Infrastructure Design Stage Considerations for Environmental Sustainability in Zambia

Abstract

Purpose –While previous studies have highlighted the importance of incorporating environmental sustainability in building designs, there is a paucity of studies which assess the extent to which design teams in developing countries consider environmental sustainability at the building design stage. Therefore, using Zambia as a case study, this study examined the extent to which infrastructure design teams in a developing country consider environmental sustainability at the design stage.

Design/methodology/approach – The study employed a qualitative research approach using structured interviews because there are hardly any studies which have explored the extent to which designers incorporate environmental sustainability in infrastructure designs in developing countries. The data were analysed thematically using the ATLAS.ti software.

Findings - The results show that environmental sustainability is not an important design consideration because it is secondary to functional, technical and aesthic considerations. Environmental considerations are also made in an ad-hoc manner and when it is cost effective for the project. Regulatory requirements pertaining to environmental protection are adhered to without any cost considerations. It was therefore theorised that building design teams in developing countries make technical, functional and aesthetic consideration during the infrastructure design stage ahead of environmental considerations.

Originality/value – There is a paucity of studies that have investigated whether building infrastructure designers consider issues of environmental sustainability at the design stage in developing countries. The findings have practical implications on how developing countries can foster environmental sustainability at the design stage and avoid generating a building infrastructure stock that will require environmental resilience adaptation in the future.

Keywords: Environmental sustainability, Sustainable building design, Building sustainability challenges, Design considerations.

Introduction

The most important decisions regarding the sustainability of a building are made during the design and preconstruction stages (Azhar *et al.*, 2011; Raji *et al.*, 2017; Raji *et al.*, 2018; Othman and Abdelwahab, 2018). This is because the extent of the environmental sustainability of infrastructure cannot be significantly altered after it has been designed. Therefore, it is important that the design team pursues environmental sustainability at the design stage of infrastructure. This is because the construction industry is responsible for about 39% of the carbon emissions in the world (Müller *et al.*, 2013; Onat and Kucukvar, 2020). Therefore, building designs with low energy demand should help in reducing the building energy demand and subsequently reduce carbon emissions (Longo *et al.*, 2019; Abediniangerabi *et al.*, 2021). Therefore, building design teams can contribute to the current climate agenda of keeping the global temperature increase to within 1.5^{o}C of pre-industrial levels in order to avoid severe climate change and extreme whether events (Cronin *et al.*, 2021).

However, often, issues of environmental sustainability are generally not usually actively pursued at the design stage. For example, in a study with 25 in-depth interviews with industry practitioners focused on 10 buildings which achieved high sustainability certification ratings, it was found that environmental sustainability considerations were treated as an add-on to the infrastructure design process and followed an ad-hoc process for their implementation (Zanni, Soetanto and Ruikar, 2017). It appears that issues of environmental sustainability are not usually focal to the design process even in buildings which subsequently achieve sustainability certification rating even in developed countries. This is because, traditionally, building design philosophy is product oriented, market driven and with a strong focus on technical efficiency (Lopes, Fam and Williams, 2012). In Nigeria, designers usually incorporate fossil fuelled generators into building designs instead of providing environmentally sustainable solutions (Unuigbe *et al.*, 2020). In Tanzania, it was found that construction cost significantly influenced building designs because of the scarcity of resources (Mosha, 2018). A study in Finland also found that cost was the most prominent factor affecting the architectural and structural design (Karjalainen *et al.*, 2021). This is because cost and other design factors are the focal points of the design with environmental aspects often neglected (Longo *et al.*, 2019). Most developed countries have environmental sustainability regulations which guide the design of infrastructure and so compel the design teams to make environmental sustainability considerations at the design team. For example, all new building in the United States are required to achieve net-zero emissions by 2030, reduce water use by 26% by 2020, and divert 50% of non-hazardous solid waste and construction debris from landfills (Hardy and Valdes-Vasquez, 2015). In contrast, in developing countries, environmental regulatory frameworks are often weak with no guidelines for designers to adhere to environmental sustainability targets (da Rocha and Sattler, 2009; Howes *et al.*, 2017; Oke *et al.*, 2019). For example, in Zambia, environmental legislation pertaining to infrastructure only covers the impact the proposed infrastructure would have on the flora and fauna of the environment and does not consider issues of GHG emissions and the carbon-footprint of the final development. This raises questions about the extent to which the design teams in developing countries consider environmental sustainability at the design stage (Othman and Abdelrahim, 2020).

In view of the fact that environmental sustainability considerations are sometimes treated as add-ons even when pursuing sustainability certification (Zanni *et al.*, 2017) and the fact that building clients in developing countries rarely pursue sustainability certification, this study examined the extent to which infrastructure design teams in Zambia consider environmental sustainability at the design stage. This is because there is a paucity of studies on the extent to which design teams in developing countries consider environmental sustainability at the design stage. The few available studies which are related to the topic point to the fact environmental sustainability is never the focus of the design team and any sustainability considerations made are motivated by cost considerations. Owing to the paucity of studies, the study was exploratory in nature and so employed a qualitative research approach. Therefore, an initial exploration of the topic was necessary to establish the theoretical context of extent to which environmental sustainability is considered at the design stage of building infrastructure projects. Environmentally sustainable building designs could help to produce low energy demand buildings and so reduce carbon emissions, and therefore contribute to the current climate agenda of keeping the global temperature rise to below 1.5^{o}C of pre-industrial levels, and avoid generating a building infrastructure stock that will require environmental resilience adaptation in the future. This can be achieved by informing practitioners and policy makers about the environmental management

practices of infrastructure designers and so help formulate policy and guidelines to enhance environmental sustainability in infrastructure projects right from the design stage.

