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Barriers to the Adoption of Green Building Materials and Technologies in Developing Countries: The Case of Burkina Faso

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BARRIERS TO THE ADOPTION OF GREEN BUILDING MATERIALS AND TECHNOLOGIES IN DEVELOPING COUNTRIES: THE CASE OF BURKINA FASO

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ABSTRACT

This research examines barriers to the adoption of green building materials and technologies in developing countries, using the case of Burkina Faso. Developing countries understand the need to incorporate sustainability as part of their national agenda; however, their ability to implement it is hampered by actual and/or perceived barriers. To gain insight on these barriers, this study solicited perceptions from various stakeholders from the design and construction field in Burkina Faso. The barriers explored in this research are grouped into the following five categories as defined in the literature: (1) government, (2) human, (3) knowledge and information, (4) market, and (5) cost and risk. A mixed method sequential exploratory design using both quantitative (i.e., online questionnaire) and qualitative (i.e., semi-structured interview) tools was carried out.

In the quantitative phase, descriptive and inferential analysis was employed to identify the most prevalent barriers within the five categories in Burkina Faso. In the qualitative phase, data was gathered from interviews and archival data, and inductive analysis was used to develop interpretive themes and explanatory concepts.

The findings from the two phases identified 31 barriers to the adoption of green building materials and technologies, with 14 barriers specific to Burkina Faso itself. These barriers were either confirmed by the literature or identified as specific to Burkina Faso.

Findings were compared to the existing literature from the United States of America as a representative of developed countries to help anticipate how to avoid barriers as Burkina Faso develops its built environment.

From the understanding of the barriers, guidelines were developed, which are the first step to initiate changes in policies and practices aimed at increasing green design and construction in Burkina Faso, and in West Africa in general.

DEDICATION

This dissertation is firstly dedicated to my country Burkina Faso, which inspired this research, and whose design and construction professionals generously gave of their time in order to answer my questions. May you always remain the country of "morally upright men".

Secondly, it is dedicated to my ancestors and to my late maternal and paternal grandparents who started our family on this journey of continued knowledge seeking, by encouraging us to always break boundaries. May you all rest in peace.

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CHAPTER ONE

INTRODUCTION

Rising environmental problems, such as deforestation, land degradation, and pollution leading to global warming, diminishing natural resources, and an increasing waste production, necessitate professionals in a variety of disciplines to rise to the challenge to mitigate these problems (Intergovernmental Panel on Climate Change report; Metz et al., 2007). As non-green buildings negative impacts contribute to these environmental problems, there has been a global call to all concerned stakeholders for more sustainable practices at all levels of society, from governmental entities, to businesses, to design and construction professionals, to individuals in society.

Climate change (is defined as the extended and persistent changes in the state of the climate, usually in terms of decades or centuries) has been extensively researched, especially as we observe its impact on our environment, such as carbon dioxide increasing globally (a primary greenhouse gas), rising temperatures and sea levels. Research on population growth finds that rapid population growth not only impacts dwindling global resources, but it has been found to be an additional driver to the increase in carbon emission, as well as a significant barrier to climate change adaptation and mitigation (York et al., 2003).

Such research has led to a growing scientific consensus that climate change is occurring due to global warming (Parkinson & Cavalieri, 2002). The IMF (2000) report found that climate change will have the most impact on developing countries even though their carbon footprint is currently smaller than developed countries. This is especially true for countries in sub-Saharan Africa who have fragile ecosystems and are already struggling to cope with the impacts of that climatic variability (Cooper et al., 2008).

Burkina Faso's climate shares many similarities with most of the Sub-Saharan countries, and therefore will be impacted by the effects of rising climate change. As such, this research using the case of Burkina Faso can provide significant help in outlining climate change adaptation policies both in Burkina Faso as well as in other Sub-Saharan African countries. Burkina Faso is also experiencing a rapid population growth which has been projected by the UN to increase from 20 million to 29 million by 2030.

The Organization for Economic Co-operation and Development (OECD) (2007) report found that almost half of the current global population live in urban areas, and that in the next 30 years, the majority of the 2 billion increase in global population will live in urban areas in developing countries. This exploding urban growth in developing countries, such as in Burkina Faso, will strain the capacity of most of its cities to provide adequate services for its citizen if current policies follow business as usual. This will increase the pressure on energy demand and supply capacity, increase demand for housing especially social housing, scarce resources, and ageing infrastructures.

The construction industry has had an impact on a country's development since the Industrial Revolution. Studies such as (Turin, 1973; World Bank, 1984; Wells, 1986) have tried to model this relationship, and they found a positive correlation between several measures of construction output and the level of income per capita, despite issues with data reliability, analysis methods, and study limitations. Further studies such as (United Nations, 1969; World Bank,1984; GEMINI, 1991; Ebohon, 2000; Ofori, 2000; Mlinga & Wells, 2002) have theoretically and empirically recognized the role of the construction industry in the economic and social development of a country.

World Bank (1994) found that developing countries should focus on improving the quality of their infrastructures, instead of just increasing the number of their infrastructures. The use of sustainable construction methods and green materials and technologies could help in this regard.

After the United Nations Millennium Declaration at the Millennium Summit in New York in September 2000, the role of the construction industry as part of a country's development has gotten a new life. Eight Millennium Development Goals (MDGs), measured through 21 targets, were devised at this summit. According to the international development agencies, the services provided by infrastructure have an unescapable effect on the economic and social targets related to the MDGs (Lopes, 2011).

Therefore, there is an urgent need for all stakeholders to understand barriers to the adoption of green building materials and technologies in West Africa, and in Burkina Faso in particular, especially if such countries want to increase their economic growth and development, while mitigating the projected impacts of climate change

1.1 Sustainable construction

Sustainable construction or Green Building Design is defined as "a holistic process which starts with raw material extraction, continues through the planning, design, and construction of buildings, and ends with their demolition and management of the resultant waste" (Carassus 2004). Depending on the literature, Sustainable Construction has other names such as Ecological Design, Green Architecture, and Green Design. One issue with the words sustainability and ecology is that they have been used in various industries, making them so commercialized, that their definitions have become to a certain extent clichéd and ambiguous. White (2013) quoted this anecdote about the numerous definitions of sustainability, "at a conference in 2008, a

speaker humorously bet that there were about 2000 definitions of sustainability in a room of, one supposes, about 2000 people". According to Johnston et al. (2007), "while there may not be quite that many definitions, one does commonly hear that there are at least 300".

McLennan (2004) defines Green design as "a design concept which optimizes construction quality in order to reduce the negative effects construction has on the natural environment". The researcher is adopting the following definition for Green Building as "construction which uses energy and resources in an efficient manner throughout the life cycle of the building (which include the materials and technologies used in the design), its design, usage, demolition, and across all building sectors (commercial, residential, new buildings and retrofits)".

Although this research focuses on green materials and technologies, water and energy consumptions are important components of sustainability. The research was not designed specifically on these two components, but the researcher let them emerge via the participants' answers.

Furthermore, sustainable construction in the real definition of the word can be distinguished from green design because of its long-term approach to environmental protection, as well as incorporating social and economic development. Each stage of the design process is optimized to reduce negative impacts and to improve quality of life without depleting natural resources, and usually incorporate components of water and energy conservation. Its primary focus is to not only build a building, but to preserve and build the future. As such we cannot yet reach the goal of being a 100% sustainable as it is an utopic ideal, we can only get as close to sustainability as possible based on our currently available green materials and technologies.

1.2 What are developed and developing countries?

It is safe to say that sustainable practices have improved globally in the last few decades, with a rise in the construction of green buildings and in the utilization of green materials. This has engendered local and global standards regarding the development, implementation, and assessment of buildings throughout their lifetime. However, the degree to which stakeholders commit to these sustainability plans and their ability to implement them successfully differs based on existing and perceived barriers to the implementation of sustainable projects and technologies (United Nations 2012).

The World Bank (2018) defines developed and developing countries based on their Gross National Income (GNI) per capita per year. In this instance, a developed country has a GNI of US$12,376 or more, and a developing country has a GNI of $12,375 or less. The United Nations Statistics Division (2013) expanded the definition of developed countries by saying one must look beyond the Gross National Income (GNI) and the Gross Domestic Product (GDP). They stated that developed countries have also reached a high level of continuous, self-sustaining economic development with a high rate of industrialization, and their standards of living are considered high. In terms of design and construction, they tend to have green building guidelines and assessment tools as opposed to developing countries. Countries defined as developed countries, include Australia, Canada, Japan, Korea, most of Europe, New Zealand, and the United States of America. Such countries are usually heavily involved in research on green materials and technologies.

Most of Africa, Asia (not including Japan), the Caribbean, Oceania (not including Australia and New Zealand), and Central and South America are defined as developing countries. In terms of design and construction, they tend to not have green guidelines and

assessment tools, are in the process of developing them, or have not implemented them successfully. Research on green materials and technologies are usually minimal.

1.2.1 Sustainability in the developed and developing worlds

Globally, the importance of sustainability and sustainable development has been recognized by developed and developing countries. The degree to which these entities commit to sustainability plans and their ability to implement them successfully differ based on barriers to the adoption of green materials and technologies (United Nations 2012).

Many developing countries have understood the importance of incorporating sustainability as part of their national agenda, however in their ability to implement those agendas, they trail behind developed countries due to many barriers. This is an interesting dilemma since developing countries are generally the ones that need sustainability measures the most, but these barriers prevent them from successfully implementing them.

This is because many developing countries which already have fragile ecosystems, often experience severe environmental-related issues such as land degradation (erosion, aridity, deforestation, desertification, drought, flooding, alkalization and salinization). They also face acute water shortages, a situation which is expected to deteriorate due to climate change, as well as rapid urbanization with infrastructures which are often not adequate (UN-Habitat report, 2006).

1.2.2 Barriers to green design and green materials implementation

Research on barriers to the adoption of green building materials and technologies seeks to define, understand, and provide solutions to those barriers. These studies have found that those barriers occur both in developed and developing countries.

Chan & Darko (2017) categorized the 26 recurring potential barriers to the adoption of green building practices and technologies found in the existing literature into the following 5 barriers groupings: government, human, knowledge and information, market, and cost and risk.

In developing countries, such as in Africa, the adoption of green building practices and technologies has not yet reached a similar degree of success as developed countries due to local and global barriers. Beyond Chan & Darko's 5 barriers categories, developing countries are also faced with other challenges such as cultural barriers, lack of transparency, lack of research, and weak governance (Hecht 1999; Du Plessis 2002).

1.3 Problem statement and research questions

In terms of design and construction projects, the input of all concerned stakeholders should be employed from beginning to end. Iwaro & Mwasha (2013) grouped green design and construction stakeholders into five general categories: clients, corporate institutions, government, professional bodies, and researchers. Their knowledge or lack of knowledge can influence sustainability promotion and drive market demand for green construction and green materials.

Research on barriers to the adoption of green materials and technologies is necessary for the promotion, adoption, and application of sustainable practices globally. When reviewing the existing literature, one finds that the majority of such research has occurred in developed countries and much less in developing countries. Amongst the research in developing countries, Chan & Darko (2017) found that it was usually concentrated in Asia, such as in China and Malaysia, and that little studies have been carried out in Africa. When they have occurred, they focused on individual countries such as Ghana, Nigeria, Kenya and South Africa, and even less have focused on West Africa individually and as a whole.

Therefore, the following research questions are formulated:

- **RQ1**. What are the barriers to green design and green materials implementation in Burkina Faso?
- **RQ2**. Do developing countries lag behind developed countries in the pursuit of green design using the cases of Burkina Faso and the United States of America?
- **RQ3.** What are the lessons and guidelines learned from this study? How can they be disseminated to facilitate green design and construction?

The scope of this research will be limited to Burkina Faso, and to gain insight on these barriers, this study will solicit the perceptions from various stakeholders from the design and construction field in Burkina Faso. This is firstly due to the limited access to data since not all countries have easily accessible databases. Secondly, this research is interested in stakeholders who are most knowledgeable about green design and green materials implementation.

This research adopts a mixed method sequential exploratory design using both quantitative (online questionnaire) and qualitative (semi-structured interviews) in order to examine barriers to the adoption of green building materials and technologies in developing countries, using the case of Burkina Faso as a representative case of a developing country in West Africa.

Findings will be compared to the existing literature from the United States of America, as a representative of developed countries, to help anticipate how to avoid barriers as Burkina Faso develops its built environment.

This dissertation due to its exploratory nature did not try to provide practical action items for implementing the proposed guidelines. Future work will entail translating the proposed

guidelines into practice, and this translation will be data driven by the stakeholders to estimate the impact of these implementations.

For this dissertation, it is assumed that some degree of sustainability development has occurred in developed countries, and to varying degrees in West Africa and in Burkina Faso. It is also assumed that beyond the policies on green design, the ability to assess how green design professionals have applied them and knowing what their perspectives on actual and/or perceived barriers to green design and green materials is is necessary in order to improve sustainability practices at the local scale in Burkina Faso, but also globally in developing countries.

1.4 Thesis Organization

This thesis consists of 8 chapters and a brief synopsis of each chapter is given as follows:

Chapter 1: Introduction

Chapter 1 provides the background information explaining the rationale for this study. It highlights the projected increase of the impacts of climate change and projected rapid increase in population growth for sub-Saharan Africa as well as for Burkina Faso, a summary of sustainability, sustainable construction and the Burkinabe construction sector; how one defines developed and developing countries and how that impacts sustainability, an overview of the barriers to the adoption of green design and green materials implementation, the problem statement and research questions, the scope of the research, a summary of the study design, the significance of the research, the assumptions for this research, and finally the outline of the subsequent chapters which make up this dissertation.

Chapter 2: Literature Review

Chapter two focuses on the literature review. It can be broken down into three broad sections, the concept and categories of sustainable development; the concept of environmentally

sustainable building design (green building components), and drivers of environmentally sustainable building design.

It describes the concept of sustainability as applied in developed and developing countries, research on the role of all concerned stakeholders in sustainable development and green design, empirical evidence of barriers to the adoption of green design in developed and developing countries as well as the research gap within which this dissertation falls. Finally, it describes how technology transfer can help stimulate innovation especially in the design and construction fields.

Chapter 3: The case of Burkina Faso

Understanding barriers to the adoption of green design and green materials in Burkina Faso is grounded in the local context. Arguments have been made that developed countries have benefited from years of pollution and unrestrained natural resources exploitation, and they are now at the stage where they can focus on applying sustainability policies.

For developing countries which are currently going through their own years of pollution and unrestrained natural resources exploitation, focusing on sustainable policies might not be their primary focus if they are not offered context specific alternatives. Therefore, an understanding of the local context, allows one to understand why barriers have occurred and to better provide recommendations which fit the local context within which they will be applied.

This chapter concerns the context of Burkina Faso (current climate, demographics, climate and geography, political climate), the literacy rate, access to financing for construction, state of the infrastructures, the national housing and urban development policies (role of construction industry in Burkina Faso, formal and informal sectors, history of housing and urban development, housing typologies in urban and rural settings, available green materials in Burkina

Faso) and existing research in this area, and regulatory frameworks for research and their barriers.

Chapter 4: Theoretical framework, research methodology, and research design

This chapter develops the reasoning behind the pragmatic philosophical worldview and the sequential exploratory mixed method design. It provides an overview of the data collection and analysis approaches for phases 1 and 2 (online questionnaire and semi-structured interview) adopted in order to triangulate data.

Chapter 5: Analysis and discussion of case study findings

Chapter 5 deals with the findings and analysis of the data from the questionnaire and interview phases, as well as the interpretation of the results. A comparison across the different groups of construction professionals is also carried out, detailing the areas of consensus and differences between the views of the stakeholder groups which participated in the study. The findings for this chapter answer research questions 1 and 3.

Chapter 6: Comparison with the case of the United States of America

Chapter 6 discusses the comparison of the findings of this study with the existing literature on barriers to the adoption of green design and green materials in the United States of America and other developed and developing countries. The second part of this chapter focuses on a discussion of research question 2, as to whether developing countries lag behind developed countries in the pursuit of green design using the cases of Burkina Faso and the United States of America.

Chapter 7: Recommendations for study findings

Chapter 7 outlines the implications, guidelines and recommendations for the findings of this study, along with a section on the connections (or deviations) to relevant literature on

barriers to the adoption of green design and green materials. The findings for this chapter answer research question 3.

Chapter 8: Conclusion

The overall conclusion of this study is explained, as well as the study limitations, significance, suggested areas for further research, and how the findings of this study will be disseminated.

CHAPTER TWO

LITERATURE REVIEW

Chapter two details the literature review and can be divided into three broad sections: the concept and categories of sustainable development; environmentally sustainable building design (green building components), and drivers to green building design.

It defines sustainability in the contexts of developed and developing countries, details the need for the input of all concerned stakeholders in sustainable development, and describes the existing literature on barriers to the adoption of green design and green materials in developed and developing countries, as well as stating the gap within which this dissertation falls. Finally, it describes how technology transfer can stimulate innovation, especially in the design and construction fields.

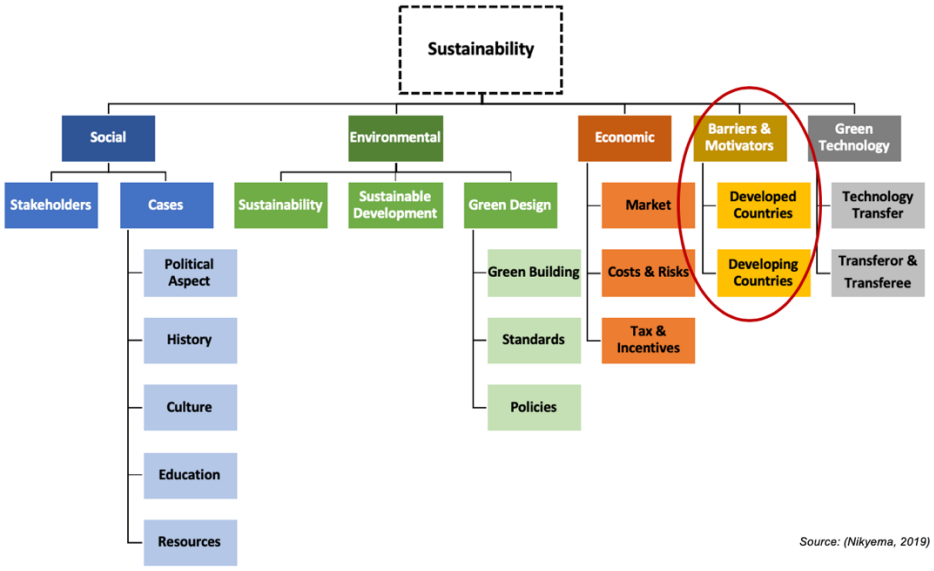


Figure 2.1: Literature Diagram
Source: (Nikyema, 2019)

2.1 Concept of sustainable development

Sustainable development came out of the 1987 Brundtland report. Although sustainable development and sustainable design are often used interchangeably, in the context of the construction industry, they are two separate terms. Sustainable development combines economic growth, social justice, and environmental quality, with each component drawing from the other and reinforcing each other.

