sustainable and have low embodied carbon" (see Brighton and Hove, 2013, p.162). In addition, there is also an increasing number of guidelines that include assessment of EC in environmental assessment of buildings (BSI, 2011; Franklin & Andrews, 2013; RICS, 2012). Therefore, it is plausible to hypothesise that integrating the assessment of EC emissions in existing construction practices can enhance sustainable construction.

3. Brief overview of the situation in Uganda

As a developing country, Uganda grapples with a challenge of addressing environmental problems without undermining economic development. Most of the technologies used are highly energy-intensive, inefficient, and associated with high levels of pollution (Okello, Pindozzi, Faugno, & Boccia, 2013). The prevalent low level of industrialization in Uganda implies that construction activities are highly labour intensive, largely involve unskilled labour, and use primitive construction methods (Alinaitwe, Mwakali, & Hansson, 2007). A recent study found that the average embodied energy consumed in small-scale brick manufacturing in Uganda is over 5 times higher than that in developed countries (Hashemi, Cruickshank, & Cheshmehzangi, 2015). Moreover, the prevailing environmental impact assessment practices do not consider assessment of energy or EC associated with constructing buildings (Kibwami & Tutesigensi, 2016). Although some initiatives began "to assist national and local governments in reviewing and updating building laws and regulations, with a view of promoting low carbon practices" (UN-HABITAT, 2013, p.6), there is limited knowledge on how such initiatives will enhance sustainable construction. This limited knowledge, coupled with the lack of studies on the extent of awareness and interpretation of sustainable construction amongst various stakeholders in the building sector, makes it difficult to understand whether the assessment of EC is appreciated as a

Table 1
Drivers of sustainable construction.

	Sustainable construction practice	Reference
Environmental		
1	Reduce the use of resources such as energy, water, and materials, during in construction	Bourdeau (1999); BRE and Cyril Sweett (2005); Chen, Okudan, and Riley (2010); Hill and Bowen (1997); Kibert (2008); Trufil and Hunter (2006)
2	Optimise lifecycle energy use (i.e. embodied and operating energy) in buildings	Bourdeau (1999); BRE and Cyril Sweett (2005); Chen et al. (2010); Kibert (2008); Nelms, Russell, and Lence (2007); Shen, Tam, Tam, and Ji (2010)
3	Recycling of products	Bakhtiar, Shen, and Misnan (2008); Bourdeau (1999); Chen et al. (2010); Hill and Bowen (1997); James and Matipa (2004); Kibert (2008); Nelms et al. (2007)
4	Reuse of products	Bourdeau (1999); Chen et al. (2010); Hill and Bowen (1997); James and Matipa (2004); Kibert (2008); Nelms et al. (2007)
5	Use of renewables in preference for non-renewables	Hill and Bowen (1997)
6	Minimise pollutants that cause environmental degradation	Bakhtiar et al. (2008); Bourdeau (1999); BRE and Cyril Sweett (2005); Chen et al. (2010); Hill and Bowen (1997); Shen et al. (2010); Trufil and Hunter (2006)
7	Environmental labelling and voluntary rating schemes	Bakhtiar et al. (2008); Bourdeau (1999); Du Plessis (2007); Hill and Bowen (1997); James and Matipa (2004); Manoliadis, Tsolas, and Nakou (2006); Tan, Shen, and Yao (2011)
8	Implementation of environmental management during construction stage such as documenting requirements in contract specifications	Hill and Bowen (1997)
9	Inclusion of environmental aspects in decisions during construction (e.g. buying greener materials)	Bourdeau (1999); Hill and Bowen (1997)
10	Development of comprehensive data bases	Bourdeau (1999); Du Plessis (2007)
11	Enforcement and compliance with environmental regulations	Bakhtiar et al. (2008); Du Plessis (2007); James and Matipa (2004); Tan et al. (2011)
Economic		
12	Financial affordability for intended beneficiaries	Bakhtiar et al. (2008); Hill and Bowen (1997); Nelms et al. (2007)
13	Employment creation such as using labour intensive construction.	Chen et al. (2010); Hill and Bowen (1997); Shen et al. (2010)
14	Competitiveness through advancing practices that advance issues of sustainability	Hill and Bowen (1997); HM Government (2009)
15	Choosing environmentally responsible suppliers/contractors who demonstrate environmental performance	Bakhtiar et al. (2008); Du Plessis (2007); Hill and Bowen (1997); Rwelamila, Talukhaba, and Ngowi (2000); Tan et al. (2011)
16	Incentives for those applying a sustainability measure (e.g. lower interest rates, tax exemption, etc.) and vice versa	Du Plessis (2007); Hill and Bowen (1997); Manoliadis et al. (2006); Nelms et al. (2007)
17	Use of local resources (e.g. materials and workforce) in construction	Abidin and Pasquire (2007); Bourdeau (1999); Du Plessis (2007); James and Matipa (2004)
Social		
18	Poverty alleviation	Edum-Fotwe and Price (2009); Hill and Bowen (1997)
19	Operations of a development to be compatible with local needs	Edum-Fotwe and Price (2009); Hill and Bowen (1997); Shen et al. (2010)
20	Education and training to increase awareness	Bakhtiar et al. (2008); Bourdeau (1999); Du Plessis (2007); Edum-Fotwe and Price (2009); Hill and Bowen (1997); Manoliadis et al. (2006); Tan et al. (2011)
21	Corporate social responsibility (CSR)	Trufil and Hunter (2006)
22	Health and safety at workplace	Bourdeau (1999); Edum-Fotwe and Price (2009); Hill and Bowen (1997); HM Government (2009); Reyes, San-José, Cuadrado, and Sancibrian (2014); Shen et al. (2010)
23	Developing capacity and skills	Du Plessis (2007); Edum-Fotwe and Price (2009); Hill and Bowen (1997); HM Government (2009); Nelms et al. (2007)