Design stage considerations

The following literature review shows that the design stage is an important stage at which the impact of infrastructure on the environment can be controlled (Azhar *et al.*, 2011). Therefore, it is important to consider designing with sustainability in mind. The review also highlighted key design considerations necessary for infrastructure and these include functionality, aesthetics and construction cost (Hamdy Mahmoud, 2017; Karjalainen *et al.*, 2021; Tang, 2018; Vinchu *et al.*, 2017). Design processes that help to incorporate environmental sustainability, challenges which hinder incorporating sustainability in designs, and solutions to some of the challenges were also highlighted.

The list of issues which designers need to consider before they finalise their designs is perhaps endless. However, functionality and aesthetics are always key considerations because the design must first meet the purpose for which it is intended and should do so in a visually appealing manner (Hamdy Mahmoud, 2017; Tang, 2018; Vinchu *et al.*, 2017). Functionality and aesthetics usually need to be achieved within a cost framework (Karjalainen *et al.*, 2021). Besides functionality, aesthetics and cost, the advent of global warming has made issues of environmental sustainability crucial.

In order to achieve environmental sustainability of buildings, studies have highlighted a myriad of factors which need to be considered at the design stage. For example, in a survey of architects, planners and property developers in Hong Kong, a factor analysis showed that for environmental sustainability in a densely populated urban area, the designs should consider land use planning, quality of life, conservation and preservation, integrated design, provision of welfare facilities, and conservation of existing properties (Chan and Lee, 2009). Another study on the design considerations for net zero carbon emissions for poultry infrastructure, found that the factors are similar to those for buildings and include reducing direct energy, improving energy efficiency, and using context specific renewable energy (Li *et al.*, 2022). Karjalainen *et al.* (2021) also found that the structural system selection, and the building form need to be considered in order to achieve environmental sustainability, while lack of expertise was found to be an obstacle.

Functionality is the ability of the infrastructure to meet the intended function. It is an important consideration because it determines whether the intended function of the infrastructure has been met. Functionality also plays a critical role in user satisfaction because it leads to designs which are effective, usable and beneficial (Hamdy Mahmoud, 2017; Vinchu *et al.*, 2017).

Functionality cannot be achieved without technical considerations to deal with aspects of the structural integrity of infrastructure. Some technical considerations include the structural system of the building, the geotechnical aspect of foundation design, and the structural frame of the building. These need considerations as precursors to achieving functionality. Geotechnical designs are required to establish the best foundation design to safely transmit the loads of the structure to a suitable bearing capacity sub-soil or bed-rock (Oyeyemi *et al.*, 2017). Technical considerations that optimise energy use such as heating, ventilation and air conditioning are also required (Hoyt *et al.*, 2015). Aluko *et al.* (2021) found that technical considerations required to meet clients' satisfaction were efficient analysis and compliance with client brief along with buildability, flexibility, and comprehensiveness of the design.

The design process must include considerations of the dimensions of aesthetics (Vinchu *et al.*, 2017). Aesthetics in building design refers to the beauty or visual appeal of the design (El-Darwish, 2019). Even in the design of structures such as bridges aesthetics is considered to be an integral, and not an additional, consideration (Tang, 2018). Aesthetics in building design is essential for the satisfaction of the end users (Hamdy Mahmoud, 2017; Weerasekara *et al.*, 2021).

Because clients often require their infrastructure to be delivered within a pre-agreed budget, designers always have to weigh their design solution with the available budget. For example, a qualitative study on the main design considerations on tall timber apartment buildings in Finland using found that construction cost was the most prominent factor affecting the architectural and structural design (Karjalainen *et al.*, 2021). The significance of construction cost on building designs is even more pronounced in developing countries were resources are scarce (Mosha, 2018).

Notwithstanding the importance of making environmental sustainability considerations at the design stage, traditional building design process are argued to be ineffective in meeting the demands of low energy architecture (Lapinskienė *et al.*, 2019). This is because traditional design processes can only analyse energy efficiency after the design is done and so have limited capacity to amend inefficient energy features (Li, 2017). Subsequently, several design processes have been suggested which focus attention on achieving environmental sustainability. For example, a design methodology was proposed which integrated the building design process and subsequently improved the energy functionality of a building in a case study (Lapinskienė *et al.*, 2019). Derrible (2018) suggested an approach for designing sustainable urban infrastructure. The approach follows a four step approach of 1) controlling the demand to reduce the need for new infrastructure, 2) integrating a needed service within the current infrastructure, 3) making new infrastructure multifunctional to provide for other infrastructure systems, and 4) designing for specific interdependencies and decentralising infrastructure if possible. The four step approach was developed by applying two sustainability principles of controlling demand and increasing the supply to the seven urban infrastructure systems of water, electricity, heating and cooling, telecommunications, transport, solid waste, and buildings. Kim and Kim (2020) suggested a framework for designing structures which is in tandem with the principle of keeping the consumption of resources low. The framework uses reusable materials by having a materials bank with a design support tool which. The main objective in this approach is to keep the consumption of materials low by reducing waste generation which is in tandem with the concept of controlling demand. The approach reduced CO_2 emissions by up to 77% because of material reuse. However, the cost was found to increase by up to 40% due to the cost of processing the reusable material. Magent *et al.* (2009) suggested a design process evaluation method for sustainable buildings. The process is comprised of 5 stages namely 1) determine the building's desired function and form the team; 2) develop a decision-based design model; 3) evaluate key decisions for value added based on timing and sequencing; 4) identify information considerations needed for key decisions; 5) and identify competency requirements for process implementation.