The Brundtland report defined **sustainability** as **"**development which meets the needs of the present, without compromising the ability of future generations to meet their own needs" (WCED, 1987).

Sustainability in developing countries is a "social challenge that entails international and national law, urban planning and transport, supply chain management, local and individual lifestyles and ethical consumerism" (Maditati, Schramm, & Kummer, 2018).

The United Nation's 2030 Agenda for Sustainable Development specified 17 sustainable development goals (SDGS) as part of their global call for action for people, planet and prosperity. The SGDs are interconnected, meaning that action in one area will impact outcomes in others. Therefore, sustainable development must balance social, economic, and environmental sustainability.

Every participating country has the same 17 SDGS, but the focus and mitigation strategies employed by individual countries is specific to them. All stakeholders (such as businesses, civil society, government) must work together to meet those goals. Therefore, sustainable development can be defined as the ultimate goal to achieve, while green design is the product which allows one to reach sustainable development.

2.2 Sustainable design

Sustainable construction or green building design is defined as "a holistic process which starts from raw material extraction, continues through the planning, design, and construction of buildings, and ends with their demolition and the management of the resultant waste" (Carassus 2004). Depending on the literature, sustainable design has also been called: ecological design, green architecture, and green design. McLennan (2004) defines green design as "a design concept which optimizes construction quality in order to reduce the negative effects construction has on the natural environment".

For the purpose of this research, the terms of green building design or sustainable design are used interchangeably. The researcher uses McLennan (2004) definition of green building as "construction which uses energy and resources in an efficient manner throughout the life cycle of the building (which include the materials and technologies used in the design), its design, usage, demolition, and across all building sectors (commercial, residential, new buildings and retrofits".

2.3 Green building components

The Industrial Revolution (late 1800s to early 1900s) revolutionized the field of green design by creating new building materials, such as steel, through the rapid and mass production of building materials. It produced modern technologies systems such as heating, ventilation, and air conditioning (HVAC) which were readily incorporated in building designs. On the one hand, buildings incorporating such technologies became the symbols of the innovation brought by the Industrial Revolution, on the other hand, these new technologies were accompanied by negative impacts such as increased costs, the use of artificial light instead of natural light, or buildings with non-operational windows.

Due to the negative impacts of non-green buildings on the environment as well as such buildings consuming a lot of our dwindling natural resources, there is a need for more green buildings and additional green materials implementation in design and construction projects. Green buildings are said to incorporate the following components: building operation and maintenance, energy efficiency, environmental quality, land use, material efficiency and resource conservation, and water efficiency (Kubba, 2012).

2.3.1 Existing guidelines for sustainable building design and implementation

As sustainable development progressed into the implementation phase, guidelines were developed for the design, construction, and assessment of green projects. Generally, developed countries are mostly at the forefront of developing those guidelines. In terms of developing countries, some countries have been able to implement guidelines adopted from developed countries. However, when they are applied without modification, they might not fit the local context; such as the climate, the local materials availability, the labor force's experience, and local zoning and policies.

Countries, such as the United States of America and other developed countries, have developed various sustainability assessment programs for green buildings during their life cycle, such as the Building Research Establishment Environmental Assessment Method (BREEAM), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), Life Cycle Assessment (LCA), and the Leadership in Energy and Environmental Design (LEED).

Some developing countries have either successfully adapted these existing guidelines or are in the process of developing their own. Generally, developing countries have understood the importance of incorporating sustainability as part of their national agenda, however it is in their

ability to implement those agendas that they trail behind developed countries due to a variety of barriers (United Nations 2012).

2.4 Stakeholders in sustainable development and green design

In terms of sustainable development and green design, the input of all concerned stakeholders is necessary. Iwaro & Mwasha (2013) grouped green design and construction stakeholders into five general categories: clients, corporate institutions, government, professional bodies, and researchers. Their knowledge or lack of knowledge can influence sustainability promotion and drive market demand for green construction and green materials.

- **Clients:** Clients' needs for sustainable projects often drive green design and construction projects, and market demand. Although they have some awareness of green design and construction practices, their knowledge is often low, and they depend on the professional body to translate their needs into design (Pitt et al., 2009).
- **Corporate Institutions**: Corporate institutions have played a major role in sustainability research at the corporate level, and in the development of sustainability guidelines and practices. This led to the creation of the field of Corporate Social Responsibility (CSR) whose practices provided guidelines on the ethical responsibility of corporations in order to diminish their impact on the environment and societies. This has helped corporations improve their image as well as giving them a competitive edge with other corporations. Their knowledge of green design and construction practices can range from a high to a low-medium degree in which they need to turn to the professional body to design their projects (Pitt et al., 2009).
- **Government**: Government policies are necessary to implement green design and construction projects. They often look towards the corporate and professional bodies to

help them craft more efficient policies, as such their knowledge is low-medium. However, the impact of their policies on green design and construction can either be positive or negative, therefore all other stakeholders should inform them of their needs (Pitt et al., 2009).

- **Professional Bodies**: It is made up of design and construction professionals such as consultants, contractors, architects, designers, engineers, and planners. They often go through formal and intense training on green design and construction practices, making their knowledge high. During the design and implementation process, their job is to guide their clients, corporate, and government entities about sustainability practices as well as translate clients' needs into concrete projects (Pitt et al., 2009). Due to this, they could be considered as sustainability leaders (Opoku & Fortune, 2011).
- **Researchers**: Researchers also play an important role in guiding green design and construction practices by providing empirical evidence on the state of sustainability and sustainable development (Pitt et al., 2009).

To alleviate barriers to the adoption of green building materials and technologies and to gain a complete assessment of sustainable development, one must be able to assess the knowledge and perceptions of concerned stakeholders on sustainability issues, especially as it pertains to green design and construction and green materials.

2.5 Barriers to green design in developed countries

Research on barriers to the adoption of green building materials and technologies seeks to define, understand, and provide solutions to those barriers. These studies have found that those barriers occur both in developed and developing countries.

In terms of developed countries, Ahn & al. (2003) found that the top five barriers to the adoption of green building materials and technologies in the United States of America (U.S.A.) were **cost**, **long payback periods**, **preferences for current building practices** over new building practices, **limited users' knowledge and skills** with green building practices and technologies, and the **high costs of green building products**.

Chan & al. (2016) expanded the list of potential barriers in the U.S.A. with the **high costs of green building materials and technologies**, **resistance to change**, **lack of users' knowledge and experience** about green building practices and technologies, and **lack of government incentives** to promote and build green projects. Studies such as (Meryman & Silman, 2004; Mulligan & al., 2014; Rodriguez-Nikl & al., 2015; Darko & al., 2017) reaffirmed the findings of prior studies in the U.S.A.

Research on barriers to the adoption of green building materials and technologies in developed international countries added to the body of literature with these additional barriers: **lack of team communication** during green projects, **lack of research** on barriers to the adoption of green building practices and technologies, **lack of users', practitioners, and market knowledge and interest** in green building practices and technologies, and **uncertainty about the benefits and performance** of green building practices and technologies (Hwang, Tan & Ng, 2013).

Hwang & al. (2017) found that **initial implementation costs** were often higher for green building materials and technologies than traditional building materials and technologies and that **lack of government support and incentives** had an impact on the adoption of green building practices and technologies in Singapore. Finally, Love & al. (2012) reaffirmed prior findings and

found that **lack of building codes and regulations** and **poor stakeholder relationships** were the primary barriers to the adoption of green building practices and technologies in Australia.

2.5.1 Barriers to green design in developing countries

Research on barriers to the adoption of green building practices and technologies in developing countries include studies by (Bin Esa & al., 2011; Zainul, Abidin & al., 2012 & 2013; Yusof & Jamaludin, 2014 in Malaysia). Studies carried out in China include (Zhang & al., 2011; Shi & al., 2013; Zhang & Wang, 2013; Du & al., 2014; Mao & al., 2015; Shen & al., 2017).

Research outside of Malaysia and China include studies by (Potbhare & al., 2009; Djokoto & al., 2014 in Ghana; Luthra & al., 2015 in India, and Katas & Orkhon, 2015 in Turkey). They reaffirmed the findings of prior studies and added the following barriers: **lack of green** building practices and technologies' **databases** and **lack of available information** on green building practices and technologies.

Chan & Darko (2017) categorized the 26 recurring potential barriers to the adoption of green building practices and technologies found in the existing literature into the following **5 barriers groupings**: **government, human, knowledge and information, market, and cost and risk**.

A review of the literature focused on barriers to the adoption of green building practices and technologies in developing countries found that the majority of these studies occurred in Asia especially in China and Malaysia. Few such studies occurred in Africa, and even fewer West Africa and in Burkina Faso; when they have occurred, they focused on countries such as Ghana, Nigeria, Kenya and South Africa. Therefore, this research will serve to fill the gap in the

existing literature on barriers to the adoption of green building materials and technologies in developing countries using the case of Burkina Faso.

Katas & Orkhon (2015) stressed the importance of country specific studies on barriers to the adoption of green building practices and technologies in order to propose context specific solutions to encourage the adoption of green building practices and technologies.

2.6 Technology

Technology in the design and construction industry include **materials, equipment, organizations, procedures and information systems** (Ofori, 1994). An organization or country's ability to acquire, create, and adapt technology (such as green building materials and technologies) has an impact on its competitiveness, either locally or globally. Developed countries often are at the forefront in creating and adapting technology. Developing countries often lag behind in this area, especially in the creation, acquisition, and adaptation of green technologies.

Ofori (2007) found that the design and construction industry in African countries often face greater challenges than in developed countries, especially in the field of green materials and technologies. In developing countries, many green technologies are undersupplied, or they are not successfully adopted due to a variety of barriers (Egmond & Erkelens, 2008). For technologies to be deemed appropriate, they should respect the environment, local social and cultural norms, and economic patterns (Graham, 2008).

Green building materials and technologies include specific technologies, systems, procedures, goods and services, and equipment.

2.6.1 Technology transfer

Technology transfer is defined as the technology transmission via borders, space, and between entities or organizations (Egmond & De Vries, 2002). It is successful when it is adopted by the receiver (Ramanathan, 1994), and has a big impact on the economy and performance of countries by stimulating their economic growth. Countries' ability to successfully compete with other countries is influenced by the degree to which technologies are efficiently shared and adopted.

It can occur at different levels and in different directions. For example, horizontal transfer occurs when technical knowledge is shared within the same industry, while vertical transfer occurs from one industry or organization to the next (Ofori, 2000). It can also occur internally (within a country) or internationally (between countries).

Studies such as Liu (2007) examined how transferred technologies are applied. Single-track transfer refers to technology applied directly without changes, new-track-transfer refers to technology applied with some modifications, and cross-track-transfer refers to technology used for a different purpose than it is intended for.

Technology transfer can act as a linchpin to promote the development of technologies, industries, or even countries. It can help some industries or countries to skip the development phase by directly accessing and adapting existing technologies. This skipping is called leapfrogging, and in some instances, it has helped some technologies or countries to catch up to more developed industries or countries (Egmond & De Vries, 2002).

Leapfrogging can be positive, especially for developing countries, because it can help them develop at a faster pace. Some opponents have argued that when industries or countries skip the development phase of technologies, they never fully own it.

In the design and construction industry, technology transfer (especially vertical transfer) has stimulated innovation. Harty (2007) found that the design and construction industry is often slow in integrating new and innovative technologies. However, when they are adapted from other industries, it has helped speed up their integration.

2.6.2 Factors influencing technology transfer

Knowledge about technologies can be gained from a variety of sources such as clients, professional bodies, suppliers, and the government. In terms of green design and technology, it is important to understand who possesses the knowledge or technology, what are their diffusion networks, and what barriers can impede their successful transmission and adoption. Some of the most widely used technology diffusion methods conferences, educational institutions, model projects, professional journals, or informal networks (Milford, 2000).

Technology adoption can be positive for the adoptee or negative, such as the new technology competing with traditional technologies which could threaten the adoptee's culture.

Norton (1999) proposed the following guidelines to aid in the successful technology transfer in the design and construction industry.

- Use local materials and transport
- Don't use scarce resources which could damage the environment
- Use locally available equipment
- Use skills which can be realistically developed within the community
- Use materials and technologies which are affordable
- Use technologies or materials which are durable
- Use technologies or materials which don't negatively affect the local climate
- Use technologies or materials which are can adapt to local customs and needs

- Use technologies or materials which can be replicated locally

Waroonkun (2007) found that the following four barriers to the transfer of technologies within design and construction projects: transfer environment, learning environment, transferor characteristics and transferee characteristics.

- **Transfer Environment**

Transfer environment includes four sub-factors: the complexity of the technology, mode of transfer, government policy, and enforcement procedures. A variety of studies found that the more complex a technology is, the harder it is to understand, and the harder it is to transfer, especially when it requires training for the adoptee.

Government policies can promote technology transfer via for example, incentives and tax credits. They can impede technology transfer if they are too stringent or not adapted to the local context and adoptees' skill levels (Ofori, 2000). The mode of transfer deals with the costs and risks of transferring technology. The riskier a technology is perceived by adoptee, the less likely it will be adopted.

- **Learning Environment**

Learning environment focuses on the transferor-transferee relationship, and how transfer programs can either promote or impede technology transfer. It has four sub-categories: the relationship between transferor and transferee, communication between transferor and transferee, management of technology transfer programs, and composition of transfer programs.

The more transferor and transferee build a good working relationship built on some degree of trust and good communication, the more likely technology transfer will be successful, especially for international technology transfer. Understanding cultural differences, building

mutual trust, and maintaining good cooperation and communication amongst concerned stakeholders will improve the chances of technology transfer and adoption (Lin & Berg, 2001).

Transferor and transferee must also be able to effectively communicate with each other to facilitate technology transfer. Malik (2002) found that the frequency and quality of the communication were also important aspects. The more established and organized technology transfer programs are, the more knowledge transfer will occur. They must include training for the local population in order to increase the likelihood of successful technology transfer (Simkoko, 1992).

- **Transferor and transferee characteristics**

Transferor characteristics include four subcategories: degree of experience, willingness to transfer technology, cultural traits, and knowledge base. Transferee characteristics also include four sub-categories: intent to learn technology, degree of experience, cultural traits and knowledge base.

The more transferor is willing to share the technology, the more the transferee will be willing to adopt it. The transferred technology must also be compatible to the transferee's way of life, especially if it perceived as having economic and technological benefits.

The degree of experience and knowledge for both transferor and transferee are also important. In terms of the transferor, the more knowledgeable and skilled he is, the easier he will be able to communicate and transfer technology. For the transferee, the more informed he is about the technology, the better he can decide whether the technology can meet his needs (Lin & Berg, 2001).

Culture also has an impact on the success of technology transfer, such as on the communication between the two parties. This is especially true when they have very different

cultures, such as African and Western cultures. The higher the cultural gap between the two parties, the less likely the technology ca ben successfully transferred (Lin & Berg, 2001).

Chosen technologies must be carefully chosen in order to enhance and not destroy the transferee's culture. They should meet local needs and be able to be used and maintained by the local population (Hill, 1983). Datta (2000) argued that transferred technologies must be adapted to enhance local and cultural processes. The participation of the local community in the selection, usage, and maintenance of technologies is also important for successful technology transfer (Hammond, 1983).

2.7 Chapter 2 summary

Sustainability in developing countries is a "**social challenge** that entails international and national law, urban planning and transport, supply chain management, local and individual lifestyles and **ethical consumerism**" (Maditati, Schramm, & Kummer, 2018).

All **stakeholders** should participate in all aspects of sustainable development and green design projects since their **knowledge/lack of knowledge** can influence the **promotion of sustainability**, drive **market demand for green construction and green materials implementation**.

Chan & Darko (2017) categorized the 26 recurring potential barriers to the adoption of green building practices and technologies found in the existing literature into the following **5 barriers groupings**: **government, human, knowledge and information, market, and cost and risk** and they occur in both developed and developing countries.

For **developed international countries** (i.e. Australia, Singapore**)** the prevalent barriers were: **lack of team communication** during green projects, **lack of research** on barriers to green building practices and technologies, **lack of users', practitioners and market knowledge** and interest in green building practices and technologies, **uncertainty about the benefits and performance** of green building practices and technologies, **higher initial implementation costs** for green building practices and technologies compared to traditional building materials, **lack of government support and incentives, lack of building codes and regulations**, and **poor stakeholder relationships** (Hwang & Tan, 2012; Love & al., 2012; Hwang & Ng, 2013; Hwang & al., 2017).

Studies in **developing countries** (China, Ghana, India, Malaysia, Turkey) reaffirmed findings of prior studies and added the following barriers: **lack of** green building practices and

technologies' **databases** and **lack of available information** on green building practices and technologies (i.e. Potbhare & al., 2009; Bin Esa & al., 2011; Zhang & al., 2011; etc.)

Beyond Chan & Darko's 5 barriers categories, developing countries are also faced with other challenges such as **cultural barriers**, **lack of transparency**, **lack of research**, and **weak governance** (Hecht 1999; Du Plessis 2002).

Developing countries often lag in the **creation**, **acquisition**, and **adaptation** of green technology (Ofori, 2007; Egmond & Erkelens, 2008). For technologies to be successfully adopted (technology transfer), they must: fit **local context**, respect **environment**, **local and cultural norms**, and local **economic patterns** (Graham, 2008).

Although it could threaten the adoptee's culture if doesn't work with local **culture**, **climate**, **materials**, and **skills**. **Leapfrogging** (skipping development phase) can help developing countries to catch up to developed countries (Egmond & De Vries, 2002), but opponents argue that it can cause those countries to adapt technology but never fully own it.

CHAPTER THREE

THE CASE OF BURKINA FASO

Understanding barriers to green design and green materials implementation in Burkina Faso is grounded in the local context, as it allows one to understand why barriers occur and to better provide recommendations which fit the local context within which they will be applied.