potential enhancer for sustainable construction in Uganda.

It is against this background that the authors sought to contribute towards the understanding and possible realisation of sustainable construction in Uganda by investigating the integration of EC in the development approval process of buildings. The investigation culminated from pursuit of three objectives: (1) to assess the level of awareness of sustainable construction; (2) to find out how sustainable construction is interpreted; and (3) to assess whether integrating the assessment of EC in the development approval process of buildings can enhance sustainable construction.

4. Methodology

A quantitative research approach was adopted in this study. A face-to-face structured interview survey research method was used to collect quantitative data. This research method was appropriate because the researcher had to first explain a proposal for integrating the assessment of EC in the development approval process of buildings in Uganda, before asking respondents to rate the extent to which the proposal contributed to the drivers of sustainable construction. The research population was limited to construction professionals because, amongst all other stakeholders in the building sector, construction professionals exert the most influence in adopting sustainability and shaping its perception within the built environment (Shen & Tam, 2002; Shi et al., 2014; William, Sourani, Sertyesilisik, & Tunstall, 2013; Zuo, Read, Pullen, & Shi, 2012). The research population consisted of major construction professionals involved in the process of constructing buildings in Uganda: Architects, Civil Engineers, Quantity Surveyors, and Environmental Impact Assessors. The sampling frame was derived from publicly available lists of professionals who were accredited to practice in 2014. Since the study population was naturally stratified into strata, a stratified random sample was used (Denscombe, 2010; Fellows & Liu, 2009). In each stratum, 30 respondents were considered as a sufficient sample size (Owen & Jones, 1994; Pallant, 2013). This generated a target sample of 120 construction professionals.

To enable assessment of validity and representativeness of the responses, two variables – number of years in practice and nature of practice – were included in the interview schedule. From the sampling frame, it was observed that most respondents (80%) were employed in private consultancy firms. In order to check representativeness of the achieved sample, respondents were asked to indicate their 'nature of practice' (i.e. private consulting firm, private non-consulting firm, government agency, construction firm, and others). The results were then compared to the characteristics of the sampling frame. Meanwhile, respondents were also asked to indicate their experience in terms of years such that those with less than five years of experience could be excluded. The justification for exclusion lies in previous studies, such as Majdalani, Ajam, and Mezher (2006), which suggest that responses from construction professionals with over five years of experience enhance research validity.