While there are several models for designing sustainable infrastructure, the overall decision to invest in sustainable infrastructure rests with the client. That is because the job of the design team is to deliver according to the client requirements. Therefore, the design team must ensure that the client requirements and objectives are clearly understood (Leung, Ng and Cheung, 2004). However, because it is expected that the designers are experts, clients are often not adequately involved in the project (cf. Ann *et al.*, 2010; Trigunarsyah, 2017). Therefore, clients are very important in the decision to design sustainable infrastructure.

Notwithstanding the importance of considering environmental sustainability at the design stage, several challenges hinder its incorporation in building designs. These challenges include the perceived high cost of sustainable buildings materials, limited understanding of the benefits of sustainable construction, and inadequate knowledge by professionals (Aigbavboa, Ohiomah and Zwane, 2017; Ametepey, Aigbavboa and Ansah, 2015; Leoto and Lizarralde, 2019; Nasereddin and Price, 2021; Pham and Kim, 2019; Probst *et al.*, 2019; Safinia *et al.*, 2017; Tabassi *et al.*, 2016). In assessing challenges facing sustainable construction adoption in South Africa, Aigbavboa, Ohiomah and Zwane (2017) found that the assumption of additional cost and a limited understanding of the benefits of sustainable construction were among the most common barriers to sustainable construction. Ametepey, Aigbavboa and Ansah (2015) found that higher investment costs and lack of professional knowledge were some of the prominent barriers to the implementation of sustainable construction in Ghana. It is therefore important that when assembling the design team for a sustainable building, the core competencies of the team should be considered in order to identify individuals with specific competencies required and the team collaborates to achieve the desired function of the building (Magent *et al.*, 2009; Moyo and Chigara, 2021). Safinia *et al.* (2017) found that the high cost of sustainable building materials and lack of knowledge regarding sustainable construction materials contributes to low level of adoption of sustainable construction in Oman. Nasereddin and Price (2021) found that the capital cost of a sustainable certified building in Jordan is around 20 to 25% above the capital cost of a traditional building. It is worth noting that factors which affect the adoption of sustainable construction practices will inevitably affect the consideration of of environmental sustainability at the design stage. From the above studies, it is clear that, while several other factors emerge from literature that affect the adoption of sustianble construction practicethe cost (or perception of it) of sustainable building is the main factor hindering the widespread adoption of sustainable construction in developing countries.

Some measures have been recommended to improve the adoption of sustainable construction. Leoto and Lizarralde (2019) recommended deepening professionals' knowledge of Life Cycle Assessments in order to overcome some of challenges associated with poor adoption of sustainable construction. In a similar vein, Tabassi *et al.* (2016) also aluded to the relevance of the imprtance of intelectual competence of project managers as a signficant factor contributing to sustainable building accomplishment. Pham and Kim (2019) also pointed out that leadership competences strengthen the environmental practices and sustainability performance relationship.

The literature review has revealed that the design stage is perhaps the most important stage at which the impact of infrastructure on the environment can be controlled (Azhar *et al.*, 2011). Factors which need to be considered at the design stage in order to achieve environmental sustainability were highlighted and include conservation and preservation of resources, reduction of energy demand and integrated design approaches among others (Chan and Lee, 2009; Karjalainen *et al.*, 2021; Li *et al.*, 2022; Sobala and Rybak, 2017). Other design considerations are functionality, aesthetics and construction cost (Hamdy Mahmoud, 2017; Karjalainen *et al.*, 2021; Tang, 2018; Vinchu *et al.*, 2017). Several design processes which aim to achieve environmental sustainability at the design stage were also highlighted (Derrible, 2018; Kim and Kim, 2020; Lapinskienė *et al.*, 2019; Magent *et al.*, 2009). Subsequently, challenges hindering associated with the adoption of environmental sustainability at the design stage were highlighted and these include the perceived high cost of sustainable buildings materials, limited understanding of the benefits of sustainable construction, and inadequate knowledge by professionals (Aghimien *et al.*, 2019; Aigbavboa, Ohiomah and Zwane, 2017; Ametepey, Aigbavboa and Ansah, 2015; Leoto

and Lizarralde, 2019; Nasereddin and Price, 2021; Pham and Kim, 2019; Probst *et al.*, 2019; Safinia *et al.*, 2017; Tabassi *et al.*, 2016). Some suggested measure to curtail the challenges were highlighted and these include deepening professionals' knowledge and leadership competence training (Leoto and Lizarralde, 2019; Pham and Kim, 2019; Tabassi *et al.*, 2016).