3.1 The context of Burkina Faso

Burkina Faso is statistically considered one of the developing countries in the world (GDP: 123rd amongst 186 countries). It is a member of the West African Economic and Monetary Union (WAEMU) and the Economic Community for West African States (ECOWAS). It is a landlocked country in West Africa, surrounded by Benin, Ivory Coast, Ghana, Mali, Niger, and Togo. Formerly known as the Republic of Upper Volta, it gained independence from France in 1960.

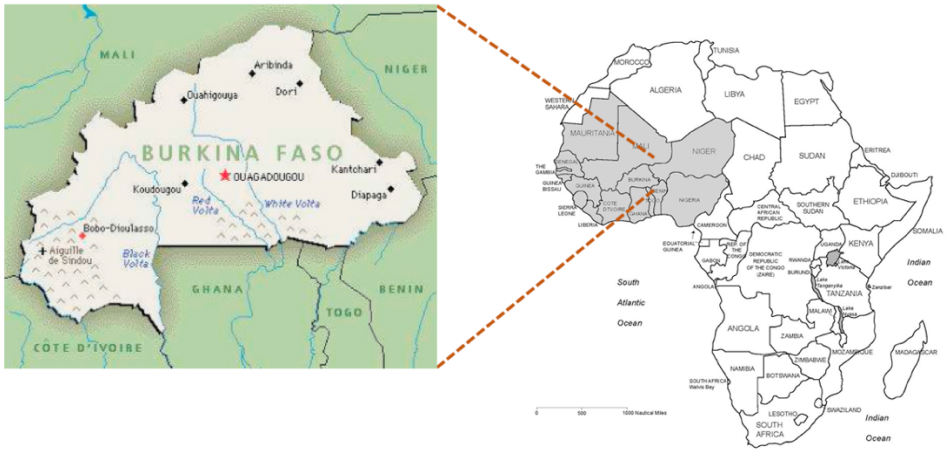


Figure 3.1: Map of Burkina Faso
Source: (Nikyema, 2020)

"Like many countries in Africa, Burkina Faso is stuck in a cycle governed by poverty, fast urbanization, weak governance, and the vestiges of its colonial past" (Du Plessis, 2002).

Burkina Faso is characterized by its low population density and the contrast between poverty and wealth levels. Burkina Faso has significant mineral deposits (gold, zinc, manganese, copper, nickel and antimony) but on the other hand, it has a scarcity of vital resources such as arable land and water (Du Plessis, 2002).

In the past 10 years, Burkina Faso has come a long way in implementing structural reforms to meet its development goals, especially in the area of economic growth where it has made enormous efforts to improve the competitiveness of its economy. Despite these accomplishments, Burkina Faso's economy is still susceptible to outside influences such as market volatility for its staple raw materials (cotton, gold), development limitations due to it being landlocked, and the volatility of the world's finances. For it to continue to meet the UN's Sustainable Development Goals (SDGs) and the goals of its own "Burkina 2025" national prospective, it must continue to develop in a constant, progressive, and sustainable manner (CAHF, 2018).

Burkina Faso has revised its investment code to attract more foreign investment. Combined with law reforms favoring the mining industry, by 2010, gold became the main source of export revenue with about 33.7 tons of gold produced which is about 10% of its GDP (Afrique Avenir, 2011). Burkina Faso now ranks in 6th place for potential gold production in Africa.

It had been a relatively stable country. Since 2016 Burkina Faso's security has been plagued by terrorist attacks, especially in the north, on its armed forces and its local population. As such, Burkina Faso is in a currently stable but fragile situation.

3.1.1 Demographics

Burkina Faso is a multi-ethnic country, with more than 27 ethnic groups, with the Mossi being the largest group (50.2% of the population). Most of the ethnic groups in the southern and central parts of country practice farming, artistry and metal work. The northern part is inhabited by the nomadic communities.

Seventy languages are spoken in the country (66 are indigenous), with French, Mooré, Dioula, being some of the official languages.

Similar to other West African countries, Islam is the predominant religion followed by African religions, and Christianity.

Burkina faces demographic challenges. It has one of the fastest growing populations in Africa, and its population has been projected by the UN to increase from 20 million in 2010 to 29 million in 2030. Most of the growth is expected to occur in urban areas and will increase the requirements for adequate infrastructure and services. This projected urban increase must be planned for, otherwise the current ageing and inadequate infrastructures will not be able to service the projected population growth.

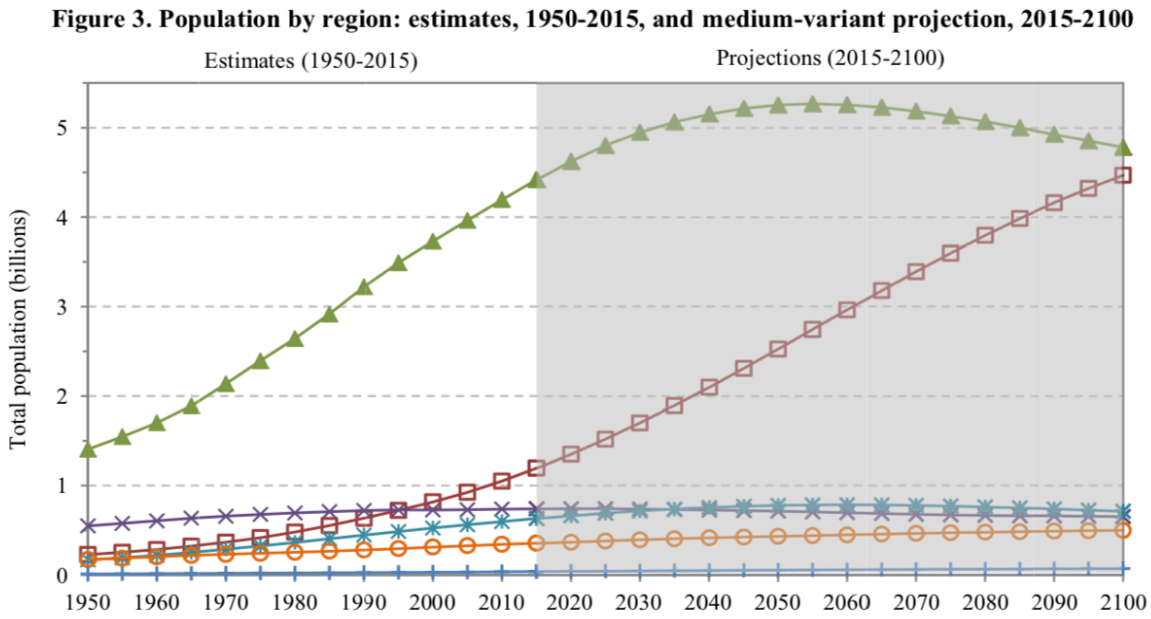


Figure 3.2: Population by region: estimates, 1950-2015, and medium-variant project, 2015-2100
Source: (United Nations, Depart. of Economics and Social Affairs, Population Division, 2017)

3.1.2 Climate and geography

Agriculture accounting for about 30 percent of its GDP, Burkina Faso's geography is a challenge to its development, due to large sections of the land being arid, prone to droughts and floods exacerbated by climate change.

With more than 80% of the population relying on subsistence agriculture, only a small fraction of it is directly involved in industry and services, making its economy highly vulnerable, and impacts of climate change could lead to increase in food insecurity and malnutrition.

Figure 3.3: Burkina Faso in dry and rainy season
Source: (https://i.ytimg.com/vi/5PxX36vH18s/maxresdefault.jpg, 2018)

Without direct access to the sea, Burkina Faso is highly dependent on its neighbors (Ivory Coast, Ghana, Togo and Benin) for transit and trade of its goods. This leads to increased import and export costs due to the above average distances to commercial exit points.

3.1.3 Literacy rate

The 2018 UN development Program Report ranked Burkina Faso as having one of the lowest literacy rates in the world, despite efforts to increase it.

Factors, such as the inadequate number of available schools, a shortage of qualified instructors, families having to pay for school fees and supplies, families' low incomes, language barriers, and terrorist attacks since 2017 on schools, have had a negative effect on the state of education in Burkina Faso.

3.1.4 Access to finance

Access to financial funding for housing and other construction projects is a major issue in Burkina Faso. The World Bank estimates that only 28% percent of the Burkinabe population can access financial services as compared to 93.5% of Americans in the U.S. Despite good bank

capitalization, interest rates are still considered high, at about 10 to 12 percent (CAHF, 2018) as compared to the U.S. which has interest rates of 2.5 to 4 percent (USEPA, 2016).

The Central Bank of West African States (BCEAO) estimated that 15 commercial banks and four credit institutions (établissements financiers) were operating in Burkina Faso as of June 2019. Housing loans are available but require collateral which the average citizen of Burkina Faso cannot afford.

3.1.5 State of infrastructures

Burkina Faso has made significant efforts in its road transportation, by creating four competing land corridors to provide alternative access to international ports: (i) the Abidjan Road and Railway Corridor; (ii) the Lomé Corridor; (iii) the Tema Corridor; and (iv) the Cotonou Corridor. Hence, the majority of its regional roads are fully paved, and roughly 2/3 are in good conditions, which is well above the average of ECOWAS regional corridors, and significantly more than other coastal countries.

Despite the improvement of transit routes, traffic management and import and export costs still remain a challenge. “Import costs tend to be higher than the average for sub-Saharan Africa and two times as high as those recorded in the countries of the Organization for Economic Co-operation and Development (OECD). Additionally, export costs and transit durations are among the highest for OECD countries.

Furthermore, Burkinabe operators are forced to pay 28% of the price of imports, as compared with the global average of 6% and the sub-Saharan average of 10% (World Bank, 2009).

3.1.5.1 Water and sanitation infrastructures

Burkina has made significant progress towards improving access to water for its population. Nearly 97% of the population has access to improved water, leaving only 2.7% accessing surface water. This progress is outstanding compared to other low-income African countries, where 1/3 of the population regularly uses surface water (AICD, 2011). Based on the World Health Organization's Joint Monitoring Program (JCP)'s definition of improved water services (running water, standpipes and protected boreholes), Burkina's overall access to safe drinking water increased from 59% in 2003 to 74% in 2007, reaching 79% in 2009 (OMS, 2009). One should note that most of the progress in access to water supply has occurred place in the urban areas.

Progress in improved water and sanitation in urban areas has been impressive, but more work needs to be done in rural areas in order to expand service and reduce costs.

3.1.5.2 Energy infrastructures

Burkina Faso draws its electricity from **28 fossil power stations** (70 percent of total power generation) and **4 hydroelectric stations.** Imported electricity from Ghana and Ivory Coast account for 10% of the total electricity produced and is subsidized by the government. According to Burkina Faso's National Institute of Statistics, the government yearly subsidy for fossil fuel electricity production was about USD 25 million in 2010. Despite this subsidy, the cost of a 1kWh in Burkina is USD 0.25, one the highest in the world (INSD, 2011), as compared to USD 0.065 in the US.

Access to electricity is mainly in urban areas, with only 112 urban localities or districts out of 350 having access to electricity, although the number of power stations installed per year

has been increasing since 2000. Despite this, electricity production is still considered low. Only 13.7% of the total population in the urban areas have access to electricity INSD (2011).

Studies such as (Ouedraogo, 2012) suggests that decentralized power generation facilities together with a local distribution network would increase access to electricity in Burkina Faso. Renewable energy sources could be used in areas where the grid does not exist, as long as it's not costly. Because of its semi-desert landscape, the country can benefit from more solar projects as it has abundant solar radiation, especially in remote areas where connecting to the grid would not be economically impossible.

Thirty to 35 percent of the total electricity produced is used by the built environment, with 60 to 67% of the building sector electricity going to air conditioning. This is about 25% of the primary energy consumed in the country (Ministry of Energy and Mines, Directorate of Energy, 2008). As a comparison, buildings in the U.S.A. consume **40% of the total produced energy** and **72% of the produced electricity**, while emitting **39% of the primary greenhouse gas emissions** (Kibert, 2005; Deru et al., 2011).

3.2 National housing and urban development policies

The UN Habitat's Urban Profile of Ouagadougou (2007), the National Housing and Urban Development Policy report (2008), and the Elaboration of the National Habitat III Report of Burkina Faso (2015) have highlighted that although legislations and relevant government, private, and public agencies exist to govern housing and urban development, **urban sprawl, inadequate and/or insufficient infrastructures, and a migration towards urban areas still occur due to a variety of reasons**. These reports found that enforcing the rules and policies of urban planning is still a challenge. The present structuring of cities reflects the historical evolution as well as processes implemented during the precolonial and colonial periods.

Studies like (Bernard & Krief, 2006; Tokuori, 2010; Bagaya, 2016) have examined the role of the construction industry in Sub-Saharan Africa and in Burkina Faso. The construction industry is an important economic player in Burkina Faso as it is in other countries. The construction industry accounts for about 12.7% to the GDP (Tokuori, 2010) and for 78% of the country's industrial sector companies. According to the Chamber of Commerce and Industry, in 2008, 3,535 construction companies were registered at the national level.

To improve and maintain this growth, the Government created in 2010 the Accelerated Growth and Sustainable Development Strategy (SCADD) with a plan to accelerate this growth by prioritizing the areas of development, infrastructures, and institutions (Ministry of Economy and Finances, 2008). As such, the government has become the biggest builder, and invests more than USD 160 million annually in the sector (Bernard and Krief, 2006).

Seventy percent of the construction companies are small and medium-sized enterprises (SMEs). The majority (79 percent) is located in the capital city, while 5 percent are in Bobo Dioulasso (second largest city) and the rest (16 percent) is spread across the other cities (Burkina Faso Chamber Commerce and Industry 2008).

3.2.1 Housing typologies in Burkina Faso

Burkina Faso is a poorly urbanized. The largest number of households live in rural areas where the habitat is characterized by the predominance of traditional constructions. In cities, housing, however, has changed from the traditional to the modern type due to international trade and Western influence having introduced new building materials.

In traditional Burkinabe culture, a self-respecting household head needs to have a house to call his own. Having a house built in "hard" materials such as cement brick is seen as a source of prestige, wealth, and social success. Traditionally, leasing did not exist, and although in

modern times citizens do lease, it is seen as a temporary measure, as one saves up to have one's own plot of land and house.

Secondly, owning one's house in final hard materials serves as a form of security and a guarantee with a bank. "The acquisition of a habitat allows the owner to access all kinds of services for which he is sidelined as a tenant" (Wyss & Suisse, 2005).

The issue of housing is closely linked to the issue of land ownership. In rural settings, nearly all households have land and a house, as compared to urban settings where only **2/3** of urban households are landowner, and even less have a house.

Wyss & Suisse (2005) summarized the primary and secondary issues that rural and urban dwellings often face in the table below.

	Urban Setting	**Rural Setting**
Priority issues for client	- Obtain a plot of land - Minimal construction needed to obtain the Urban Living Permit (PUH)	- Find the financial means to get a metal sheet roof instead of a straw roof
Secondary issues for client	- Acquisition of definitive materials - Expensive imported products - Masons often incompetent	- No water for making bricks - High price of imported products - How to ensure the sustainability of buildings

Table 3.1: Primary and secondary issues in rural and urban dwellings
Source: (Wyss & Suisse, 2005)

3.2.1.1 Housing in rural settings

In rural settings, land ownership has not as of yet become a major issue. Land management is usually regulated by the local chief and traditional landowners, although there

have been legal changes such as the 2009 Rural Land Law which has for goal to manage land and land tenure in a manner which advances development goals

The traditional houses of Burkina Faso are rich in forms and structures. Their traditional building typologies have adapted over centuries to the social, cultural, climate, available materials and needs of the local population.

I. Type 1: Far north of Burkina Faso

Houses are made of temporary materials, in the form of domes or tent dwellings which reflect the nomadic lifestyles.

Figure 3.4: Fulani dwelling, Burkina Faso
Source: (*Nko'o*, 2006)

II. Type 2: Center of Burkina Faso

The dwellings are circular with cone straw roofs with banco walls or improved banco walls. Banco walls are made of mud or clay without cement cladding. Improved banco walls are mud or clay walls with a cement coating. These housing types vary based on the region, techniques and mastery of the building art.

Figure 3.5: Mossi village, Burkina Faso
Source: (*Nko'o*, 2006)

III. Type 3: Center of Burkina Faso

Houses are made of a mixture of earth, water and cow dung with straw roofs. They are characterized by orthogonal shapes with flat roofs. They vary based on the region and skill of the builder.

Figure 3.6: Tiébélé village, Burkina Faso
Source: (*Nko'o*, 2006)

Figure 3.7: Tiébélé village, Burkina Faso
Source: (*Nko'o*, 2006)

3.2.1.2 Sustainable versus durable

The most widely used construction techniques has primarily been earth-based due to the local climate, culture, and availability (Kéré, 1995). The three types of rural housing use locally available materials of mud, clay, cow dung, wood for wood beams, and straw for the roofs.

Although these techniques are considered sustainable but not durable. They require yearly maintenance.

Due to the increased availability of imported materials, as well as due to the desire to live in "modern" buildings, there has been a noticeable increase in construction using imported materials such as cement, concrete, and steel. Hema et al. (2017) found that **69.4% of dwellings in Burkina Faso used adobe for the walls, and 13.8% used hollow cement blocks.**

These figures have been shifting as cement-based constructions is becoming more popular due to its assumed modernity and durability. However, the manner in which these buildings are built, which oftentimes do not incorporate green design and green material technologies, makes them less adapted to the local tropical climate (Hema et al., 2017). Furthermore, the fact that these materials are mostly imported, increases their cost, decreases their accessibility, and increases the negative impacts the buildings have on the environment.

In modern times, the importation of materials, such as the corrugated metal sheet, has transformed the way traditional rural houses are built. Wyss & Suisse (2005) found that sheet metal accounted for 28% of rural roofs. Their utilization has also transformed the traditional circular housing typology for more rectangular shaped houses.

Negative aspects of the incorporation of metal sheet roofing to rural housing, is that such roofs are not thermally adequate for the hot climate. Prior straw roofs allowed for ventilation of the house, but metal roof houses do not provide for adequate ventilation, and do not adequately protect the occupant from the heat or cold evenings. Another negative aspect is that the introduction of these imported materials is causing a loss of the local construction culture and tradition.

The government has carried out research and promotion of more “friendly local materials”, but their usage had more to do with vernacular architecture, tradition, culture, material availability, lowered costs, and local labor and skills, rather than due to a conscious green design agenda.

3.2.1.3 Housing in urban settings

In the capital city, Ouagadougou, **48% of buildings are built using cement blocks for the building envelope**. High rise buildings are generally made of concrete bricks, steel, or bricks with a concrete roof. **24.7% of houses are made of adobe blocks** which grew from the traditional architecture, as well as being influenced by imported materials such as steel sheets. Finally, compressed earth block houses are the modern equivalent of the molded earth block (Guillaud, 1995).