For each of the three research objectives, a corresponding question was included in the interview schedule in order to collect the necessary data. For the first objective, awareness of sustainable construction was assessed by asking respondents to indicate their general level of awareness of sustainable construction, based on a measurement scale of 'not at all', 'slightly', 'somewhat', 'moderately' and 'extremely aware'. To address the second objective, a question on how sustainable construction was interpreted was included, based on the approach used in Zainul Abidin (2010). However, in this case, respondents were asked to choose three out of six statements they considered to best describe sustainable construction (see Table 2). In addressing the third objective, the drivers of sustainable construction presented in Table 1 were abstracted into assessable statements (see Table 3). A proposal in Kibwami and Tutesigensi (2016), which is illustrated by a process model (see Appendix A), was then explained to the informants. In that proposal, assessment of EC – which was based on emissions associated with manufacture and transportation of construction materials, emissions from use and transportation of plant, and emissions from transporting workforce – was suggested as a requirement during Environmental Impact Assessment (EIA) for building projects and also, as a prerequisite for issuance of building and occupation permits. Informants were then asked to indicate the extent to which implementation of the proposal would contribute to each of the statements in Table 3. Responses were recorded based on a five point Likert format (1 = not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely, 0 = don't know). The resulting data were used to test a (null) hypothesis – integrating the assessment of EC emissions in the development approval process of buildings does not enhance sustainable construction.

The data collected were analysed using IBM SPSS Version 19. Some interviewees provided at least one 'don't know' response but such responses were taken to be non-substantive and hence the interviewees were excluded from analysis relating to respective variables (Foddy, 1993). The achieved response rate was considered by benchmarking on previous studies (Kervin, 1992). Response bias, which is the effect of those who did not respond, was assessed using wave analysis (Creswell, 2014; Lankford, Buxton, Hetzler, & Little, 1995); three waves each denoting three weeks of data collection were analysed using one way between-groups analysis of variance (ANOVA). Descriptive statistics (i.e. mean, percentages, standard deviation etc.) and Chi square tests of independence were used to analyse the pattern of responses regarding number of years in practice, awareness of sustainable construction, and interpretation of sustainable construction. Before interpreting results from Chi-square tests, the assumption regarding minimum expected cell frequency was first inspected and where it was found to be violated, the maximum likelihood ratio was used (McHugh, 2013).

With respect to enhancing sustainable construction variables, reliability analysis using Cronbach's coefficient alpha (Cronbach, 1951) was undertaken on the 11 items ($\alpha = 0.78$), 6 items ($\alpha = 0.71$), and 6 items ($\alpha = 0.74$), constituting the environmental, economic, and social sustainability pillars respectively, as well as all the 23 items ($\alpha = 0.85$). The analysis revealed acceptable levels of internal consistency since the α values were greater than 0.7 (DeVellis, 1991; Kervin, 1992). This led to creation of four composite variables: enhancing sustainable construction – environmental (eSC-Env), enhancing sustainable construction – economic (eSC-Eco), enhancing sustainable construction – social (eSC-Soc), and enhancing sustainable construction – overall (eSC-EnvEcoSoc), represented by the average ratings over the 11, 6, 6, and 23 items respectively. Collapsing Likert ratings in this way is often criticised (see Jamieson, 2004; Knapp, 1990) because it infers that an ordinal scale has been interpreted as an interval scale. However, this has no harm where, like in this work, two-tailed *t*-tests are used with relatively equal stratified sample sizes (Baker, Hardyck, & Petrinovich, 1966). The measurement scale for these composite variables was calibrated by taking 3 as the threshold for distinguishing between 'enhances sustainable construction' (i.e. rating >3) and 'does not enhance sustainable construction' (i.e. rating <3). A threshold value of 3 on the 5-point Likert scale used in this research is widely used (see Kulatunga, Amaratunga, & Haigh, 2009; Larsson, Eriksson, Olofsson, & Simonsson, 2013; Pheng & Gracia, 2002) and this justifies the choice.