It is evident that the design stage is very important for ensuring environmental sustainability of buildings (Azhar *et al.*, 2011; Raji *et al.*, 2018) and several design processes and initiatives have been proposed for incorporating environmental sustainability into building designs (Derrible, 2018; Kim and Kim, 2020; Lapinskienė *et al.*, 2019; Magent *et al.*, 2009). However, there is a paucity of studies which have assessed the extent to which developing countries make environmental sustainability considerations at the design stage of building infrastructure. The little available literature on the matter suggests that design teams hardly ever make environmental sustainability considerations at the design stage. An assessment of the extent to which design teams in developing countries incorporate environmental sustainability at the design stage of building infrastructure is necessary in order to establish measures which need to be taken in order to avoid generating a building infrastructure stock that will require environmental resilience adaptation in the future.

Research methods, participants and sampling

In order to establish the extent to which environmental sustainability was pursued at the design stage, an exploratory qualitative research approach with semi-structured interviews was used to examine the design process followed by infrastructure design teams in Zambia. An exploratory qualitative approach was used because there are hardly any studies exploring design practices in infrastructure projects in sub-Saharan Africa or developing countries in general and so the topic is fairly new and data not available. Because semi-structured interviews permit a deeper understanding of the opinions of the respondents while fairly reasonably objective (Carruthers, 1990; Horton *et al.*, 2004), they were favoured over structured and unstructured interview. This is because structured interview are rigid and unstructured interviews are difficult to analyse varying question (Horton *et al.*, 2004). Because the study was exploratory in nature, the qualitative approach was appropriate (cf. Madter *et al.*, 2012). This is line with the recommendation that qualitative studies are more appropriate for research in relatively new areas of research where there is uncertainty about the conceptions under investigation (Basias and Pollalis, 2018). Therefore, we adopted a qualitative research approach to generate theory based on data from selected building construction projects in Zambia (cf. Denzin and Lincoln, 2011; Eisenhardt, 1989). Multiple cases of building design processes were considered to develop insights on the form and extent of consideration of environmental sustainability in building designs in Zambia (cf. Yin, 2009).

In order to select participants for the study, medium to large infrastructure projects either recently completed or under construction were first identified. Because it is common sometimes for infrastructure to be fully designed outside the country and marginally modified to fit the local context, only projects fully designed locally were included in the sample. The projects were identified by asking known practitioners in the architectural, construction and engineering sector in Zambia about recently completed or on-going infrastructure projects in the country. Subsequently, the design team for the project was identified and contacted for willingness and availability to participate in the study. The range of projects covered in the study included shopping malls, warehouses, packaging manufacturing process plant, and a multi-facility

complex. The design teams included architects, quantity surveyors, civil and structural engineers and electrical engineers.

Subsequently, a sample of 14 interviewees was obtained comprising of mostly senior members of building design teams. Braun, Clarke and Gray (2017) argue that large sample sizes are not critical determinants of quality in quantitative studies. This is because qualitative studies from a relatively small sample can still results in a broad range of core issues when the interviewees have experienced the phenomenon in question (Starks and Brown-Trinidad, 2007). Several qualitative studies have reported findings from relatively small samples ranging from one to ten interviewees (e.g. d'Young, 2008). Subsequently, several qualitative studies have reported findings from relatively small samples ranging from one to ten interviewees (e.g. d'Young, 2008). This is because rich knowledge from a purposefully selected small sample presents unique strengths of qualitative research even though this has been highlighted as a limitation in some studies (Smith, 2018). Therefore, a sample of 14 was considered adequate. Further, the interviews produced repeating comments suggesting that information redundancy was reached which also suggested data saturation (Saunders *et al.*, 2018). The sample comprised of thirteen male (93%) and one female (7%) participants each with a minimum of a university bachelor's degree in a construction related field and industry experience ranging between five and 23 years. Because the participants were fairly well educated and experienced, there is evidence of the truth value of the study findings.

[Insert Table 1: Sample Demography]

Study area

Zambia is a large, resource rich, sparsely populated landlocked country in the centre of Southern Africa which shares its borders with eight countries (Angola, Botswana, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, and Zimbabwe) (World Bank, 2021). It has an average per capita CO_2 emission of 0.36 tonnes compared to a world average of about 4 tonnes with an annual CO_2 emission of 6.7 million tonnes which translates to less than 0.01 per cent of the world emissions.

Data collection and analysis

All the interviews were conducted using an online meeting platform. The online platform was preferred because of the convenience of the interviews being conducted in the comfort of both the interviewer and interviewees' premises in view of the Covid-19 pandemic. The duration of the interviews ranged between 13 minutes and 27 minutes with an average of 20 minutes. All interviews were recorded, transcribed verbatim using online transcription software, checked and corrected manually and thematically analysed using the Atlas.ti software. Consent to record the interviews was obtained from each participant at the start of the interviews. The analysis process was undertaken based on the content analysis process principles that focus on consolidating data collected during interviews (Wolcott, 1994). Based on Maciel, Ford and Lamberts (2007) we analysed the transcribed interview data using a combination of categorisation, condensation and deeper interpretation to answer the research questions. During categorisation, data were grouped into the key building design and sustainability concerns. The analysis process focused on identifying the key factors that construction design professionals consider when developing infrastructure designs (cf. Li, Strezov and Amati, 2013) and establish the extent to which environmental sustainability is taken into account. The interview schedule was framed around a

set of core questions focusing on establishing the key issues that professionals considered during the design stage of buildings with the aim of mapping out the critical design considerations and establish whether designers regarded environmental sustainability as an essential design consideration. Prior studies have shown that the target practitioners in the Zambian construction industry are fairly knowledgeable about environmental sustainability (Oke *et al.*, 2019; Phiri and Matipa, 2004). Therefore, to avoid bias in the assessment of the extent to which the interviewees considered aspects of environmental sustainability at the design stage, the core question relating to the design process did not initially allude to environmental sustainability. Environmental sustainability considerations were probed last in the interview only after a neutral evaluation of the design process and client involvement was done. This approach ensured that aspects which the designers felt were cardinal to consider in the design process were established first. As expected, the key design considerations did not initially include environmental sustainability but the follow up questions which were environmental sustainability specific showed the environmental sustainability factors considered at the design stage.