As in rural settings, the availability of imported materials leads to the increase in the use of concrete, steel, bricks, in urban environments. The majority of these buildings don’t incorporate green design and green material technologies and are not adapted to tropical climate. **The usage of these non- traditional materials will exacerbate the negative impact on the environment and existing infrastructures as more people are predicted to live in cities by 2050.**

In urban areas, the citizen can access real estate in the following ways:

- Land transferred from an existing private familial or tribal parcel
- Buying a virgin plot of land to build upon it
- Buying a house in an existing subdivision
- Qualify for a rent to sell or a pay as you go social house

According to the World Bank (2018), in urban settings, access to real estate is hampered by the unemployment rate of 6.1%, poverty level (40% of the population lives at or below poverty levels), increasing land prices, and lack of available information tracking about land pricing, and land regulation (Le Fou, 2018).

Land registration, for those who can afford it, is a lengthy and complicated process. According to CAHF (2019), it takes four procedures and roughly 67 days to be able to register one's property, as compared to an average of 53.9 days in Sub-Sahara Africa and 20.1 days in OECD high income countries. Registration requires 12 percent of the total property value as compared to an average of 7.6 percent in Sub-Saharan Africa and 4.2 percent in OECD high income countries.

Non-parceled neighborhoods

The alternative for these citizens is to live in informal non-parceled neighborhoods, called "quartier non-lotis" in French, in the outskirts of the capital. This partly explains why Ouagadougou is sprawling more and more in an unplanned and exploding manner.

Although such neighborhoods vary in their degree of development, going from some which have evolved to having their own character and being more developed, to some which are still at their embryonic stage, generally access to running water and electricity tends to be scarce, and sanitation is often inadequate.

The hope for these citizens, in these non-parceled neighborhoods, is that over time the government will come in to make these informal neighborhoods more formal, and therefore bring in roads, water, electricity and other amenities. Wyss & Suisse (2005) found that once the occupant's plot has been recognized by the government, they have 5 years to invest in their parcel, through a process called "highlighting", which means that they must be able to build a

wall fence around their parcel, a small house, and have an external bathroom in order to get their Urban Living Permit (PUH) (Permis Urbain d'Habiter). Only after they have received their PUH can the plot occupant call himself a plot owner with all the rights to that plot.

If the PUH is not acquired after 5 years, the land return to the State, and the occupant will be evicted. Furthermore, if the government doesn't formally subdivide the non-parceled neighborhood, and if the government needs that land for some other project, the occupants will be evicted forcibly and will have to move to another non-parceled area and start the process of hoping to be part of a subdivision all over again.

Wyss & Suisse (2005) found that the precariousness of their situation has an immediate effect on the choice of building materials for these citizens. Until they become part of a subdivision and get their PUH, these citizens have to live in a house with the bare minimum. They feel that they should not invest too much in a house which runs the risk of being torn down if they are evicted. As such, they often turn to adobe and mud bricks, not for their sustainable aspects, but because they are seen as being cheap and temporary.

An additional advantage of "hard" materials such as cement for such citizens is that since it takes them on average 8 years to be able to build a definitive house, cement bricks can be stored and built with over time, as compared to adobe or mud which needs to be maintained yearly. Wyss & Suisse (2005) found that for such citizens, see their definitive house as being a dream achieved, and therefore, they would want materials such as cement which they view as not requiring anymore maintenance. Furthermore, as their house plan will evolve over time and depending on their financial means, cement bricks are more flexible to modification as compared to materials such as adobe and mud.

3.2.1.4 Urban housing typologies

Urban housing can be classified into three main categories: low income construction, medium standing construction and luxury construction.

I. Type 1: Low income construction

Such construction usually occurs in low-income working-class neighborhoods. As fig. 3.8 on the left shows, they are found either within existing subdivisions or as part of the unplanned spontaneous non-parceled “neighborhoods”. Depending where in the process the occupant is towards getting his PUH, the type of materials used differ, although they are still considered **temporary materials**: adobe bricks, cement-coated banco or banco with metal sheet roofing. Therefore, these constructions are not durable without yearly upkeep after the rainy season.

Figure 3.8: Example of subdivided and non-subdivided neighborhoods
Source: (Wyss & *Suisse*, 2005)

Figures 3.9; 3.10; 3.11; 3.12:
Examples of low income houses
Source: (*Nko'o*, 2006)

II. Type 2: Medium standing construction

These are made of improved banco, carved laterite block, block of compressed earth or more final materials such as agglos cement (cement brick and gravel), and with metal sheet roofing. These materials are more durable, but less conscious of the local ecosystem than the materials used in the low-income neighborhoods.

In rare cases, they are found in low-income neighborhoods if the occupant is confident that his neighborhood will become a subdivision or to show that his wealth has increased.

Figure 3.13: Medium income house
Source: (*Nko'o*, 2006)

Figure 3.14: Example of medium income house
Source: (*Nko'o*, 2006)

III. Type 3: Luxury construction

These are found in residential and commercial neighborhoods They are built with final materials such as agglos cement, reinforced concrete, bricks, steel and glass. Roofs for such constructions usually are sheet metal roofs with false ceilings (plywood or staff) concrete slabs, or in some instances, shingles. Such buildings are the most durable, but their usage of **non-traditional materials** will exacerbate the **negative impact** on the environment and existing infrastructures as more people are predicted to live in cities by 2050.

Figure 3.15: Example of luxury house
Source: (*Nko'o*, 2006)

Figure 3.16: Example of luxury house
Source: (*Nko'o*, 2006)

Figure 3.17: High rise buildings Ouagadougou
Source: (Nikyema, 2019)

IV. Social housing

Providing social housing has always been a goal for the Burkinabe government, although the degree to which construction of social housing has occurred has waned or peaked depending on the administration in place. According to Burkina Faso's first Five-Year People's Development Plan 1986-1990 report, social housing was seen as creating communal spaces where the Burkinabe citizen could grow and thrive.

Social housing is supposed to not only solve social work, but also have an economic component, by improving living standards, improving the occupants' health, emphasizing cultural identity through the usage of local materials, incorporating housing with socio-cultural amenities and jobs. As such, social housing was seen as providing self-sufficient communities.

Social housing was prosperous between 1983 and 1987, because of the then administration's desire to produce social housing. A lot of these social housing projects occurred in Ouagadougou and in Bobo Dioulasso. Examples are Cité An 2, An 3, City of 1200 housing.

Nowadays, one could argue that the government no longer focuses on social housing as it was originally defined above, especially since current "social housing" projects from the private

or public sectors seem to be geared towards the middle-class citizens. Secondly, the government-owned real estate companies, the Construction and Property Management Company of Burkina Faso (SOCOGIB) and the Center for the Management of Residences (CEGECI), target primarily the upper middle class and upper-class citizens in order to be able to consistently sell their houses.

The predicted expansion of the population calls for making houses available. Notwithstanding the government's and local communes' efforts to create massive subdivisions, these projects don't meet the increasing demand for housing, and even more so for social housing.

Every year, the need for new housing in Ouagadougou, is estimated at about 6,000 homes. Although SOCOGIB has built so far, a million homes since 1984, more homes need to be built in order to meet the increasing demand, in urban settings. Despite its financial and budgetary limitations, the government of Burkina Faso is working to meet the demands for housing via new projects as well as trying to find financing options which would allow for social housing loans at low rates over long terms.

3.3 Availability of green materials

Although some of the locally used materials were touched upon in the previous section, it is important to understand them in the context of Burkina Faso, from how to define a green material, research and application of green materials in Burkina Faso, and what green materials are available in Burkina Faso.

3.3.1 Green Materials in the context of Burkina Faso

Green materials are usually called "local materials" in the context of Burkina Faso, but the definition has evolved over time.

According to Burkina's LOCOMAT (National Strategy on Local Building Materials), local materials are better defined as "being **produced locally**, **from domestic raw materials** (or resources) **specific to a country** with the aim **of minimizing its cost.** They are **environmentally friendly** and have a **positive macroeconomic impac**t on the national level" (Wyss & Suisse, 2005).

3.3.2 Issues of durability in green or local materials

Another aspect in the definition, is its durability. Wyss & Suisse (2005) found that when a user lacked in-depth technical knowledge about a given material, they would perceive it not due to its scientifically established properties, but due to their personal experience with the given material.

In Burkina Faso, research and projects on local materials have mostly focused on Block of Compressed Earth (BTC French acronym). However, because of failed projects and their need for a yearly upkeep after the rainy season, BTC are perceived as not durable, and a temporary material for the poor.

On the other hand, the population have a more positive appreciation of the Block of Cut Laterite (BLT French acronym) and sandstone which are deemed more durable than the BTC. Hence concrete bricks, metal sheets, steel, are widely used due to their durability despite not meeting the requirement of local green materials.

3.3.3 Research and application of local or green materials in Burkina Faso

In this context, any promotion of local or green materials is a difficult endeavor and calls first for a convincing discourse to overcome the population's resistance. Failed local material housing projects (ADAUA, Cissin) over the past 2 decades are a stark reminder of the impact of false perception. These false perception over local materials were aggravated by the following

(Boubekeur & Cabannes, 1982, Dévérin-Kouanda, 1992, Gilbert & Koala, 1997, Wyss & Suisse, 2005):

- limited preliminary studies and follow through of the research undertaken,
- relatively high cost of production of the materials with a negative impact of the cost of the buildings
- construction professionals not properly informed and trained
- limited transfer of technology
- absence of the minimum building maintenance requirements
- lack of assessment tools and limited final evaluation

These research and projects were financially supported by the Government partners (United Nations Development Programme, UN Habitat, Swiss Cooperation) and did not benefit from continued assistance from the two parties.

The government introduced new initiatives in 2006 to boost the use of local materials in the construction sector: A ministerial function was created; a housing bank established; a code of town planning and construction, and a National Policy for Housing and Urban Development (PNHDU) were adopted.

Valorization of local building materials (MLC) is therefore one of the strategies of the government to achieve its goal of creating more social housing accessible to a greater number of citizens. The 10,000 houses Project is an example.

However, the results and impacts are mitigated. Indeed, the government should be at the forefront of the promotion of local materials and lead by example. The reality is that the government itself is not using local materials for its own buildings, nor in the different government commissioned housing project to showcase the value of local materials.

3.3.4 Types of local green materials available in Burkina Faso

There is a wide range of resources used as building materials and which can be defined as locally produced with little or no imported inputs added to the raw materials. They are extracted either, manually, in a mechanized manner (using specific equipment) or in motorized manner (using external energy sources; diesel, electricity fuel etc.)

Despite their availability, their production for the most part remains as a small-scale industry and are usually produced by the informal sector. Table 3.2 below highlights the materials which are more readily available, and which have benefited from the most research and promotion as local materials.

Type	Description
Cut Laterite Block (BLT)	Manually or mechanically extracted **Size: the most popular 20 x 17 x 30; 15 x 32 x 13**
Compressed Earth Block (BTC)	Modern evolutionary form of adobe with the addition of cement to increase the resistance and quality of the blocks; **standard dimension: 29.5 x 9.5 x 14**
Adobes (banco)	Bricks obtained using malleable earth which offers good cohesion mainly due to the presence of clay and straws which act as a binder; bricks molded into wood or metal molds.
Rubble stones (wild stones)	Blocks of natural stone extracted or collected, used in the masonry of concrete; **no dimensions**
Lime	Is a generally powdery and white matter obtained by combustion of limestone; used as a binder.
Vibrated Mortar Tiles (TMV)	Roofing element in vibrated mortar produced from a mixture of sand, gravel, cement and possibly dyes; standard size: **25 x 50; thickness 6 to 12 mm**
Granite	Is a magmatic rock with a grainy texture used in masonry or the implementation of concrete; **no standard size**

Table 3.2: Inventory of resources available in the promotion of local construction materials
Source: (Ministry of housing and Urban: Project LOCOMAT report, 2009)

Due to their small-scale production as well as being for the most part produced by the informal sector, they are sold directly from their place of production through agreements

between the producer and customers. The price of the materials and the quality of the products differ according to the skill of the producers.

The small scale of formal industries, and the informality of informal industries in the sector, make it hard for them to train and keep skilled workers. The advantage of such industries, on the other hand, is their flexibility and adaptability to changes in the construction market since they hire depending on the demand (IRD, 1993).

3.4 Research structures in Burkina Faso

Another area which needed to be researched is what structures exist to promote research in Burkina Faso, and where it stands globally in terms of disseminating research.

In terms of the construction industry, knowledge production is especially important since it can help promote and find solutions for "the need to effectively deal with complex projects; the effective use of new, innovative building materials, systems, services; managing change (both project change and organizational change); coping with the uniqueness of projects; and managing team member interfaces (e.g., consultant-contractor)" (Egbu, 2006).

Studies such as (Frenken, 2002; Onyancha & Ocholla, 2007; Abramo et al., 2009; Hoekman et al., 2009; Klitkou et al., 2009; Sooryamoorthy, 2009) found that research collaboration helped researchers to better share knowledge, skills and techniques, allowing for the transfer of tacit knowledge, and creating knowledge communities between the collaborating researchers and connecting them to the wider scientific community by increasing the visibility of their research.

Despite these benefits, Africa is currently only contributing to a small percentage of the global knowledge production and dissemination (Arvanitis et al., 2000; Narvaez-Berthelemot et al., 2002; Onyancha & Ocholla, 2007; Boshoff, 2009; Adams et al., 2010).

Boshoff (2009) found for example that sub-Saharan Africa's share of world scientific papers actually decreased from 1% in 1987 to 0.7% in 1996. Pouris & Pouris as cited in Boshoff (2009) found that Africa's global share of scientific papers was 1.8% between 2000 and 2004.

Based on data available on the World Bank's website on research and development expenditure, Burkina Faso spent 0.67% of its Gross Domestic Product (GDP) in 2017 as compared to South Africa which spent about 1% of its GDP on research and development (highest percentage of GDP spent on research and development in Africa), or the United States of America which spent 2.80% of its GDP on research and development. Comparatively, countries such as Australia, Israel, Japan, Republic of Korea, and Singapore committed between 1.8 and 4.55% of their GDP to R & D in the same year.

This shows that despite Burkina Faso's comparatively low percentage of GDP on research and development, it recognizes the need for research and development, as they increased their percentage of GDP spent on research and development (0.1% in 2007).

Researchers found that a country's research and development is generally improved by collaborative research from its neighbors (Frenken, 2002; Onyancha & Ocholla, 2007; Abramo et al., 2009; Hoekman et al., 2009; Klitkou et al., 2009 Sooryamoorthy, 2009).

They found that for the chosen African countries (including Burkina Faso), their number of publications increased through their collaboration with their African colleague, although the degree to which the number of publications increased differed.

They also found that that there exists an inclination to share more knowledge with their colleague outside of Africa than amongst each other. Narvaez-Berthelemot et al. (2002) explained this finding by saying that developing countries give preference to collaborations with

developed countries, a reason being a dependence on developed countries seen as the leaders of theories development.

Research and collaborative research and sharing should be encouraged between African countries. This could be accomplished through student and staff exchanges; scholarly exchanges; establishment of researcher networks; and regional conferences. Common subjects or topics should be identified and explored for possible collaborative research. Funding for research and collaborative research should be prioritized (Onyancha & Maluleka, 2011).

3.4.1 Structures in charge of research in Burkina Faso

The main actors carrying out research in Burkina Faso include:

- University of Ouagadougou
- Polytechnic University of Bobo Dioulasso
- University of Koudougou
- National Center for Scientific and Technological Research (CNRST): INERA, IRSS, IRSAT, FRSIT and INSS
- National Forest Seed Center
- Centre de Recherche en Santé de Nouna (CRSN) / (Nouna Health Research Center)
- Clinical Research Unit of Nanoro
- Muraz Centre
- The National Laboratory of Public Health
- Directions of research departments
- Institut de Recherche pour le Développement / (Research Institute for Development)
- Several regional institutions of coordination or evaluation (OCCGE, CAMES)
- NGOs

- Centre de Recherche Biomoléculaire Pietro Annigoni (CERBA) (Pietro Annigoni Biomolecular Research Center)
- Other private actors.

Figure 3.18 below shows the percentage of Burkina Faso's gross domestic expenditure on research and development allocated to scientific research and innovation. The year 2002 saw a sharp increase of the Gross Domestic Expenditure on Research and Development (GERD) estimated at 0.34%, but then it steadily dropped to its lowest point in 2007 with an estimated GERD of 0.11%. As of 2017, it has steadily climbed back up to its highest point of 0.67%. Despite this improvement, Figure 3.18 shows that funding for research and development is still limited and insufficient.

The main factor is that funding for research and development is highly dependent on foreign donors. Although this is common to most African countries, Burkina Faso compared to some of its neighbors is actually on the right path, and it would benefit the country to invest at least 1% of its GDP and R&D.

Compared to the majority of other African countries, Burkina Faso has a clear strategy for leading research, unfortunately it lacks the appropriate funding to effectively implement it. "External funding represents 95%, and sometimes even 100%, of research funding. This aid directly supports research programs, running costs and salaries which should be financed by the government" (Van Lill & Gaillard, 2014).