Using the Kolmogorov-Smirnov (K-S) test (Field, 2013), the variables eSC-Env ($p = 0.2$) and eSC-EnvEcoSoc ($p = 0.2$) were confirmed as parametric ($p > 0.05$), whereas the variables eSC-Eco ($p = 0.04$) and eSC-Soc ($p = 0.03$) were confirmed as non-parametric ($p < 0.05$). Thus the differences between eSC-Env, eSC-Eco, and eSC-Soc variables were explored using the Friedman test, which is a non-parametric test (Pallant, 2013). Since eSC-EnvEcoSoc was a parametric variable, the one-sample *t*-test (Bryman & Cramer, 2011) was used to test the hypothesis referred to above.

To accept the null hypothesis, the obtained mean rating had to be significantly below the set threshold rating of 3. The effect size *d*, an important parameter in the interpretation of one sample *t*-test

Table 2
Interpretation of sustainable construction.

	Statement
1[a]	Construction practices that minimise harm to the environment such as avoiding constructing in wet lands
2[a]	Construction practices that minimise over usage of natural resources like water and sand
3[b]	Construction practices that ensure minimal lifetime maintenance costs of buildings
4[b]	Construction practices that make profit without compromising people's needs
5[c]	Construction practices that practice corporate social responsibility
6[c]	Construction practices that enhance quality and satisfaction of human life such as promoting safety at workplace

[a] Environmental sustainability.
[b] Economic sustainability.
[c] Social sustainability.

Table 3
Enhancing sustainable construction.

	Statement
1 [a]	Minimising over usage of resources like energy and materials during construction
2 [a]	Improving on the overall energy consumption of buildings
3 [a]	Promoting use of waste to manufacture new products
4 [a]	Encouraging reuse of a product several times before discarding it
5 [a]	Encouraging use of renewables like biodiesel instead of non-renewables like diesel
6 [a]	Minimising pollution like carbon dioxide emissions
7 [a]	Promoting environmental labelling and rating systems
8 [a]	Encourage considering environmental issues during the construction stage
9 [a]	Facilitation of decisions to consider materials that are sustainably produced
10 [a]	Enabling development of comprehensive data bases related to emissions
11 [a]	Enhance enforcement and compliance with environmental regulations
12 [b]	Lead to financially affordable options like walking instead of driving
13 [b]	Creation of more employment opportunities like using people instead of diesel-equipment
14 [b]	Enhancing competitiveness in construction through advancing sustainability practices
15 [b]	Enable choosing suppliers or contractors that demonstrate environmental performance
16 [b]	Creation of financial incentives
17 [b]	Encourage using local materials and workforce
18 [c]	Generation of income like for those producing sustainable materials and energy
19 [c]	Making construction operations more compatible with local needs
20 [c]	Increase awareness about carbon emissions in construction
21 [c]	Promoting corporate social responsibility
22 [c]	Promoting health and safety at workplace
23 [c]	Developing capacity and skills regarding matters of accounting for carbon emissions

[a] Environmental sustainability.
[b] Economic sustainability.
[c] Social sustainability.

results (Creswell, 2014; Green & Salkind, 2005), was calculated using t (t value obtained from the t-test) and n (sample size) from Equation (1) (Green & Salkind, 2005, p.157). The effect size d was interpreted as the magnitude of the difference between the two mean ratings (i.e. threshold mean and obtained mean). Based on Cohen's criteria of classifying effect sizes: 0.2 as small, 0.5 as medium, and 0.8 as large (Cohen, 1988), the obtained effect size d was classified accordingly.

$$d = \frac{t}{\sqrt{n}} \tag{1}$$

5. Results and discussion

5.1. Overview of responses

All the potential respondents in the target sample of 120 (16% of the research population) individuals were contacted, indicating a contact rate of 100%. However, of the 120 potential respondents, data were successfully collected from 85 respondents. This indicated a response rate of 71% which, according to Kervin (1992, p.422), is acceptable for personal interviews.