Findings and discussion

The themes for the considerations made at the design stage of infrastrcutire developmenet made in Zambia which were extracted from the interview transcripts are summarised in Figure 1. The themes show that designers consider technical, functional, aesthetic, and environmental aspects of the infrastructure during the design stage. However, it is worth noting that when the questions were asked without referece to environmental sustainability, no themes of environmental sustainabilty emerged from the data. It is interesting to note that environmental sustainability does not seems to be an important consideration because, unless it is specifically queried, the designers do not mention it as a key consideration. Environmental considerations are therefore made in an ad-hoc manner and when it is cost effective for the project. Therefore, it was theorised that building design teams in Zambia make technical, functional and aesthetic consideration during the infrastructure design stage ahead of environmental considerations. Environmnetal considerations made in an ad-hoc manner include energy use and conservation, and the environmental legal framework. This is in tandem with Zanni, Soetanto and Ruikar (2017) who found that environmental sustainability considerations were treated as add-ons even for infrastructure which achieved high sustainability certification ratings. This also resonates with the conclusion by Lopes, Fam and Williams (2012) that building designs are product oriented, market driven and with a strong focus on technical efficiency. This can be attributed to the fact that the design team must ensure that they respond to the requirements of the client (Leung, Ng and Cheung, 2004). This means that when the client has not specifically requested for environmental sustainability considerations, the design team will not strongly focus on them.

***[Insert Figure 1:** Results (Open codes, axial codes, selective themes and theory)]*

Technical Considerations

The results show that technical considerations are one of the most important considerations made at the design stage. In the context of this study, technical considerations refer to the design aspects which are required to make the project workable to meet the expectations of the client. The specific technical consideration made broke down into structural, design and the requirements of the project. The structural considerations focused on the geotechnical properties of the sub-soil, the

choice of frame system and the structural design suitable for the infrastructure. This can be seen in participant comments such as, ". . . *of course we would be interested in the topography of the site. That is number one, the number two, geotechnical investigations are also very important* . . ." (P1). P2 said, "*Well, the initial important factor is the foundation; that is critical . . ., you have to pay extra care to ensure that, you know, the foundation doesn't fail."* P11 said, ". . . *especially the structural aspect of the building where we're able to advise the architect that this may work and this may not work and where they can consider certain other things"* Oyeyemi *et al.* (2017) equally highlighted the need for geotechnical considerations at the design stage. Technical considerations are also used to optimise energy use such as for heating, ventilation and air conditioning (Hoyt *et al.*, 2015). Because traditionally building design philosophy is product oriented, market driven and with a strong focus on technical efficiency (Lopes, Fam and Williams, 2012), it is not surprising that participants felt that the technical considerations are a crucial consideration at the design stage.

Functionality

The next key consideration identified from the data was the emphasis on designing a building that conforms to the functional requirements of the clients. Functionality refers to the ability of the infrastructure to effectively meet the requirements of the client and so serve the intended needs. Two aspects of functionality emerged and these are the building services for the infrastructure and the specific requirements of the clients. Building services such as ventilation, air conditioning, and other facilities require consideration at the design stage in order to achieve functionality. Other than that, the specific needs of the client such as the design layout, reticulation, and all desired functions are important considerations to achieve design functionality. These can be seen in comments such as, *"…they [clients] had their own specific way for how the entire development should be arranged . . ."* (P4) P5 said, "*So we came up with some functional structures for the warehousing and also for the bulking centre . . ."*. Functionality is said to be the most important aspect of space design (Vinchu *et al.*, 2017). It is therefore not surprising that participants highlighted its importance as a design consideration. Functionality is critical for user satisfaction and so is also an important determinant of design effectiveness (Hamdy Mahmoud, 2017; Vinchu *et al.*, 2017).

Aesthetics

Aesthetics also emerged as an important consideration in the design process. Aesthetics is a complex property in architecture but generally refers to how visually pleasing a design is (El-Darwish, 2019; Vinchu *et al.*, 2017). Aspects of aesthetics which emerged from the data include that designs should be appealing, attractive, modern, and unique. This can be seen in comments such as,*"… one behaviour or characteristic that most of the clients have is that they will want the building to maintain its aesthetics, functionality and all other required design aspects"* (P7). P5 added that, . . . *and beyond functionality we tried to bring in a bit of aesthetics so that they are also aesthetically appealing and attractive."* Aesthetics play a crucial role ensuring user satisfaction and so contribute to meeting the design requirements (Hamdy Mahmoud, 2017; Tang, 2018). It is therefore not surprising that it emerged as an important consideration in designs.

Environmental sustainability considerations

None of the interviewees initially expressly mentioned environmental sustainability related aspects as one of the factors they considered during the building design process. As highlighted in the methodology, the core question relating to the design process did not initially allude to environmental sustainability in order to avoid leading the interviewees. It was felt that this

approach would yield an unbiased description of what is actively considered at the design stage. However, when probed further, most interviewees stated that environmental sustainability was considered on projects. Subsequently, three sub-themes for environmental sustainability emerged and these are energy, conservation and the environmental legal framework.