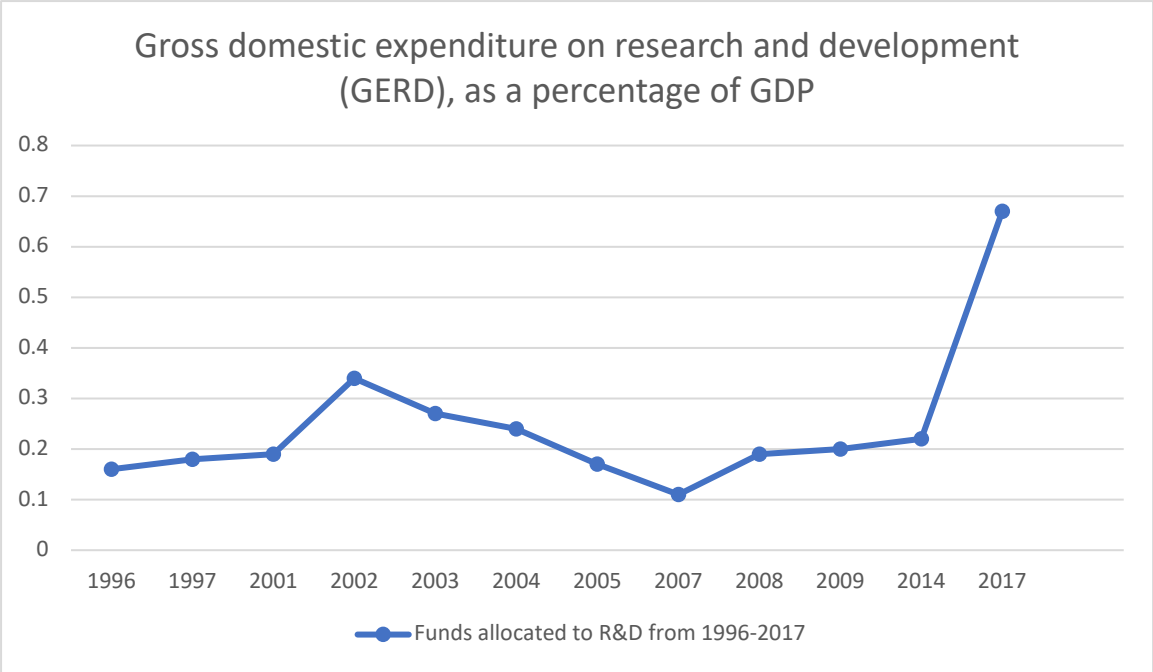


Figure 3.18: Gross domestic expenditure on research and development (GERD), as a percentage of GDP
Source: (Nikyema, 2020)

Since 1990, the annual external budget has been estimated at around USD 600 million financed by roughly 20 different organizations. Funding occurs in the form of bilateral cooperation, primarily with Canada, France, UNDP, USAID, and the World Bank. Multilateral organizations provide 20% of the external subsidies and private institutions cover about 6% of the funding (Van Lill & Gaillard, 2014). In terms of academic research funding, it depends on the collaboration with the following sources (in descending order): the French, Dutch, Canadian (ACDI and IDRC), Swedish, and Danish governments and USAID (Rath, Khelfaoui & Gaillard, 2009).

Obstacles to research funding have been classified as: insufficient conviction from political leaders and the elite that research can find solutions to development problems, insufficient funding, political instability, and international competition (Van Lill & Gaillard, 2014). This skepticism towards research is best summarized by the following saying attributed to

a Burkinabe political leader: “Researchers who are merely doing research can be found but researchers who are producing results are hard to find” (Khelfaoui, 2000).

A review of the three main Burkinabe actors involved in funding research (FONRID, FONER, and FARES) shows that scientific research is still relatively young in Burkina Faso, and as such, it faces many obstacles. Its dependency on foreign funding makes scientific research in Burkina Faso highly susceptible to global financial crises.

3.5 Chapter 3 Summary

Burkina Faso is a French speaking West-African landlocked country, surrounded by Benin, Ivory Coast, Ghana, Mali, Niger, and Togo. It is statistically considered one of the developing countries in the world (GDP: 123rd among 186 countries). It currently has a population of 20 million people, which is forecasted to increase to 29 million by 2030. It is estimated that **60% of the population will live in urban settings by 2050** (UN Habitat, 2015) which will impact its **ageing infrastructures**.

80% of the Burkinabe workforce is in the Agriculture sector making it vulnerable to **irregular climate** (droughts and floods exacerbated by climate change), outside influences. It is a land of **contrasts** with a **scarcity of vital resources** such as arable land and water (Du Plessis, 2002*)*, contrasting with its significant mineral deposits (i.e. gold, zinc, manganese, copper, nickel and antimony) (Du Plessis, 2002*)*. "Like many countries in Africa, it is stuck in a cycle governed by **poverty, fast urbanization, weak governance**, and the vestiges of its **colonial past**" (Du Plessis, 2002).

Research and Development and more specifically on local materials is very much dependent on external funding and is not sustainable for the country to implement and advocate for its population to adopt green design in buildings and housings.

45% of the Burkinabe population **doesn't have constant access to basic needs**, but that doesn't mean sustainability should only be for the rich at the top of the pyramid, especially with the above rising environmental impacts and forecasted population increase. **Therefore, the goal of this research is to see how to achieve sustainability without constraining basic needs.**

CHAPTER FOUR

THEORETICAL FRAMEWORK, RESEARCH METHODOLOGY, RESEARCH DESIGN

This chapter focuses on the pragmatic philosophical worldview chosen for this study, the case study design utilizing a sequential exploratory method, and it details the research design.

There are three theories which form the conceptual framework for this research. Maslow's Hierarchy of Needs theory explains human satisfaction, how it influences human development, and serves to explains the adoption or rejection of green design in developed and developing countries. Stakeholder theory explores stakeholders' influences and how stakeholders' pressure is one of the key drivers impacting the success of projects, such as green design projects. Diffusion of Innovation Theory examines the conditions that increase or decrease the likelihood that an innovation is adopted by members of a given culture.

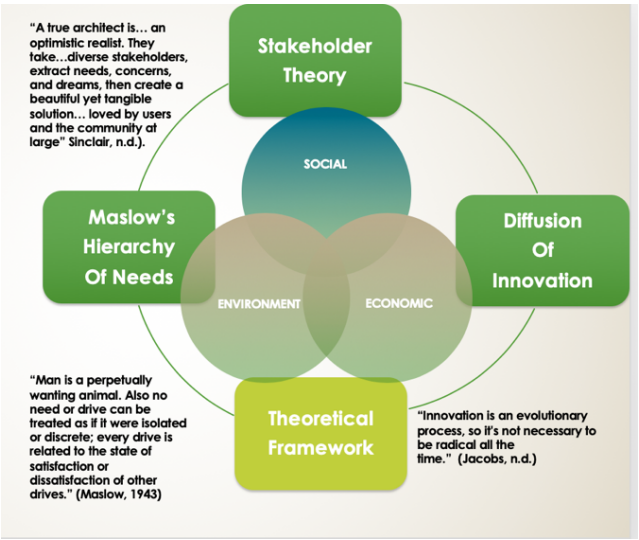


Figure 4.1: Theories informing theoretical framework
Source: (Nikyema, 2018)

A variety of theories are available to describe barriers and drivers of green design commitments; however, the following assumptions help explain the choice of these three theories. This research assumes that green design commitment can be influenced by human behavior factors, organizational factors, and factors which drive or inhibit change.

4.1 Maslow's Hierarchy of Needs Theory

Maslow's Hierarchy of Needs theory originates from psychology and was developed by Abraham Maslow in his 1943 paper "A Theory of Human Motivation" in Psychological Review. It classifies society's universal needs from most concrete to most ethereal. Each need level must be satisfied in order for the individual to move on to the next need level.

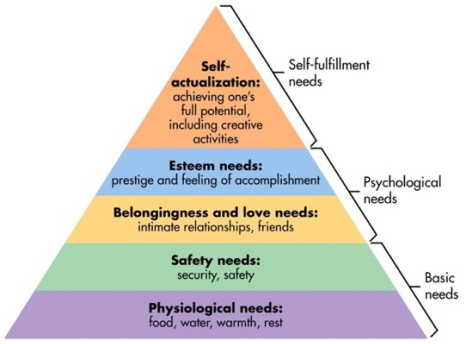


Figure 4.2: Maslow's Hierarchy of Needs (Adapted from Maslow, 1943)
Source: (http://mindbodycoach.org/tag/goals-motivation-therapy/)

Maslow (1943) stated that when needs are not met, with the exception of the physiological needs, deficiency occurs, and one can experience a physical indication of the deficiency via feelings of anxiousness and tenseness. Even though the hierarchy of needs is represented in a pyramid shape, in real life, needs don't occur in sequences due to the human brain's ability to process parallel processes at the same time. This means that different needs motivation can occur at the same time. Guttman (2016)'s diagram below is a better representation of the parallel processing of the needs in the human brain.

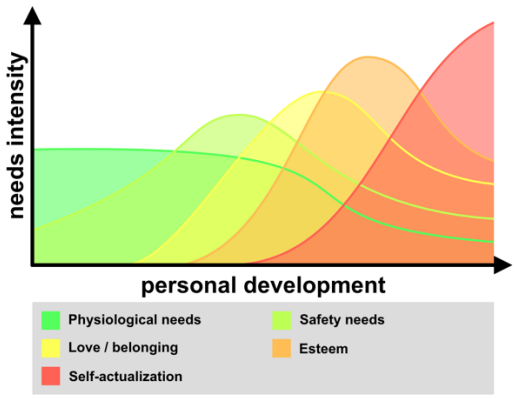


Figure 4.3: Maslow's Hierarchy of Needs: parallel processes
Source: (Guttmann, 2016)

A variety of studies have explored the application of Maslow's theory to the concept of sustainability and green design. For instance, Etzioni (1998) examined consumption patterns, and suggested that when one reaches the Self-actualization needs, one considers reducing one's consumption to make society more sustainable. Studies such as (Tischler, 1999; Parris & Kates, 2003) argue that when basic needs are met, people are not focused on daily survival, making them able to concentrate on sustainability issues (considered higher level needs).

Globally, nations that have reached higher living standards (both economically and socially) can better focus on sustainability practices since their basic needs have been achieved (Tischler, 1999; Udo & Jansson, 2009). Many researchers have adopted Maslow's theory to address sustainable development issues. Studies such as (Melloul & Collin, 2002) have applied Maslow's theory into an assessment of community needs in Israel's groundwater management or have applied it as a framework for the promotion of ecological sanitation in different cultures (Rosenquist, 2005), or to measure sustainable development in developing countries (Walsh 2011). Yawson, Armah and Pappoe (2009)'s study expanded Maslow's theory at the country scale by defining the needs from most concrete to most ethereal: 1. Good economic conditions,

2. Improved safety and security levels, 3. Mutual support and cooperation at the global level, 4. Esteem needs, 5. Self-actualization needs.

These studies show that Maslow's Hierarchy of Needs theory can be applied in the context of developed and developing countries as a general explanation of the process through which an entity or country can be motivated to achieve higher needs levels such as with sustainability practices.

Opponents of Maslow's theory of needs argue that it is largely a western concept, and caution should be taken when applying it to developing countries which oftentimes have different societal structures and different definitions of what primary needs are. However, it can still be used as an overarching theory of change, and lessons can be taken from it in order to motivate sustainability practices.

4.2 Stakeholder Theory

Stakeholder theory stems from the fields of business ethics and organizational management and focuses on the morals and values involved in organizational management. The term "stakeholder" was coined by the Stanford Research Institute in 1963. It is defined as "the groups without whose support the organization would cease to exist" (Friedman, 2006).

Stakeholder theory is made up of four primary concepts (Jones & Wicks, 1999). Firstly, companies have relationships with different stakeholder groups, and these relationships have an impact on their decision making (Laplume, Sonpar, & Litz, 2008; Co & Barro, 2009; Freeman, 2010). These stakeholders' relationships are established in the companies' processes and outcomes. Thirdly, each separate stakeholder's interests are valuable, and one stakeholder group's interests should not be counted above other stakeholder groups (Donaldson &

Preston,1995; Clarkson, 1995; Co & Barro, 2009). Finally, a company's inclusive decision making should be its primary focus (Donaldson & Preston,1995).

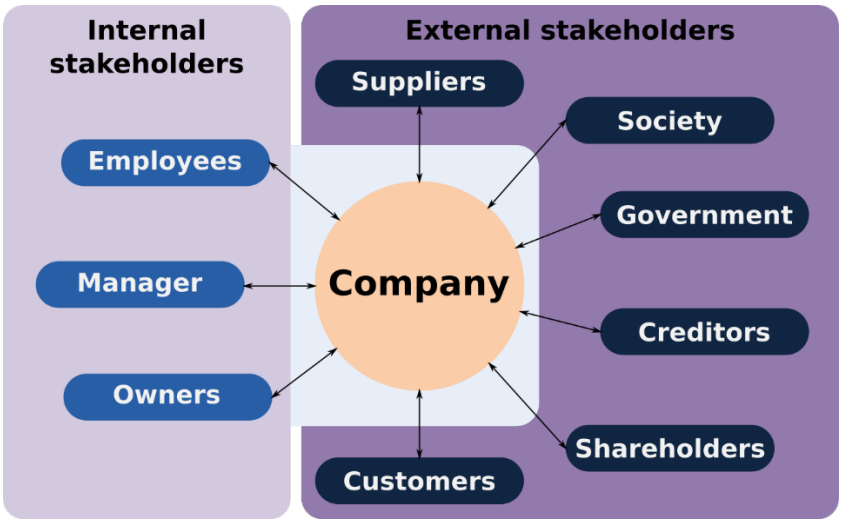


Figure 4.4: Stakeholder diagram
Source: (Freeman, 1984)

Stakeholders can be broadly divided into various groupings, such as primary and secondary stakeholders or internal and external stakeholders. Stakeholders can include groups such as customers, employees, local communities, the government, suppliers, shareholders, other stakeholder groups such as the media, competitors, non-governmental organizations (NGOs) or activists (Friedman & Miles 2006). Even companies' competitors can sometimes be considered as stakeholders since they can have an impact on the company and its stakeholders. On the one hand, it's important to have a variety of stakeholder groups in decision making, but on the other hand, one of the criticisms of Stakeholder theory, is that too many voices can sometimes drown out the decision making. Other criticisms include the difficulty in defining stakeholder groups, and boundaries of what constitute stakeholders are sometimes hard to delineate Miles, 2011; Miles, 2012).

Stakeholder theory has been applied in numerous fields. In terms of sustainable and green building projects, the input of all concerned stakeholders should be implemented throughout the

entire design and construction phases. Studies such as Iwaro & Mwasha (2013) grouped green design and construction stakeholders into five broad categories: clients, corporate institutions, governments, professional bodies, and researchers, and they all have a vital part to play in the successful execution of the projects.

Stakeholder pressure can be used by companies to gain competitive advantage in their operations, especially in sustainable operations (Bonini, Mendonca & Oppenheim, 2006; Bielak, Bonini & Oppenheim, 2007). Stakeholders' input in decision-making is also an important part of organizations being able to reach their set goals (Freeman, 2004).

Government administrations have been found to be primary stakeholders, and their promotion of sustainability practices is essential in pushing the degree to which organizations or individuals adhere to sustainability practices (Delmas 2002; Delmas & Toffel 2004; Bhaskaran et al. 2006; Majdalani, Ajam & Mezher 2006; Gabzdylova, Raffensperger & Castka 2009). This is because their contribution increases pressure on companies or individuals by enforcing policies and regulations, which in return brings change to organizational practices (Carraro, Katsoulacos & Xepapadeas 1996; Rugman & Verbeke 1998; Majumdar & Marcus 2001; Delmas 2002).

Environmental and community studies found that organizations or government administrations can be pressured to increase their commitment towards environmental sustainability, such as with an environmental plan or environmental management systems (EMSs) (Henriques & Sadorsky 1996; Florida & Davidson, 2001). Therefore, the reciprocal relationships between stakeholder groups can bring positive change.

Stakeholder theory has also been applied in the field of green innovation; on green innovation as part of a company's philosophy (Chen, 2008a; Chen, 2008b; Gluch & Thuvander, 2009) or on green innovation as part of a company's environmental practices (Qi, Shen, et al.,

2010). Weng, Chen & Chen (2015) examined stakeholder theory's impact on green innovation as well as environmental and corporate performance. In the figure below, they diagrammed these relationships.

Figure 4.5: Weng, Chen & Chen: Conceptual Framework
Source: (*Weng, Chen & Chen, 2015)*

Stakeholder theory is another relevant theory for this study. It can be used to understand the relationships between different green design and construct professionals, how the barrier groupings influence each other, and on the adoption of green building materials and technologies in Burkina Faso.

4.3 Diffusion of Innovation Theory

The third theory which influenced this research is the Diffusion of Innovation (DOI) Theory. "An innovation is an idea, behavior, or object which is perceived as being new by an individual or other unit of adoption" (Rogers, 1995). It was developed by E.M. Rogers in 1962 and is considered one of the oldest social science theories. It stems from the field of communication to explain the process through which an innovation is developed, expands, and is successfully or unsuccessfully diffused (or spread) to a specific population or social systems.

If the diffusion is successful, people or the social systems will adopt it. Adoption is defined as the person or social system being convinced to change their mind or behavior, or to purchase the product. For adoption to be successful, the person or social systems must recognize the product as being new or innovative, it is the innovative aspect which makes diffusion possible or not.

Booz & Hamilton (1982) found that minor adjustments to existing products can still be considered innovative. Innovations must also meet certain criteria such as being applicable, profitable, useful, and able to compete with other technologies (Van de Ven, 1986; Wheelwright & Clark, 1992. Whether an innovation is adopted or not depends on individual person, as some people are quicker to adopt innovation than others. Understanding the target population and the context where the innovation will be deployed will increase its chances of being adopted.

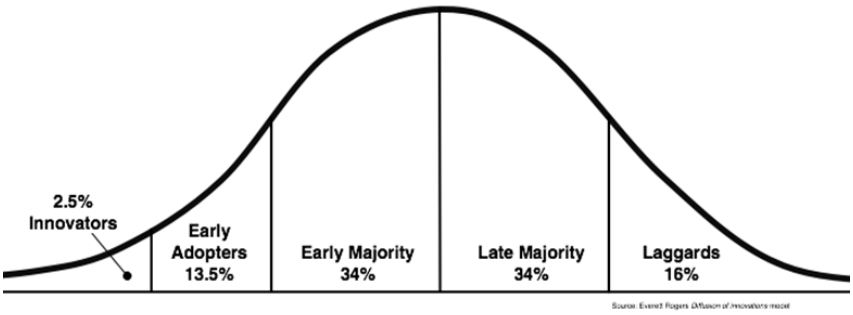


Figure 4.6: Diffusion of Innovation Curve
Source: (*Rogers, 1962)*

Innovators: want to try the innovation first, are open to risk, and tend to be innovators themselves. It is easy to promote innovations to them.

Early Adopters: tend to have leadership roles, are aware of the need for change, and are comfortable adopting new ideas. But they require some promotion, such as information sheets, but could adopt the innovation without it.

Early Majority: are not leaders like early adopters but are still more likely to adopt new ideas than the average person. But they need evidence-based information on the innovation.

Late Majority: are people who don't like change and will only adopt innovation after it has been adopted by the majority of people. They will need heavier promotion such as the adoption rate of the innovation.

Laggards: are traditional people who resist change and are the hardest group to promote innovation to. Promotion strategies can include statistics, fear appeals, and pressure from the other adopter groups (Rogers, 1971).

New innovations need to be better than the innovations they replace, be compatible with the adoptees' context, be easy to understand and use, need to be tested before the adoption, and need to provide concrete results (Rogers, 1971).