Although 29% of the potential respondents did not respond, nonresponse bias was negligible. According to the results obtained from wave analysis of responses regarding the variables of enhancing sustainable construction: wave 1 contained 30 respondents (35%), wave 2 contained 29 respondents (34%), and wave 3 contained 26 respondents (31%). One way between-groups ANOVA showed that there was no statistically significant difference at the $p < 0.05$ level for the three waves: F (2, 68) = 1.48, $p = 0.24$. Multiple wave comparisons revealed that for: Wave 1 vs Wave 2, $p = 0.61$; Wave 1 vs Wave 3, $p = 0.65$; and Wave 2 vs Wave 3, $p = 0.21$. It was therefore inferred that even if a fourth wave containing the non-respondents (29%) was to be included, there would not have been significant changes in the responses.

According to results presented in Table 4, no professional had less than five years of experience, which enhanced the validity of responses. Meanwhile, consistent with earlier observations regarding the characteristics of the sampling frame (Section 4), majority (87%) of the professionals in the achieved sample worked in private consultancy firms. This indicated that the achieved sample was sufficiently representative of the study population.

5.2. Awareness of sustainable construction

On average, most respondents were 'moderately aware' (53%), followed by those who were 'extremely aware' (26%) of sustainable construction (see Table 5). These results, which suggest

Table 4
Years of practicing experience.

Professional	Descriptive statistics for years of experience				Total respondents	Percentage
	Minimum	Maximum	Mean	Standard deviation		
Architect	6	35	14.10	8.05	20	23.5
Engineer	6	31	14.48	6.76	21	24.7
Quantity Surveyor	7	51	20.11	11.96	21	24.7
Environmentalist	5	26	12.87	5.95	23	27.1

Table 5
Awareness of sustainable construction.

Level of awareness	Architects	Engineers	Quantity Surveyors	Environmentalists
Not at all aware	0%	0%	0%	0%
Slightly aware	0%	10%	14%	13%
Somewhat aware	10%	5%	33%	0%
Moderately aware	50%	62%	48%	48%
Extremely aware	40%	24%	5%	39%

that there is relatively high level of awareness of sustainable construction among construction professionals in Uganda, are in agreement with previous studies from other developing countries. In Zambia, a 60% level of awareness of sustainable construction among construction professionals was reported in James and Matipa (2004), whereas 83% of the 'practitioners' in Ghana were reported to be aware of sustainable construction (Ametepey, Gyadu-Asiedu, & Assah-Kissiedu, 2015). However, a high level of awareness of sustainable construction does not equate to increased implementation of sustainability concepts. For instance, Zainul Abidin (2010) found that the high level of awareness of sustainable construction in Malaysia did not reflect the extent to which sustainability concepts were implemented in construction projects. Therefore, although construction professionals in Uganda were found to be highly aware of sustainable construction, this cannot be interpreted as prevalence of sustainable construction practices. A plausible interpretation could be that initiatives of promoting sustainable construction can be easily appreciated. Meanwhile, a Chi-square test for independence (with Likelihood Ratio) indicated that the level of awareness among the four types of professionals significantly varied X^2 (9, $n = 85$) = 25.32, $p = 0.003$. The differences were greatly accounted for by Quantity Surveyors who were found to be generally least aware, considering the combined percentages on responses for 'moderately' and 'extremely' aware: Architects (90%), Engineers (86%), Environmentalists (87%), and Quantity Surveyors (53%).