Energy Efficiency

Energy use emerged as an important consideration at the design stage of building infrastructure. This theme captured highlighted the need to consider the use of renewable energy, natural lighting, and natural ventilation in building designs in order to enhance the environmental sustainability of the infrastructure. These considerations were subject to them being cost effective. For example, some interviewees reported that they incorporated solar electric energy and energy-efficient appliances in their designs if they are cheaper than electric power from the national grid. There were comments like, *"…..we also advise them to see if in the long run such materials and such systems, i.e. solar, LED lighting and the lights are cheaper on the life costing of the project"* (P5). The need to consider the efficient use of energy in designs was also highlighted by Li *et al.* (2022) who found that using context specific renewable energy was important. Context specific renewable energy in our case points to the use of solar energy due to its abundance in sub-Sahara Africa. However, it is worth noting that energy efficiency was only accepted as a design solution when it was more cost effective than other solutions.

Conservation

The need to conserve resources including energy emerged as an important design stage consideration for environmental sustainability. The results show that resource and energy conservation can be achieved through building insulation, water use, and pollution control. The sub-theme of conservation is similar to findings by Chan and Lee (2009). In a study on design considerations in Hong Kong, and interestingly while using a quantitative approach, Chan and Lee (2009) equally found that pollution control is one of the items which contributed to environmental sustainability in a factor analysis cluster which they labelled Conservation and Preservation. This similarity provides some backing for the validity of the axial codes in the environment theme. The importance of reducing energy use and increasing energy efficiency were also found by Li *et al.* (2022).

Legal Issues

Regulatory requirements on environmental sustainability were highlighted as being a factor that led to incorporating sustainability in building design. Regulations generally impose a requirement of environmental protection on building projects. The need to comply with these regulations is evident in some comment. For example, P1 said, *". . . right before we started this project, definitely it was mandatory looking at the magnitude of this project, that we did an environmental impact assessment …"* Further, P9 mentioned that *"… [The environmental regulator] looks at the design and [decides whether they are], environmentally friendly. . . even the local authority, because these drawings are sent to them for approval"*. This finding shows that regulations force the design team to consider environmental sustainable irrespective of the associated cost of doing so because it is not optional. This findings is new and has some significant implications. Considering that cost was found to be the main hindrance to designing with sustainability in mind, regulations can be used to make sustainability consideration mandatory so that cost will no longer present a challenge.

***[Insert Figure 2**: Reasons for not implementing sustainable designs]*

The participants were queried for reasons why environmental sustainability was treated as a secondary ad-hoc consideration subject to the primary design considerations. The results are shown in Figure 2. The results show that cost knowledge, expertise, leadership and materials are the reasons why sustainability is not pursued at the design stage. It is worth noting that all instances where environmental sustainability considerations were made, cost was the driver. The comments suggest that designers will actively pursue environmental sustainability only if it is cost effective. In this case, cost effectiveness is viewed as when the whole life cost of sustainable solutions is equal to, or less than, conventional alternatives. The significance of cost as a determinant of architectural and structural designs was also found in a study in Finland (Karjalainen *et al.*, 2021). The comments show that the interviewees felt that environmentally sustainable designs are more expensive than traditional solutions and therefore not cost effective and so were not pursued. This can be seen in comments like, *". . . on the implementation of sustainable designs, we, unfortunately, didn't do much…., most of the options we had wanted to consider were substantially expensive to us. And looking at the size of the project, they weren't really cost effective. It was a bit expensive for us to go into that at that time"* (P1). In this regard, P11 gave an example of a project where they failed to incorporate sustainable design due to cost considerations by stating that, *"The major reason is [that] the initial costs of implementing a sustainable design are huge…. Among the things [we considered], for example, the sewer system was designed in such a way that the effluent will be processed and the resultant water will be good enough to drink actually. But the treatment plants itself, I think had a cost almost of 300 thousand dollars of which the client wasn't ready to incur".* Further P13 stated that, "… *when you start talking about sustainability, you start talking about going green and [that] means having a project that's capital intensive*…" P2 summed up the impact of cost by stating that, *"It's obviously for them to choose whether they can afford to or want to go down that route".*

The interviewees seem to unanimously agree that the main reason sustainable building solutions are not pursued is their high cost compared to traditional solutions. This finding is in line with many other studies which have found that costs is one of the most significant factors which hinders the adoption of environmentally sustainable solutions in the built environment (cf. Aigbavboa, Ohiomah and Zwane, 2017; Ametepey, Aigbavboa and Ansah, 2015; Nasereddin and Price, 2021; Obianyo *et al.*, 2021; Safinia *et al.*, 2017). Therefore it is not surprising that the interviewees highlight cost as the reason for not incorporating environmental sustainability in the designs.

Other factors besides cost which were given for not incorporating environmental sustainability in the designs include lack of leadership on sustainability on the project, lack of expertise and knowledge of sustainability, and unavailability of sustainable building materials. There were comments such as, "*I would say that practically from my experience, it rarely happens because the team leader again must have that aspect in mind; that he needs to engineer his team towards thinking through the sustainability issues of the project*" (P7) P5 added, ". . . *in terms of choices of materials, there seems to be not much on the market that gives you a lesser footprint or sustainable materials that can be used on a commercial building of that nature.*" Therefore, lack of leadership, lack of expertise and knowledge, and the unavailability of sustainable building materials also limits the amount of sustainability considerations made at the design stage. There is need for the designers to keep up to date with advances in science and technology because designers who are up to date have more chances of keeping up with new developments (Pariafsai, 2016) such as sustainable designs.