DOI Theory has been applied in the field of sustainable development where innovation improves not only economic performance but has a positive impact on environmental and social performance in the short and long terms (von Weizäcker, Lovins, & Lovins, 1997; Biondi; Iraldo, & Meredith, 2002; Alakeson & Sherwin, 2004). Sustainable innovations which include all stakeholders' voices tend to be radical or transformative in nature, due to their going beyond traditional innovation (Rycroft & Kash, 2000)

Rogers et al. (2005) found that there are positive and negative outcomes to innovation adoption and defined these outcomes into three consequences categories: desirable vs. undesirable, direct vs. indirect, and anticipated vs. unanticipated. Wejnert (2002) categorized them as public vs. private, and benefits vs. costs. Public consequences affect the public, while private consequences affect the individual.

Opponents of DOI Theory argue that innovation diffusion is often hard to quantify due to the complex human networks, making it hard to measure causes of adoption (Damanpour, 1996). Some variables cannot be accounted which could lead to missing critical adoption predictors (Downs & Mohr, 1976). Innovation can threaten the adoptees' cultures (Downs & Mohr, 1976), especially in cases where the knowledge sharing is not reciprocal (Giesler, 2012).

This theory will aid in directing the proposed guidelines to mitigate the barriers to the adoption of green building materials and technologies in this study. Furthermore, when looking at best-case scenarios for the proposed guidelines, this theory will aid in examining cases of innovation and green projects failures.

4.4 Research methodology and approach

Section 4.4 details the research methodology utilized in this study. This section starts with the researcher's philosophical worldview, the research design, and a description of the methods used in phase 1(online questionnaire), and phase 2 (semi-structured interviews). Phase 3 comparative analysis is covered in chapter 6, and the proposed guidelines are covered in chapter 7.

4.4.1 Philosophical worldview

Since this research is a mixed methods case study design utilizing a sequential exploratory method, the pragmatic worldview is the best suited for this research. The pragmatist worldview focusses on what works (applications), and what solutions can be found to remedy problems (Patton, 1990). The pragmatist worldview believes that each problem is a unique case where one has to understand the social, historical, political, and other external factors which influence the case. This fit with the research's study design since it focused on understanding the different perspectives of the selected stakeholders as it pertains to perceived barriers to green design and green materials implementation within the social, historical, political and other external factors in Burkina Faso. Furthermore, since Pragmatist researchers don't see the world as an absolute unity, a mixed methods approach fits with this worldview.

4.4.2 Research design

A mixed method approach is advantageous to gain a better understanding of the research problem, and to triangulate data by utilizing different approaches (Bryman, 2004). It also allows the researcher to apply both inductive and deductive reasoning.

Case study and survey design are the most prevalent research strategies used in sustainable design research (Gibberd, 2003, Irad & al., 2007; Morelli, 2011). Case studies are useful for exploratory studies where new processes, behaviors, or phenomena are not well understood within their context. They also allow one to answer 'how' and 'why' questions (Hartley, 1994).

As it pertains to this research, it aims to get the perspectives of design and construction professionals on barriers to the adoption of green building materials and technologies using the case of Burkina Faso, as a representative case of a developing country in West Africa.

Therefore, this study is a single case design with multiple embedded units of analysis. Findings of this study are then compared to the existing literature from the United States of America (representative of developed countries) to help anticipate how to avoid further negative impacts of these barriers, as Burkina Faso continues to develop its built environment.

RESEARCH OBJECTIVES	RESEARCH QUESTIONS	RESEARCH METHODS
To discover what are the barriers to green design and green materials implementation in West Africa.	**RQ1.** What are the barriers to green design and green materials implementation in Burkina Faso?	Archival data; literature review; questionnaire survey; semi-structured interviews
To understand whether developing countries lag in the promotion and pursuit of green design and green materials implementation in West Africa.	**RQ2.** Do developing countries lag behind developed countries in the pursuit of green design using the cases of Burkina Faso and the United States of America?	Literature review; and comparative analysis of literature and findings
To provide guidelines on green design and green materials implementation based on an analysis of best practices and the results of this study.	**RQ3.** What are the lessons and guidelines learned from this study? How can they be disseminated to facilitate green design and construction?	Literature review; and comparative analysis of literature and findings

Table 4.1: Research question and methods
Source: (Nikyema, 2019)

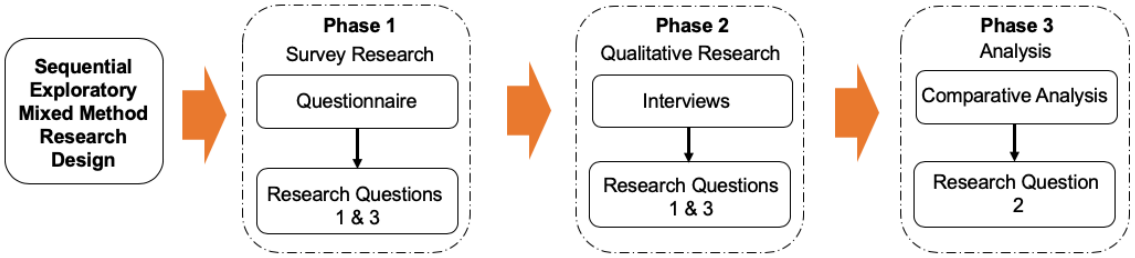


Figure 4.7: Research design process
Source: (*Adapted from Creswell & Clark, 2017)*

This mixed method research employs a **sequential exploratory mixed method research design** and is made up of three consecutive data collecting phases (Creswell, Plano Clark, et al., 2003). Data in phase 1 (quantitative phase) is gathered via an online Qualtrics questionnaire and will answer research questions 1 and 3. Semi-structured interviews (informed by results from phase 1) are then conducted in order to gain qualitative data from participants from Phase 1. This

phase serves to explain and/or elaborate on the findings from phase 1 (data triangulation), as well as answer research questions 1 and 3.

In phase 3 (comparative analysis), findings from phases 1 and 2 are compared to the existing literature from the United States of America (best practices) to answer research question 2. Finally, findings from phases 1 to 3 are integrated to provide guidelines to mitigate the barriers found in this study to answer research question 3.

Employing multiple data gathering phases helps clarify, verify, and address any possible limitations from data gathering phases, and to triangulate data to gain more comprehensive answers to the research questions (Hunt, 2007; Denscombe, 2008).

4.4.3 Online Questionnaire

This section highlights the five phases undertaken from the questionnaire design to the analysis of the questionnaire findings as represented in figure 4.8.

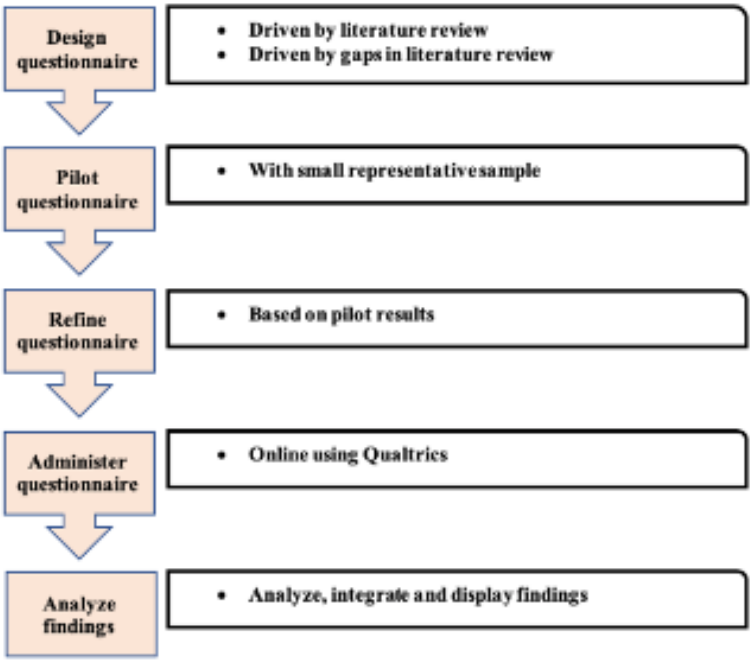


Figure 4.8: Flow chart for questionnaire
Source: (*Adapted from Hasim,2014)*

4.4.3.1 Questionnaire design

Online questionnaires are quick to administer, are a cost-effective method to allow researchers to reach large geographic areas while minimizing costs, and allow for remote data collection (Dillman, 2011; Sue & Ritter, 2012). Questionnaires have also been used extensively to assess participants' perceptions of sustainability (Abigo & al., 2012; Adewunmi, Omirin & Koleoso, 2012; Nielsen, Jensen & Jensen, 2012; Lee & Kang, 2013; Islam & Siwar, 2013).

The online questionnaire was developed from data from the existing literature on barriers to the adoption of green building materials and technologies, prior studies in this field, as well as in conjunction with expert design and construction professionals in Burkina Faso and in the United States of America.

The questionnaire was developed in French and in English, although the English version was intended for reporting and publication purposes. Only the **French version was administered** to the participants in Burkina Faso to accommodate their spoken language.

The barriers used in the online questionnaire were drawn from the existing literature, as well as in conjunction with expert architects in Burkina Faso. This allowed the researcher to test whether these tools would be suitable to gather data in the context of Burkina Faso.

The **explored barriers were grouped into the following five categories** as defined by Chan & Darko (2017): (1) government, (2) human, (3) knowledge and information, (4) market, and (5) cost and risk.

The online questionnaire was made up of **25 questions** comprised of demographic questions, multiple choice questions, five-point Likert scale rankings (1=strongly agree to 5=strongly disagree) within matrix tables, and open-ended questions to allow participants to comment and expand freely on their views. Please refer to Appendix B for the questionnaire.

4.4.3.2 Questionnaire piloting and refining

Prior to the questionnaire implementation, forms and the questionnaire were submitted to the Institutional Review Board (IRB) at Clemson University for approval (Appendix B). After IRB approval, the questionnaire was piloted to identify issues stemming from the questionnaire design.

It was piloted in 2018 to 10 expert participants recruited to represent the target population. Studies have found that piloting questionnaires to 10 or more participants allows for a reasonable sample to test one's instruments (Ferber, 1974; Malhotra, 2006; Creswell, 2009). Additionally, the researcher did not want to deplete her potential sample pool due to the small population of design and construction professionals in Burkina Faso.

To represent the target population of the study, the expert participants were architects, engineers, and in the academic, governmental and public domains. They were asked to evaluate the clarity and consistency of the questions, identify potential errors, and provide suggestions and recommendations. Changes were made to the questionnaire based on their feedback.

There are several tools available online to design, collect, and analyze online questionnaires. SurveyMonkey was initially chosen for the pilot due to its ease of access and implementation, however the researcher felt that it did not allow her enough flexibility in the data extraction and analysis. The Qualtrics software was then chosen, re-piloted, and used for the questionnaire administration for this study (Qualtrics, 2016).

4.4.3.3 Questionnaire administration

This section covers the sampling techniques, data administration methods, and the manner in which the data was protected. The online questionnaire was administered during summer 2019.

Sampling Techniques

The chosen population was limited to registered design and construction professional in Burkina Faso, about 500 people. **Convenience and snowball sampling** were used in this study. Convenience sampling entails getting samples from readily available participants willing to take part in the study (Teddlie & Yu, 2007.

Snowball sampling was employed in cases where the membership rosters were not readily available online, or if a particular design and construction stakeholder group did not have a professional organization. In these instances, the researcher started with one or two rich informants and through them, received access to other members. Combining these two sampling methods allowed the researcher to overcome the issue of having a small population from which to sample from.

Sample size determination

Choosing the correct sample size is an important decision for any research, as the objective is to select the smallest sample size which allows for an adequate confidence level and margin of error. Having the correct sample size also helps decrease the occurrence of sampling error and sampling bias (Dillman, 2011). Based on the population of 500 design and construction professionals in Burkina Faso, with a 95% confidence level and a 5% margin of error, the desired sample size was **218 participants**.

Questionnaire invitation for participants with e-mails

Participants with an e-mail listed in the databases received an initial e-mail inviting them to participate in this study. It included the Informed Consent letter, as well as an individual link to the Qualtrics questionnaire. To encourage their participation, they received a reminder e-mail one week and two weeks after the initial contact.

When accessing the Qualtrics questionnaire, participants were again shown the informed consent letter, at the end of which they chose whether to participate (by selecting YES) or not to participate (by selecting NO). Only those who selected YES were able to access the questionnaire.

The questionnaire was **anonymous** to protect participants' identities. Only participants who agreed to participate in the second phase of the study were asked for their names and contact information.

Questionnaire invitation for participants with phone numbers

Participants who only had a phone number listed in the databases received a phone call from the researcher inviting them to participate in the study, as well as being read the Informed Consent letter. If they verbally agreed to participate in the study, their e-mail was requested in order to be e-mailed a personal Qualtrics questionnaire link.

Their access to the Qualtrics questionnaire, their invitation to be participate in the study, how their identity and data would be protected then followed the same structure as participants with e-mail addresses.

Data protection

Data from this research was strictly kept in the researcher's computer which is equipped with a private password, the backup hard drive also equipped with a password, and both were kept in a locked drawer of the researcher's desk within her locked office.

The Qualtrics questionnaire link was encrypted and each participant received an individual link to the questionnaire. Qualtrics also assigned each participant a unique random identifier. No one beside the researcher and her advisor saw the individual participants' answers.

Participants' data will be kept by the researcher for ten years after the data collection completion for publication purposes, as well as informing future research. However, when the data will be shared with possible funders, collaborators, or other researchers, it will be de-identified in order to protect the participants' identities.

4.4.3.4 Questionnaire analysis

Studies such as (Henn et al., 2006; Leedy & Ormrod, 2010) found that the most widely used descriptive statistical data analysis tools are central tendency measurement, dispersion measurements and frequency distributions.

The collected data was downloaded to Excel (Microsoft, 2018) to organize it for analysis. It was analyzed using JMP PRO 14.3.0 and SPSS(2018). Questionnaire questions were scaled and tested for reliability using Cronbach's alpha. The average Cronbach's alpha coefficient for the questions was 0.8, indicating that the questions were reliable.

Descriptive and inferential statistics were used for the data analysis for the questionnaire data. For individual questions, descriptive statistics was employed, but for the aggregated barrier analysis and stakeholder analysis, descriptive and inferential statistics were used to analyze the data.

The analysis phase consisted of three types of analysis. Analysis 1 entailed computing the mean, median, and standard error for each individual question. Due to the data not following a normal distribution (due to it being Likert-scaled), tests of significance could not be performed for these questions. Analysis 2 required the aggregation of the questions under each barrier category. The one sample t-test for each aggregated barrier groupings was carried out to formally find out whether on average participants had positive or negative responses (agreed or disagreed) with each particular aggregated barrier groupings.

Once the data is aggregated in the form of a mean for each barrier grouping, the Central Limit statistical theory implies that the aggregated data is likely to be normally distributed. Due to this, the formal one sample t test could be used in order to test the significance of the average response provided for each barrier groupings questions.

Analysis 3 consisted of a comparison of the potential differences in responses between the different stakeholder groups. A comparison of the mean response of each specific stakeholders' groups for each specific barrier groupings was first undertaken using a series of one sample t-tests. A series to two-sample t-tests were then carried out to compare the stakeholder groups against each other for each barrier groupings in order to test whether they are significantly different from each other.

4.4.3.5 Questionnaire limitations

When carrying out research, possible limitations and potential sources of error can occur (Dillman, 2011; Sue & Ritter, 2012).

Measurement error

As participants interpret things differently, questionnaire questions and answer options could lead to inaccurate data due to the potential of being interpreted differently. Even though this source of error couldn't be eliminated, attempts were made to minimize the degree of measurement errors via seeking the input and feedback from experts and piloting the questionnaire.

Non-response bias

Due to the limited population size and some issues in gaining access to some respondent groups, non-response bias can occur when estimating a population characteristic based on a

sample where some participants groups are underrepresented. This was addressed via the sampling strategy and by testing for non-response bias.

Technical problems

Technical problems, such as Qualtrics freezing or crashing leading to participants not being able to complete their questionnaires, could have resulted in missing data. This was mitigated via participants being able to return to their questionnaire (until it was closed by the researcher) until they completed and submitted it.

Validity and Reliability

Construct Validity threats were dealt with via the utilization of multiple sources of evidence. Due to this study using a sequential exploratory mixed methods design, the qualitative data results served to explain and augment the results from the quantitative phase. A study protocol was also used which established a chain of evidence.

Internal Validity threats were mitigated via this study incorporating several cycles of analysis, in which the results were checked at different study applied theoretical applicable logic to build solid rules.

For threats to external validity, the study instruments were piloted, and experts were used to check the study protocols.

4.4.4 Semi-structured interviews

This section highlights the five phases undertaken from the semi-structured interview design to the analysis of the interview findings as represented in figure 4.9.

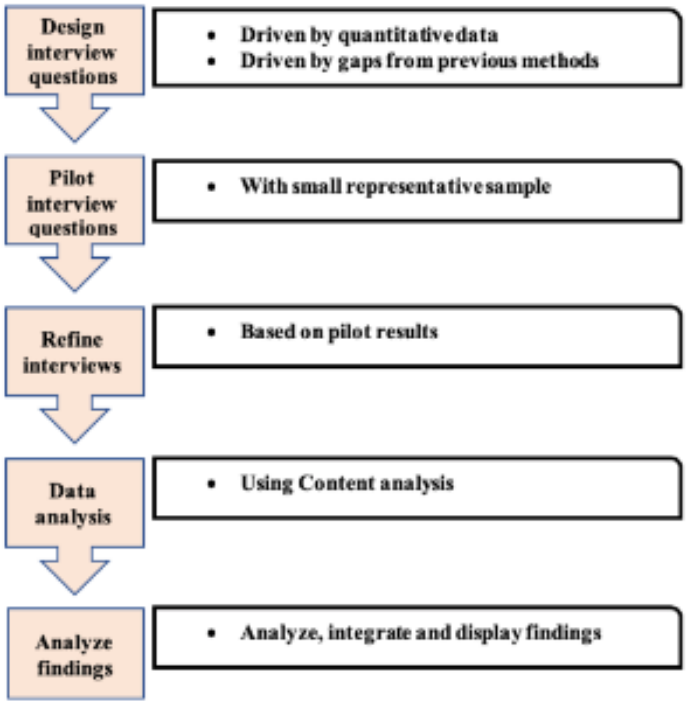


Figure 4.9: Flow chart for semi-structured interviews
Source: (*Adapted from Hasim,2014)*

4.4.4.1 Semi-structured interview design

The semi-structured interviews in phase 2 of the data collection were conducted to deal with the limitations of the previous phase, as well as to enrich the data with qualitative data. Questionnaires are limited in the number of questions which can reasonably be asked of participants, often do not allow participants to explain their perceptions in-depth, and it's frequently difficult to gain context into participants' responses (Gable, 1994; Bryman, 2008).