5.3. Interpretation of sustainable construction

The interpretation of sustainable construction varied across the six response statements (see Fig. 2). A statement describing sustainable construction as 'practices that minimise harm to the environment' was most selected (86%). Generally, the two statements that relate sustainable construction to environmental sustainability were most selected, followed by statements related to economic sustainability, and lastly, social sustainability. These results suggest that construction professionals in Uganda mostly interpreted sustainable construction as synonymous with environmental sustainability. This finding has previously been reported in several studies such as Zainul Abidin (2010, p.424), wherein "all respondents associated environmental aspects with sustainable construction", and Majdalani et al. (2006) who discovered that Architects and Engineers placed greater importance on environmental concerns. Meanwhile, the lowest selections observed in social sustainability statements were also not very surprising. For instance, in a Chinese study (Shen et al., 2010), it was discovered that social performance attributes are usually not considered in feasibility assessment of projects. On the whole, these findings offer two suggestions. Firstly, that the perception of sustainable construction by construction professionals in Uganda is not so different from other countries'. Secondly, the findings offer suggestive evidence that integrating the assessment of EC in the development approval process of buildings in Uganda could be easily appreciated as it primarily

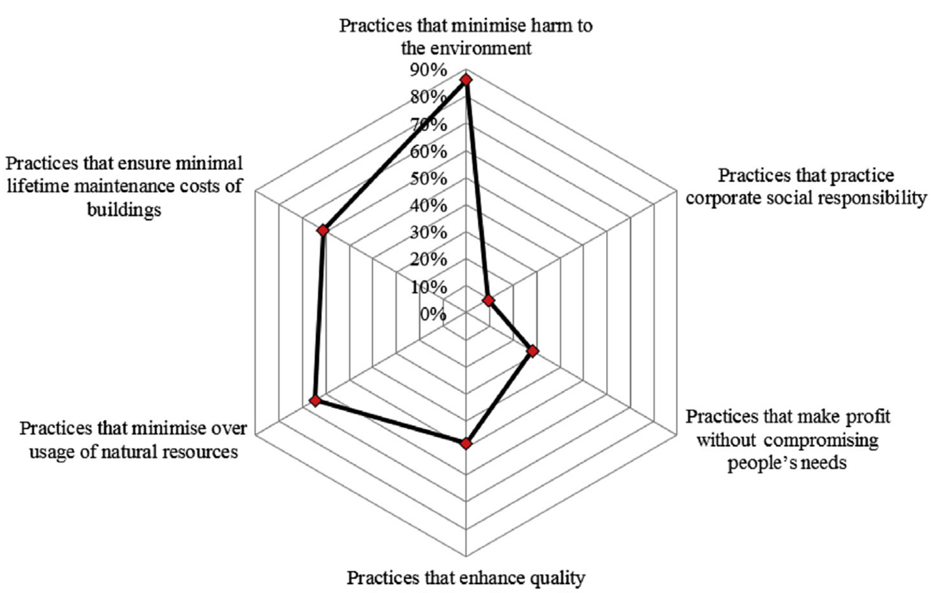


Fig. 2. Interpretation of sustainable construction.

concerns environmental sustainability.

5.4. Enhancement of sustainable construction

Data for eSC-EnvEcoSoc ranged from 2.13 to 5, with an average of 3.60, which was over and above the threshold rating of 3. Results from the one-way between groups ANOVA showed that there was no statistically significant difference at the $p < 0.05$ level in the ratings by the four types of professions: $F(3, 67) = 1.53$, $p = 0.22$. The p value obtained for Levene's test for homogeneity of variance was 0.23, confirming that the variance of ratings was insignificant. Therefore, all professionals shared similar opinions.

From the one-sample t-test with alpha set at 0.05, the sample mean of 3.60 ($Sd = 0.56$) was significantly different from the threshold rating of 3.0; $t(70) = 8.94$, $p < 0.0005$. Such level of significance implied that the observed ratings reflected a pattern, rather than chance. Therefore, there was compelling evidence to reject the null hypothesis in favour of the underlying alternative hypothesis. This suggested that integrating the assessment EC in the development approval process of building projects in Uganda enhances sustainable construction. The 95% confidence interval ranged from 3.46 to 3.73. The obtained effect size d of 1.06 indicated a large effect confirming that the difference between the threshold rating of 3.0 and the sample mean rating of 3.6 was reliably large enough. These findings empirically corroborate the assertion that accounting for carbon emissions from buildings can greatly enhance sustainable construction. Therefore, assessment of EC presents an opportunity for furthering the sustainability agenda of the building sector in Uganda, and perhaps, developing countries alike.