These findings are not surprising because other scholars have also found similar results. Aigbavboa, Ohiomah and Zwane (2017) also found that a limited understanding of the benefits of sustainable construction were among the most common challenges facing the adoption of sustainable construction in South Africa while Ametepey, Aigbavboa and Ansah (2015) found that

lack of professional knowledge were some of the prominent barriers to the implementation of sustainable construction in Ghana. It was also found that leadership competences strengthen the environmental practices-sustainability performance relationship (Pham and Kim, 2019) and that the intellectual competence of project managers represents the most considerable factor on sustainable building accomplishments (Tabassi *et al.*, 2016). Therefore, the findings here collaborate other findings and show that these factors also affect the extent to which environmental sustainability is considered at the design stage.

Conclusion

The objective of this study was to get insights into the extent to which construction design professionals in a developing country give consideration to environmental sustainability at the building design stage using Zambia as a case. The findings show that environmental sustainability considerations are only made as secondary add-on considerations when the sustainable alternatives are found to be cost effective. The primary focus of designers is to achieve design functionality which is aesthetically pleasing and meets the technical requirements of the needs of the clients. Besides this, only regulatory requirements pertaining to environmental protection are adhered to without any cost considerations. Factors which limit the extent to which environmental sustainability is considered at the design stage are lack of leadership on sustainability on the project, lack of expertise and knowledge of sustainability, and unavailability of sustainable building materials.

The findings suggest that for as long as sustainable solutions are seen to be more costly than traditional alternatives, environmental sustainability will not be a consideration at the design stage of the project. It is important to promote environmentally sustainable designs because it is more difficult to incorporate environmental sustainability later on in the project. Also, while issues of GHG emissions from buildings is not yet topical in developing countries, it is likely to become so as the effect of global warming becomes more pronounced. Designing environmentally sustainable and resilient buildings could avert the problem of adapting existing buildings to make them more environmentally sustainable. Considering that the findings show that designers adhere to environmental protection regulations without regard to cost, legislation and regulations can be used to compel designers to incorporate environmental sustainability in building designs. In this regard, legislation can stipulate environmental sustainability targets such as GHG emissions and energy efficiency targets of buildings which designers need to show that they have adhered to. This can help developing countries avoid a building stock which is not environmentally sustainable and requiring adaptation. Most developed countries have already legislated environmental sustainability targets for buildings and are also working on retrofitting existing buildings to make them more environmentally sustainable.

While the study has some important practical implications, it is also subject to some limitations and so the findings need to be considered with some caution. The most significant limitation is that the sample was selected purposively and the size is relatively small. Notwithstanding, Smith (2018) argued that even if small sample sizes are highlighted as limitations in some studies, the rich knowledge of purposefully chosen samples are unique strengths of qualitative research. Also, the findings have not been validated. Therefore, future studies can focus on a qualitative study to validate the factors which hinder the consideration of environmental sustainability at the design stage.

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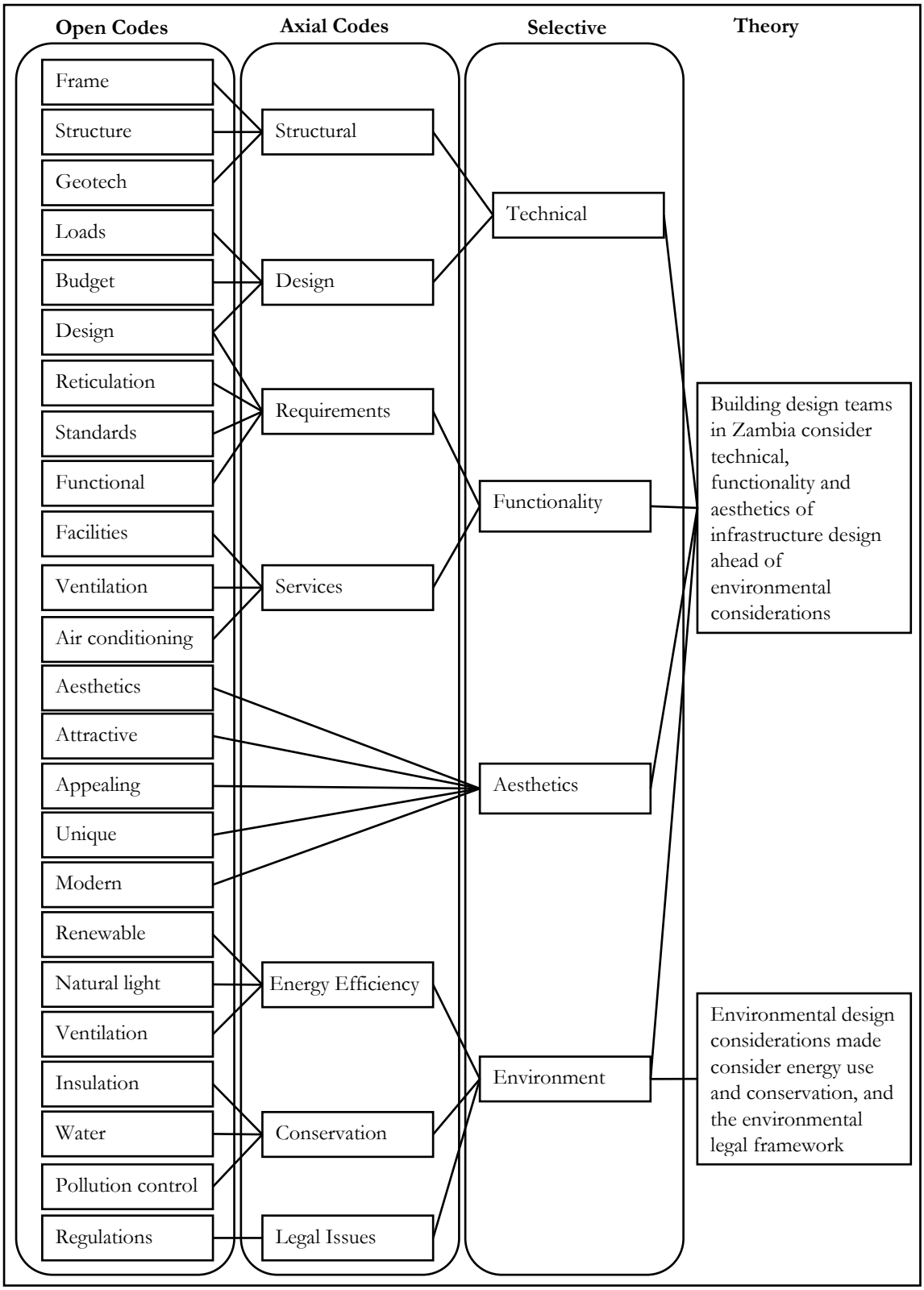