Benefits of semi-structured interviews include building trust between researcher and participants leading to richer data and being able to follow a replicable data gathering protocol while allowing for flexibility in tailoring interviews for each participant (Cohen & Crabtree, 2006; Noor, 2008; Dewey & Zheng, 2013).

Finally, semi-structured interviews help in data triangulation via data validation, verification, and the ability to fill possible data gaps from prior data gathering phases (Gable 1994; Hussein 2009; Islam & Siwar 2013; Yeasmin & Rahman 2012).

4.4.4.2 Semi-structured piloting and refining

As with the questionnaire phase, prior to the semi-structured interviews implementation, forms and the interview protocol were submitted to the Institutional Review Board (IRB) at Clemson University for approval (Appendix C). After IRB approval, the semi-structured interview was piloted to identify issues stemming from the semi-structured interview design. It was piloted in 2018 with the same 10 expert participants as in the questionnaire phase.

4.4.4.3 Semi-structured interviews administration

Participants Recruitment

The participants for the semi-structured interview phase were the same participants from phase 1 (online questionnaire) who indicated that they wished to be contacted for the semi-structured interviews. They did so by entering their contact information for the researcher to contact them to schedule the interviews. The interviews were administered during summer 2019.

The results from the first data collection phase were used to guide the questions for the semi-structured interview questions. As such they followed the same structure as the online questionnaire. Please refer to Appendix C for the semi-structured interview guide.

Semi-structured interviews administration

Participants were assigned a fictitious name (such as participant 1) to order to protect their identity. An introductory phone call or e-mail (one week after the completion of the participant questionnaire) were made in order to confirm their continued willingness to participate, and to schedule their individual interviews.

At the beginning of the phone or in-person interviews, participants were reminded of the study purpose, measures protecting their identity were explained, the letter of informed consent was orally agreed to, and they were asked if they were willing to be audio recorded using a voice recorder. For cases (10 participants) were participants did not want to be recorded, the researcher took abundant notes which she transcribed at the end of the interview.

The interviews were conducted in **French** to accommodate the spoken language of the participants. **Twenty rich interviews** were conducted which is in line with the recommendations for semi-structured interviews. Guest, Bunce and Johnson (2006) stated that interviewing between six and twelve participants allows for data comparison, for themes to emerge, and to answer research questions.

Interviews ranged from **30 minutes to 1 hour 30 minutes**, based on the participants' availability and level of engagement. They were recorded (when allowed) with a Sony digital recorder which made it easier to transfer the recorded interviews to the researcher's laptop.

Archival Records

The study employed archival records when available to support or contradict the responses from both phases 1 and 2. Having a variety of compatible data sources not only allows for data triangulation, but also adds to the richness of the case studies (Creswell, 2009). The researcher uses governmental reports, websites, and a variety of policy documents in order to analyze the data.

4.4.4.4 Semi-structured interviews analysis

In order to analyze qualitative data, one must be able to generate, organize, manage, and combine large volumes of textual data. Creswell (2009) lays out the following steps for analyzing qualitative data:

- Thoroughly read and familiarize oneself with all the data
- Identify and organize together data groupings sharing similar themes and codes
- Thoroughly note initial thoughts and reflections
- Analyze data to identify patterns, themes, and sequences
- Construct matrices, network maps, and diagrams
- Link generalizations together

The researcher defined her 3 major data analysis stages as Transcription and data familiarization, Thematic analysis and coding, and Categorization, pattern matching and interpretation. They are explained in the following sections.

Transcription and data familiarization

The 20 recorded semi-structured interviews were transcribed using the Microsoft Word software based on Silverman (2011)'s transcription guide. They were then translated from French to English before analysis could be started. The researcher ensured that the translation occurred without losing context and meaning. The process of interviewing, transcriptions, and translations were carried out by the researcher, which aided her in familiarizing herself with the data. Data familiarity is emphasized as an important step by several qualitative research proponents (such as Creswell, 2009;Miles et al., 2014). During the transcription and translation phases, the researcher continuously noted emerging themes as they were revealed.

Thematic analysis and coding using MAXQDA

Making use of computers and the appropriate software makes organizing and managing the large amount of qualitative data easier (Bryman, 2008). MAXQDA was used for that purpose as it is useful for qualitative and mixed methods research. It allowed the researcher to perform a range of functions, such as storing, coding, sorting, retrieving, visualizing and querying data.

MAXQDA allowed the researcher to easily organize and classify data, categorize it in coding sections under relevant themes, and link them into larger theme groups when necessary. Coding was the next step after the thematic analysis of the data. Saldaña (2013, pg. 3) defined a code as "*a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data",* meaning that one tried to identify word and phrases that represented participants' thought.

The researcher initially started her coding using four themes derived from her study objectives: Understanding Sustainability, Contextual Characteristics, Sustainability Barriers, and Recommendations. Please refer to Appendices J and K for examples of coding from the data analysis.

Categorization, pattern matching and interpretation

As more interviews were analyzed, adding to the data, and the coding went through several iterations, new themes emerged to understand barriers to barriers to the adoption of green building materials and technologies in Burkina Faso. Given the robust and diverse responses from the twenty interviewees, new themes were allowed to form idiosyncratically.

An across-case comparison of the emergent themes was carried out across all interviews in order to analyze general themes. This process was carried out via grouping and consolidating all the sub-nodes into larger categories. As part of qualitative research, themes and sub-themes go through several iterations of grouping, ungrouping, and regrouping in new ways so that they are they end up being categorized in the most appropriate categories.

At the completion of the analysis, over a **hundred themes and sub-themes** emerged to explain barriers to the adoption of green building materials and technologies in Burkina Faso. Some of these themes were similar to the existing literature and some were specific to the case of

Burkina Faso. Please refer to Chapters 5 to 7 for the detailed explanations of the findings and the answers to the research questions.

4.4.4.5 Semi-structured interviews limitations

Over the phone interviews were beneficial in allowing the researcher to interview participants remotely, to allow for the interviewing of a larger group of participants, and to help the researcher to economize in time and money.

However, some limitations of over-the phone interviews are that the researcher is not able to observe participants' mannerisms during interviews, it's harder to establish bonds with researcher and participants, and some participants might be less open during a phone interview than in person. Despite these possible limitations, due to the mixed methods nature of this study, these limitations can be mitigated.

Validity and Reliability

Silverman (2006) defined validity as being the degree to which an explanation represents the social phenomena it represents, meaning that it is a truth which allows one to incorporate different perspectives and viewpoints. In order to ensure validity, Silverman (2006) stated that assumptions about the data must not be made during the study, and to utilize data triangulation to ensure that the data is free from biases.

The "between method" and the "within method" were used to counter the threats to reliability and validity in this study. For the "between method", the literature review and the three data collection stages (online questionnaire, semi-structured interviews, and comparative analysis) were used to gain a richer picture of the phenomenon.

For the ‘within method’, the three data collection stages, utilizing the same participants for phases 1 and 2, allowed the researcher to gain a deeper understanding of the phenomenon, as well as to check the data for its truthfulness, its internal validity, and to minimize any possible biases.

A study protocol was used throughout the study to make sure that it is valid and replicable which established chains of evidence to ensure that the qualitative data could augment and inform the quantitative data. This would alleviate threats to the construct and internal validity.

Data was carefully recorded and transcribed in order to make sure it was error free, and member checking was utilized to guarantee this. Archival data when available was also used to support or contradict the data. If the researcher encountered anomalies or outliers, she strived to address them by checking whether they were errors, or whether they were new themes not covered by the literature review or collected data. This helped to increase the credibility of the results.

Member checking was employed by contacting the participants and showing them the data to make sure that the results were accurate. Rich and thick descriptions were also used when displaying the qualitative data in order to allow the reader to experience the phenomenon, making the results more realistic and richer, and which in turn increased the validity of the results.

Silverman (2006) defined reliability as the degree to which the data is consistent. Yin (2009) found that using a case study protocol made the study more reliable and replicable. Piloting the semi-structured interview tested the tools, made sure that the collected data answered the research questions, as well as refined it. To deal with threats to reliability, the interview transcripts were coded with the recordings (when applicable) to ensure that the researcher’s own biases didn’t influence the coding. Utilizing MAXQDA was also beneficial to reduce reliability issues, and code definitions were checked to make sure that they were appropriate via continuously comparing them to the data and using memos.

Researcher Biases

The researcher is a citizen of Burkina Faso (the chosen case for this research) and is well versed in the existing literature on barriers to the adoption of green building materials and technologies in developed and developing countries, which could have influenced her findings. However, due to the limited research in this field in Africa and in Burkina Faso, due the exploratory nature of this study, and due to the utilization of the case study protocol, this alleviated any potential biases on the part of the researcher. She was open to all participants' perspectives, allowed the data to evolve and let it drive emerging theories, and used data triangulation to corroborate or dispute findings.

Research Assumptions

Even though Silverman (2006) stated that data assumptions must not be made during the study, the researcher assumed that some significant degree of sustainability development had occurred in developed countries, and to varying degrees in Burkina Faso.

Study Limitations

The scope of this research was limited to the case of Burkina Faso and to similar West African countries. Although the proposed guidelines are specific to Burkina Faso, some might be generalizable to similar West African countries or other developing countries.

Table 4.2: Overview of the semi-structured interview research process

Stages	Steps	Outcome
Conceptualization	-Initial review of the research problem	-Investigating how green design & green materials implementation is adopted globally
Literature review	-Understand the origins of sustainability -Identify the key stages in the evolution of sustainability - Understand the components of green design -Understand existing barriers to green design and green materials implementation from literature -Understand those barriers as they pertain to West Africa and Burkina Faso in particular -Understand the construction context in Burkina Faso	-Research context clarified -Contemporary issues and context identified as they influence key research decisions -Identification of target stakeholders to understanding perceptions on barriers to green design and green materials implementation in Burkina Faso
Research Design	-Understand the role of theory in research -Understand the different philosophical influences -Identification of mixed methods sequential exploratory design -Selection of case of Burkina Faso -Making contact with prospective participants	-Positioning of the research under the pragmatist worldview -Gaining access to participants databases -Selection of semi-structured interview as a secondary data collection method -Design of case study interview protocol -Data collection
Data Analysis	-Transcription of the interviews to MS Word -Uploading transcripts to MAXQDA -Creation of nodes based on analytic framework -Coding the interviews based on existing nodes -Coding of interviews based on new emerging nodes from the data -Comparing overall coding for interviews	-Understanding contextual drivers and barriers to green design and green materials implementation in the context of Burkina Faso
Write up	- Documentation of the whole research process and findings	-Conclusions and recommendations -Implications for the case of Burkina Faso and West Africa in general

Source: (Nikyema, 2020)

4.5 Chapter 4 Summary

This research assumes that green design commitment can be influenced by human behavior factors, organizational factors, and factors which drive or inhibit change.

Three theories were used to inform this research: Stakeholder Theory, Diffusion of Innovation Theory, and Maslow's Hierarchy of Needs Theory.

Although 45% of the population of Burkina Faso doesn't have constant access to basic needs, this doesn't mean that sustainability is a concept which has no place in the context of Burkina Faso, especially with the increasing negative environmental impacts and the forecasted population increase (which has the potential to strain resources and infrastructures). **Therefore, the goal of this research is to achieve sustainability without constraining basic needs.**

The pragmatic worldview was best suited for this research since it sees each phenomenon as a unique case where one must understand the social, historical, political, and other external factors which influence the case.

This mixed method research employs a **sequential exploratory mixed method research design** with three consecutive data collecting phases (online Qualtrics questionnaire, semi-structured interviews, comparative analysis).

To gain insight on the five barrier groupings as defined in the literature: (1) government, (2) human, (3) knowledge and information, (4) market, and (5) cost and risk, this study solicited perceptions from various stakeholders from the design and construction field in Burkina Faso.

Findings were compared to the existing literature from the United States of America as a representative of developed countries to help anticipate how to avoid barriers as Burkina Faso develops its built environment.

From the understanding of the barriers, guidelines were developed, which are the first step to initiate changes in policies and practices aimed at increasing green design and construction in Burkina Faso, and in West Africa in general.

CHAPTER FIVE

ANALYSIS AND DISCUSSION OF CASE STUDY FINDINGS

Chapter 5 discussed the findings from Phase 1 the online Qualtrics questionnaire and Phase 2 the semi-structured interviews.

Data from these two phases are used to answer research question 1: what are the barriers to green design and green materials implementation in Burkina Faso?

The findings for this chapter are also used to answer research questions 3 which is discussed in chapter 7.

5.1 Results from the Online questionnaire

This section focuses on the findings of the Qualtrics online questionnaire. It is divided in seven sub-sections which discuss the demographic profile on the participants, their general perceptions of green building materials and technologies, a discussion of the findings of the 5 barriers grouping questions: government (1) and human (2), knowledge (3) and market (4), and cost and risk (5).

5.1.1 Demographic profile of participants

Table 5.1 below outlines the demographic profile of the online Qualtrics questionnaire. A total of **218** participants answered the questionnaire, and the response rate was **43%**.

Table 5.1: Demographic profile of the participants (N=218)

Characteristic	Frequency	Percentage
Professional body affiliation		
Architects	119	54.5
Contractors	5	2.29
Educators	10	4.58
Engineers	65	29.8
Government	3	1.37
Materials Suppliers	3	1.37
Planners	10	4.58
Researchers	3	1.37
Level of education		
Technical degree	38	17.43
Bachelor's degree	78	35.77
Master's degree	83	38.07
PhD degree	19	8.71
Professional practice experience		
0-5 Years	28	12.84
6-10 Years	28	12.84
11-15 Years	36	16.51
16-20 Years	55	25.22
20+ Years	71	32.56
Professional practice experience		
Less than 5years	72	33.02
5 – 10 years	104	47.70
10 – 15 years	50	22.93
16 – 20 years	16	7.33
20 and above	18	8.25
Size of design and construction firms		
1 – 4 employees	53	24.31
5 – 9 employees	36	16.51
10 – 19 employees	66	30.27
20 – 99 employees	42	19.26
100+ employees	21	9.63

Source: (Nikyema, 2020)

The two big stakeholders group were **architects (54.5%)** followed by **engineers (29.8%)**. This reflects the fact that these stakeholder groups had professional associations with

registered member lists, making it easier for the researcher to access a larger pool of those participants. Snowball sampling was employed in cases where the membership rosters were not readily available online, or if a particular design and construction stakeholder group did not have a professional organization.

The **majority of the design and construction professionals held university degrees**, with the majority holding Master's Degrees (38.07%) followed by Bachelor degree holders (35.77%). This was true for the architect group (38.65% had Master degrees & 36.97% had Bachelor degrees), the educator group (40% had Master degrees & 30% of participants respectively had Bachelor and PhD degrees).

For the engineers group the majority held Bachelor degrees or Master degrees (38.46% respectively). For the contractor (80%) and material suppliers (66.66%) groups the majority held technical degrees. The majority of planners held Master degrees (50%) and Bachelor degrees (40%). The majority of researchers (66.66%) held PhD degrees, and for government participants, their education ranged from technical degrees to Master degrees. **This shows that any policy aimed at design and construction professionals need to occur across all educational levels.**

In terms of experience, **33% of the total number of participants had 20+ years of experience** (architects, educators), **followed by 16 to 20 years** (25%) (contractors, engineers). For the other stakeholder groups, their experiences ranged from little experience (0-5 years) to 20+ years.

They worked primarily in medium (10-19 employees; 30%) **to small firms** (1 to 4 employees companies; 25%). The majority of architects worked in small (29.41%) and medium (26.05%) firms. Engineers worked primarily in medium (10-19 employees; 40%) and small firms (1 to 4 employees; 21.53%).

Contractors worked primarily in small firms (40% worked in 1-4 employees firms & 40% in 5 to 9 employees firms). Educators (20-99 employees; 50%) and researchers (20 to 99 employees; 66.66%). Materials suppliers' firms ranged from small firms (33.3%) to 100+ employees firms (33.3%).

5.1.2 General perceptions about green design and construction

This section covers questions which assesses green design and construction professionals' general perceptions about green design and construction.

Q2. Type of buildings generally worked by participants

Table 5.2: Type of buildings participant firms specialize in (N=218)

Type of building	Number of participants	Percentage
Residential	184	84.40
Commercial	164	75.22
Governmental	98	44.95
Educational	94	43.11
Other	16	7.33

** Multiple responses were possible*

Source: (Nikyema, 2019)

Participants were asked what types of building their firms primarily worked on. **The majority of participants worked primarily on residential construction (84.40%), followed by commercial construction (75.22%).** Other recurring responses were governmental (44.95%), educational (43.1%) and other (7.33%). This was true across all stakeholder groups. Participants also described other projects that have worked on as local materials testing projects, health centers, sanitary infrastructures, religious structures, and landscape projects.

Q3. Degree of knowledge about green design and construction

Table 5.3: Green design and construction knowledge (N=218)

Degree of knowledge	Number of participants	Percentage
Extremely knowledgeable	10	4.58
Very knowledgeable	64	29.35
Somewhat knowledgeable	83	38.07
Not very knowledgeable	58	26.60
Not at all knowledgeable	3	1.37

Source: (Nikyema, 2019)

This study established that the majority of participants described themselves as being **somewhat knowledgeable** about green design and construction (38.07%), **followed by very knowledgeable (29.35%), meaning that the majority of participants had a good command of green design and construction.**

This was true for architects, educators, and engineers stakeholder groups. All contractors felt that they were not very knowledgeable about green design and construction (100%). For government, materials suppliers, planners and researchers participants, their knowledge of green design and construction ranged from very knowledgeable to not very knowledgeable.

This means that there is a need to increase green design and construction education for all stakeholder groups, with a focus on government, materials suppliers, planners and researchers groups. However, bigger samples for these stakeholder groups could increase or decrease the outcomes for this question.

Q4. Types of green technologies used in participants' projects

Design and construction professionals worked primarily with green materials and technologies which did not require a lot of specific technical skills such as natural light (48.6% of total participants incorporated it always; 37% of total participants incorporated it

frequently), natural ventilation (47.2% of total participants incorporated it always, 38.9% of total participants incorporated it frequently), passive design, and sustainable materials (22.9 % of total participants incorporated it always, 44.9% of total participants incorporated it frequently).