The descriptive statistics for eSC-Env, eSC-Eco, and eSC-Soc were as follows: eSC-Env ($Mean = 3.76$, $Sd = 0.59$), eSC-Eco ($Mean = 3.18$, $Sd = 0.72$), and eSC-Soc ($Mean = 3.74$, $Sd = 0.68$). Since the mean rating for each of the three variables was above 3, it implied that assessment of EC could potentially facilitate the third order state of sustainability – balancing environmental, economic, and social sustainability. However, statistically significant differences were found in the distributions of the three variables. The Friedman test indicated that: eSC-Env, eSC-Eco, and eSC-Soc $X^2(2, n = 71) = 49.68$, $p < 0.0005$. Inspection of the median values showed highest ratings for eSC-Soc ($Md = 3.83$), followed by eSC-Env ($Md = 3.73$), and lastly eSC-Eco ($Md = 3.17$). This finding showed that although social aspects were least understood as constituting sustainable construction (see Section 5.3), they would be enhanced to a greater extent than environmental and economic aspects. This suggests that integrating the assessment of EC in the development approval process of buildings could promote grasp of socially responsible construction practices.

6. Conclusions

Agenda on promoting sustainability in the building sector suggests that embodied carbon (EC) emissions should be considered in sustainability assessment of building projects. This is particularly important in developing countries where increased construction activities resulting from rapid urbanisation have impacts on the environment, in terms of carbon emissions.

This study provides evidence that construction professionals in Uganda are highly aware of sustainable construction. Although this could not be interpreted as prevalence of sustainable construction practices, it suggests that initiatives of promoting sustainable construction could be easily appreciated. Meanwhile, the concept of sustainable construction was found to be largely interpreted in terms of environmental sustainability. This implies that measures that highly promote environmental sustainability could be easily adopted.

It was found that integrating the assessment of EC in the development approval process of building projects can enhance environmental, economic, and social pillars of sustainable construction. This finding has provided new evidence to corroborate the assertion that assessment of carbon emissions from buildings can improve sustainable construction.

Furthermore it was found that amongst the three pillars of sustainable construction, social sustainability would be enhanced the most. This is evidence linking assessment of EC to promoting social sustainability.

Given the findings in this study, the authors contend that with appropriate adaptation, other developing countries can benefit from integrating EC assessment in their processes of building project approval if such integration is consistent with the proposal used in this study.

7. Recommendations

Making use of the findings of this work in the case of Uganda will require some initiatives not limited to the following recommendations:

a) Initiatives to increase the level of awareness of sustainable construction amongst various stakeholders are required in order to enhance sustainable construction and also potentially minimise conflicting interests. This is justified on the basis that although construction professionals were found to be highly aware of sustainable construction, the levels of awareness varied significantly amongst the various types of professionals.
b) Environmental sustainability should serve as the entry point to initiate promoting of sustainable construction since sustainable construction was found to be largely interpreted in terms of conserving the environment. To achieve this, the existing environmental policy framework, such as the National Environmental Act and the Environmental Impacts Assessment regulations, can be used.
c) The proposal used in this study should be piloted in the jurisdiction of Kampala Capital City Authority with a view of full implementation at a later stage. The piloting will provide more understanding of the different aspects of implementing the proposal.
d) The findings of this study only provide a foundation for further inquiries since data collected were limited to construction professionals. Therefore opinions of other stakeholders like external funders, developers, contractors, manufacturers, and construction material suppliers, are also necessary. This can be something to consider in further research.