Figure 1: Results (Open codes, axial codes, selective themes and theory)

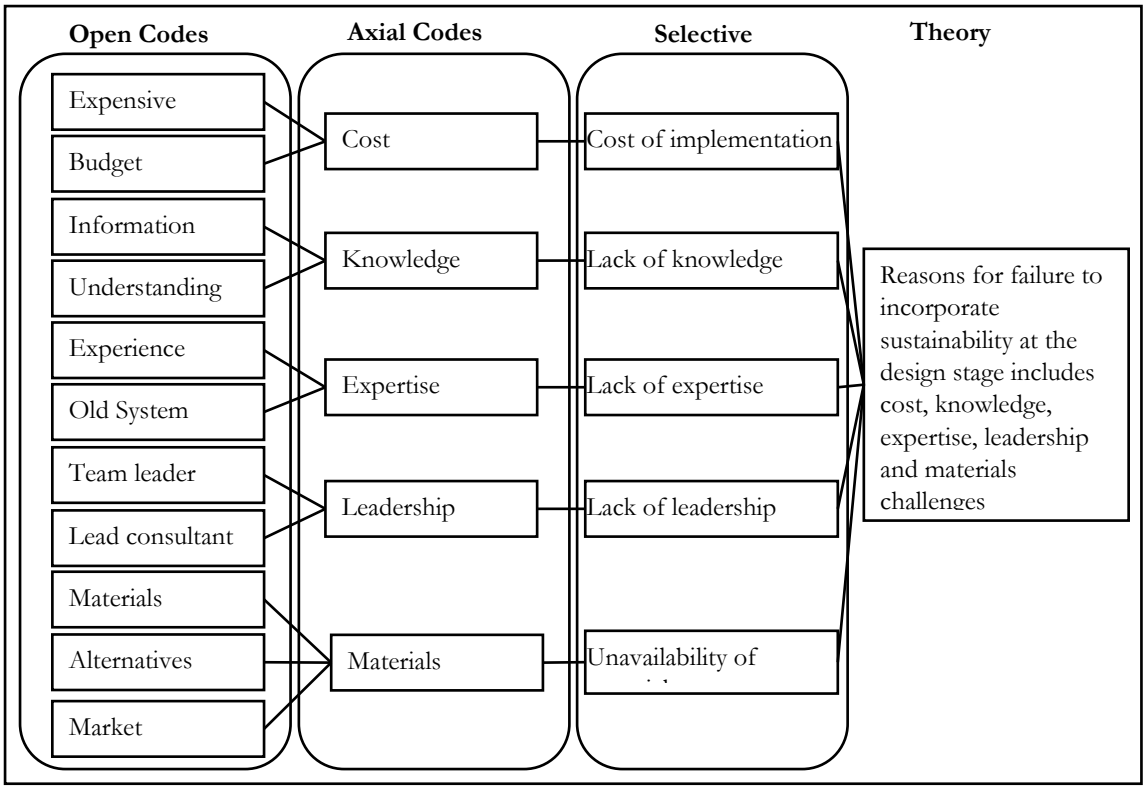

Figure 2: Reasons for not implementing sustainable designs

Table 1: Demographic Information

Category	Frequency	Percent
Profession		
Architecture	4	29
Quantity Surveying	4	29
Structural Engineering	4	29
Electrical Engineering	2	13
	14	100
Education		
Undergraduate degree	11	79
Master's degree	3	21
	14	100
Experience in construction Industry		
5-10 years	2	14
10-15 years	5	36
Over 15 years	7	50
	14	100
Gender		
Male	13	93
Female	1	7
	14	100