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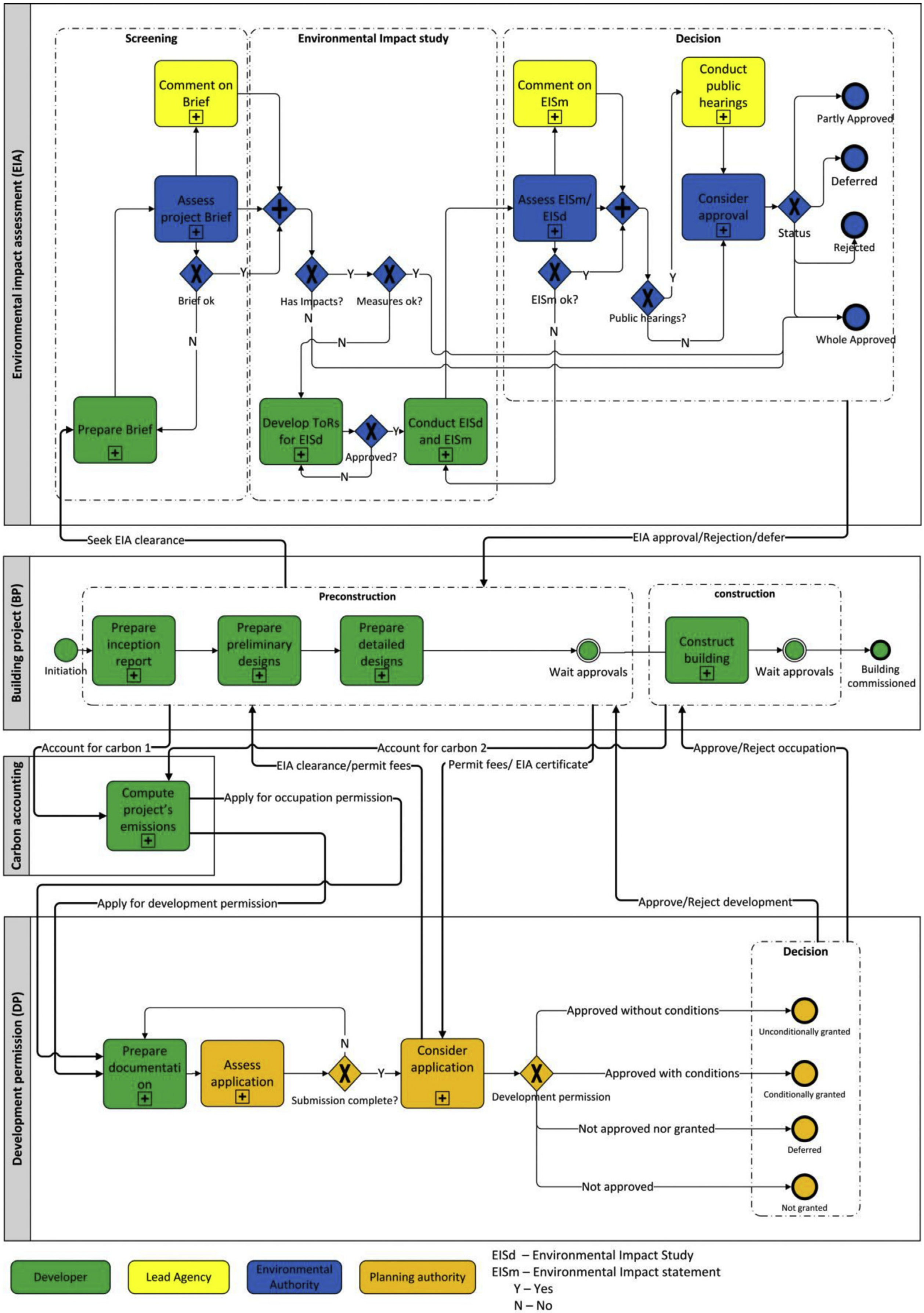
Appendix A

Integrating carbon accounting in the development approval process of buildings in Uganda.



Source: Kibwami and Tutesigensi (2016, p.338)

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