They worked the least with renewable energy (36.2% of total participants incorporated it sometimes, 20.1% of total participants incorporated it rarely and 7% of total participants incorporated never), water treatment and conservation techniques (25.6% of total participants incorporated it sometimes, 27.5% of total participants incorporated it rarely and 14.2% of total participants incorporated never), smart and energy efficient appliances (35.3% of total participants incorporated it sometimes, 27.9% of total participants incorporated it rarely and 14.6% of total participants incorporated never), and waste reduction techniques (23.8% of total participants incorporated it sometimes, 36.6% of total participants incorporated it rarely and 24.3% of total participants incorporated never).

In Burkina Faso, renewable energy is still an emerging field, except for solar energy. Recently, policies have been implemented to increase the use of solar energy, and the Burkinabe government is researching and investing in it, such as solar farms. Access to solar energy systems is still generally expensive for the average citizen.

Smart and energy efficient appliances' purchases are generally carried out by the homeowner, and most often do not fall under the umbrella design and construction professionals. They are usually imported and tend to generally be costly for the average Burkinabe citizen, making their usage in Burkina Faso presently low. Water treatment and conservation techniques are commonly water collection systems such as cisterns but tend to be found more in urban settings.

It was surprising that green roofs were not amongst the green technologies most widely used, (8% of total participants incorporated it always, 26.6% of total participants; 35.7% of total participants incorporated it frequently). In the comment section, participants' responses highlighted the ambiguity of the definition of this technology.

Some participants defined it in terms of a modern green roof as defined in developed countries, and with this definition, they reported that they rarely or never used it. For participants who defined it in local terms (such as straw roofs: traditional vernacular or modern adaptations), they reported it as always, frequently, or sometimes using it.

In the comment section, participants also mentioned using green materials specific to Burkina Faso such as BLT, BTC, adobe, wood, banco, and cut stones. When looking at the frequency of their usage, participants stated that they used these local green materials often (39%) and from time to time (24.77%). **This shows that green materials are not consistently used in Burkina Faso, so more promotion needs to occur to increase their usage in Burkina Faso.**

Q5. Advantage of green buildings over traditional building

This question asks participants whether green buildings has an advantage over traditional buildings in Burkina Faso using a series of components. The majority of participants felt that green buildings had an advantage over traditional buildings in **environmental benefits** (42.6% of total participants strongly agreed; 50.9% of total participants agreed), **occupants' health and comfort** (42.6% of total participants strongly agreed, 45.8% of total participants agreed), and **operating costs** (17.4% of total participants strongly agreed, 34.4% of total participants agreed).

They felt that **green buildings did not have an advantage over traditional buildings in building performance, design and construction costs, durability, and marketability**. This might be due to memories of failed green projects due to lack of technical knowhow.

Participants who felt that green buildings did not have an advantage over traditional buildings in **design and construction costs** mentioned the high costs of green materials in Burkina Faso, their limited availability on the market, transportation costs, and their small-scale artisanal production.

They felt that the higher initial costs of green materials did not encourage clients to choose such materials in Burkina Faso, especially since construction is generally considered pricey. Others also mentioned that local green materials are not generally seen as being viable options for clients because they are seen as being materials for the poor and are not suitable for clients who practice auto construction (building their houses over years, stopping and starting when they have the financial means) since such materials can degrade over time. This pushes clients to towards more durable materials such as bricks, concrete, and cement, which are more durable but less sustainable. Finally, some participants mentioned that if local green materials are well promoted in Burkina Faso, they could inspire national pride.

Q6. *Challenges to the implementation of green design and construction in Burkina Faso*

The biggest challenges to the adoption of green building materials and technologies in Burkina Faso were **client demand** (18.8% of total participants strongly agreed, 48.6% of total participants agreed), **lack of stakeholder awareness** (especially with clients) (15.1% of total participants strongly agreed, 64.2% of total participants agreed), **lack of green technologies** (19.2% of total participants strongly agreed, 61% of total participants agreed), and **lack of**

stakeholder involvement (especially on the part of the government) (16% of total participants strongly agreed, 53.6% of total participants agreed).

Part of these challenges to the adoption of green building materials and technologies in Burkina Faso could be tied to lack of stakeholder awareness. On the part of the clients, they might not know of or be convinced about the benefits of local green materials. For design and construction professionals, some are not convinced of the properties and durability of local green materials.

In the open-ended section for this question, participants often highlighted that they felt that the government administration of Burkina Faso is not sufficiently involved in the promotion and usage of local green materials, especially since they are the biggest builders in the country.

In terms of the lack of green technologies, participants stated that many of the local green materials are manually produced, keep their availability on the market small. This in turn makes the materials sector unstable, as it can be affected by market volatility. Other challenges mentioned by the participants were lack of research on local green materials, and lack of available financing from the government towards construction in general and green construction in particular.

Q7. Most important considerations when considering green design and construction in Burkina Faso

This question asked participants about the most important considerations when considering green design and construction in Burkina Faso. Participants felt that **minimizing construction & operating costs** (53.6% of total participants strongly agreed 38% of total participants agreed), **affordable construction** (50.9% of total participants agreed; 44.4% of total participants strongly agreed), **environmental preservation** (33% of total participants strongly

agreed, 54.1% of total participants agreed), and **cultural heritage** (27.5% of total participants strongly agreed, 55% of total participants agreed).

In the open-ended section for this question, construction costs and making construction affordable were most often noted by participants. They felt that if construction costs and local green materials costs were reduced, the average Burkinabe citizen would be able to focus on building a more sustainable house. This would be in contrast to their current primary focus of a durable house (means using cement, concrete and bricks).

5.1.3 Government and human related barriers

This section focuses on the government and human barriers. Table 5.4 below highlights the summary statistics for the responses to these barrier groupings, as well as the aggregate question response for the government and human barriers as a whole.

Table 5.4. Summary Statistics for Government and Human Barriers Questionnaire Responses

	Government				**Human**		
	Mean[a]	N	Conclusion		Mean[a]	N	Conclusion
Gov1	0.24 ± 0.05	210	Barrier	**Hum1**	0.64 ± 0.04	218	Barrier
Gov2	0.67 ± 0.04	210	Barrier	**Hum2**	0.80 ± 0.03	201	Barrier
Gov3	0.59 ± 0.04	207	Barrier	**Hum3**	-0.16 ± 0.06	207	Not a barrier
Gov4	0.07 ± 0.06	190	Not a barrier	**Hum4**	-0.60 ± 0.06	195	Not a barrier
Gov5	0.86 ± 0.04	216	Barrier	**Hum5**	0.35 ± 0.05	215	Barrier
Gov6	-0.21 ± 0.05	195	Not a barrier				
Aggregate	0.4 ± 0.02	218	Barrier	**Aggregate**	0.22 ± 0.02	218	Barrier
Statistical Test Results	Paired T-test comparing Government response average to Human response average was found to be significant **(p< 0.001)** with government factors being considered on average more of a barrier compared to human factors						

a. Mean response ± standard error / response values range from -1.5(strongly not a barrier) to 1.5 (strongly a barrier)
b. Statistical test was only run for aggregate question response and not for single question responses (Non-parametric test results agreed with t-test results)

Source: (Nikyema, 2020)

For **government-related barriers**, participants felt that the **low awareness of government entities** of green design and construction, **lack of government supported practices** focused on green design and materials, **lack of government supported practices** focused on green design and materials, and lack of **government supported funding programs** for green design and construction were the most prevalent barriers.

They did not feel that "green design and construction standards are not adapted to fit local needs" was a barrier. Some participants stated that there was a need to first develop local green design and construction standards, especially as it pertains to green materials and technologies standards. Then these local standards could be compared to international standards to see whether they fit with, added to or needed to be adapted to local standards.

Participants did not find that "there was a high of international donors participation in green design and construction" was a barrier. They explained this in the open-ended section. They felt that international donors participated more in the areas of research, government projects, and big design and construction projects in partnership with the government. For smaller projects, especially residential projects, there was more participation of local Burkinabe design and construction firms than international firms.

The aggregate question response for the **government barrier** finds that **it is considered to be a barrier for the average respondent.**

For **human-related barriers**, participants felt that the **public's low awareness of the benefits** of green design and construction**, lack of effective initiatives** on green design and construction, the **public's resistance to change** towards green design and construction, and the **lack of public demand** were the most prevalent barriers.

They found that “the public feared losing its cultural identity due to green design and construction” was not a barrier. It was surprising that “there was a resistance to change on the part of the public towards green design and construction” was found to be a barrier. The open-ended section for this question allowed participants to expand on their views.

Some felt that there was resistance to change on the part of the public towards green design and construction due to local green materials being seen as being materials for the poor, memories of failed projects, and issues of durability of local green materials and technologies. In such instances, the public could be found to be resistant to construction using local green materials when they could have durable house built using cement, bricks, and concrete.

Others felt the issue stemmed more from a lack of knowledge of the benefits of green design and construction by the public. They felt that citizens of Burkina Faso were more interested in having a decent house, and if they were shown the benefits of houses built in local green materials and green materials’ prices decreased, then they would be willing to use such materials in their construction.

The aggregate question response for the human barrier finds that it is considered to be a barrier for the average respondent.

5.1.4 Knowledge and market related barriers

This section examines knowledge and market related barriers. Table 5.5 below highlights the summary statistics for the responses to these barrier groupings, as well as the aggregate question response for the knowledge and market barriers as a whole.

Table 5.5. Summary Statistics for Knowledge and Market Barriers Questionnaire Responses

	Knowledge				Market		
	Mean[a]	N	Conclusion		Mean[a]	N	Conclusion
Kno1	0.68 ± 0.04	214	Barrier	**Mar1**	0.21 ± 0.05	217	Barrier
Kno2	0.99 ± 0.03	216	Barrier	**Mar2**	0.87 ± 0.04	218	Barrier
Kno3	0.62 ± 0.05	210	Barrier	**Mar3**	-0.01 ± 0.06	205	Not a barrier
Kno4	-0.53 ± 0.06	195	Not a barrier				
Kno5	-0.47 ± 0.06	195	Not a barrier				
Kno6	0.55 ± 0.04	205	Barrier				
Aggregate	0.4 ± 0.02	218	Barrier	**Aggregate**	0.37 ± 0.03	218	Barrier
Statistical Test Results	Paired T-test comparing Government response average to Human response average was found to be significant **(p< 0.001)** with government factors being considered on average more of a barrier compared to human factors						

a. Mean response ± standard error / response values range from -1.5(strongly not a barrier) to 1.5 (strongly a barrier)
b. Statistical test was only run for aggregate question response and not for single question responses (Non-parametric test results agreed with t-test results)

For **knowledge-related barriers**, participants felt that **the lack of education opportunities** for design and construction professionals, **lack of access to financing** for education for design and construction professionals, that there is **not enough design and construction professionals knowledgeable** about green design and construction, and **the limited number of networking venues** focused on green design and technologies, were the most prevalent barriers.

They did not find that there was a high degree of participation for international design firms and international construction firms as barriers in Burkina Faso. Once again in the open-ended section, they explained this by saying that international donors were more prevalent in the areas of research, government projects, and big design and construction projects in partnership with the government. For smaller projects, especially residential projects, there was more participation of local Burkinabe design and construction firms than international firms.

The aggregate question response for the knowledge barrier finds that it is considered to be a barrier for the average respondent.

For **market-related barriers**, participants felt that the **lack of green technologies available in the markets** and the **lack of supply networks for green technologies** were the most prevalent barriers.

Participants did not feel that design and construction markets were necessarily resistant to change and innovation in Burkina Faso. Some mentioned that the markets were interested in the potential of new green materials, but the problem is that such materials often did not go beyond the level of research laboratories.

The aggregate question response for the market barrier finds that it is considered to be a barrier for the average respondent.

5.1.5 Cost and risk related barriers

This section examines the cost and risk barrier. Table 5.6 below highlights the summary statistics for the responses to this barrier grouping, as well as the aggregate question response for the cost and risk barrier as a whole.

Table 5.6. Summary Statistics for Cost and Risk Barrier Questionnaire Responses

	Cost and Risk		
	Mean[a]	N	Conclusion
Cos1	0.83 ± 0.03	213	Barrier
Cos2	0.19 ± 0.06	199	Barrier
Cos3	0.62 ± 0.06	205	Barrier
Cos4	-0.85 ± 0.06	198	Not a barrier
Aggregate	0.4 ± 0.02	216	Barrier
Statistical Test Results	Paired T-test comparing Cost and risk response average was found to be significant **(p< 0.001).** With Cost and risk factors being considered on average more of a barrier compared to Market and Human factors.		

a. Mean response ± standard error / response values range from -1.5(strongly not a barrier) to 1.5 (strongly a barrier)
b. Statistical test was only run for aggregate question response and not for single question responses (Non-parametric test results agreed with t-test results)

For **cost and risk-related barriers**, participants felt that the **fear of increased financial risks** associated with sustainable technologies, the resistance to change and innovation creates an **increased fear of risk associated with green technologies**, and the **uncertainty about the performance** green technologies were the most prevalent barriers.

Participants did not find that the "fear of litigation due to green technologies failures" was a barrier. This is because litigation over failed green projects does not often occur in Burkina Faso. There have been examples of collapsing buildings killing people, but rarely was the design or construction firms prosecuted.

The aggregate question response for the cost and risk barrier finds that it is considered to be a barrier for the average respondent.

5.1.6 Comparison of stakeholder groups

A comparison across the different groups of construction professionals (Architect, Engineer, Others) is also carried out for each barrier grouping, detailing the areas of consensus and differences between the views of the stakeholder groups which participated in the study.

Table 5.7 below shows the views of the stakeholder groups for the government and human barriers.

Table 5.7. Stakeholders Average aggregate Barrier Response Results

	Government				Human			
	Mean[a]	N	p-value[b]	Conclusion	Mean[a]	N	p-value[b]	Conclusion
Architect	0.40 ± 0.03	119	<0.001	Barrier	0.25 ± 0.03	119	<0.001	Barrier
Engineer	0.39 ± 0.04	65	<0.001	Barrier	0.24 ± 0.05	65	<0.001	Barrier
Other[c]	0.43 ± 0.05	34	<0.001	Barrier	0.07± 0.07	34	0.33	Not a barrier

a. Mean response ± standard error / response values range from -1.5(strongly not a barrier) to 1.5 (strongly a barrier)
b. p-value results obtained using One-sample independent T-test/ Test deemed significant if p-value < 0.05. Test results were adjusted using Bonferroni correction.
c. Other includes the following stakeholders (Contractors, Educators, Government, Material Suppliers, Planners, Researchers)

For the **government barrier**, all three stakeholder group on average found this barrier category **to be a barrier.** For the **human barrier**, the Architect and Engineer groups on average found this barrier category **to be a barrier**, but the Others grouping did not.

Table 5.8. Stakeholders Average aggregate Barrier Response Results

	Knowledge				Market			
	Mean[a]	N	p-value[b]	Conclusion	Mean[a]	N	p-value[b]	Conclusion
Architect	0.32 ± 0.03	119	<0.001	Barrier	0.30 ± 0.04	119	<0.001	Barrier
Engineer	0.38 ± 0.04	65	<0.001	Barrier	0.53 ± 0.06	65	<0.001	Barrier
Other[c]	0.37 ± 0.05	34	<0.001	Barrier	0.28± 0.09	34	0.05	Barrier

a. Mean response ± standard error / response values range from -1.5(strongly not a barrier) to 1.5 (strongly a barrier)
b. p-value results obtained using One-sample independent T-test/ Test deemed significant if p-value < 0.05. Test results were adjusted using Bonferroni correction.
c. Other includes the following stakeholders (Contractors, Educators, Government, Material Suppliers, Planners, Researchers)

For the **knowledge barrier**, all three stakeholder group on average found this barrier category **to be a barrier.** For the **market barrier**, all three stakeholder group on average also found this barrier category **to be a barrier.**

Table 5.9. Stakeholders Average aggregate Barrier Response Results

	Cost and risk			
	Mean[a]	N	p-value[b]	Conclusion
Architect	0.31 ± 0.04	118	<0.001	Barrier
Engineer	0.17 ± 0.05	65	0.002	Barrier
Other[c]	0.07 ± 0.08	33	0.42	Not a barrier

a. Mean response ± standard error / response values range from -1.5(strongly not a barrier) to 1.5 (strongly a barrier)
b. p-value results obtained using One-sample independent T-test/ Test deemed significant if p-value < 0.05. Test results were adjusted using Bonferroni correction.
c. Other includes the following stakeholders (Contractors, Educators, Government, Material Suppliers, Planners, Researchers)

For the **cost and risk barrier**, the Architect and Engineer groups on average found this barrier category **to be a barrier**, but the Others grouping did not.

5.1.7 Concluding questions

The concluding two questions asked participants about their perspectives for the future of green design and construction in Burkina Faso, and what should the role of the media in the promotion of green design and construction in Burkina Faso. These questions were open-ended in order to allow participants to expand on their views on these questions.

Q18. What do you foresee is the future of green design in your country?

Overall, **the majority of the total participants saw the future** of green design and construction in Burkina Faso **as positive** (48.5% of total participants). The responses for this question fell under 3 camps:

Table 5.10: Positive future descriptors (N=106)

Description	Number of participants
Positive	28
Optimistic	22
Positive but still work to be done	13
Exciting	11
Promising	10
There has been a lot of progress	7
Beautiful	6
Encouraging	4
Bright	3
Hopeful	2

Source: (Nikyema, 2019)

Table 5.10 above displays the descriptors used by the 106 participants who saw the future as positive. However, the majority of them stressed that the future would be positive only if the following recommendations were implemented.

- Need for more research on green materials, but especially on promotion and dissemination of the findings, because oftentimes they stayed at the research level
- More incorporation of local green materials, especially in social housing
- Need for more factories and funding to manufacture local green materials
- Need for the government to be more involved, especially in the promotion of local green materials in their construction
- Need for more training for design and construction professionals
- More funding for construction, especially for the clients
- Tying the Burkinabe economy with construction, if the economy works, it is reflected in the construction

- If all concerned stakeholders get involves in the utilization and promotion of local green materials
- Lowering the cost of local green materials to make them more competitive
- Raise the awareness of the local population to the benefits of green materials, especially in preserving the local cultural heritage

Q19. What do you think is the role of the media in promoting green design and construction in your country?

For the participants, **72% felt that the media should have a role in promoting green design and construction** in Burkina Faso, but that the media was currently used effectively for that purpose. Their responses fell under these broad categories:

- Need for the media to be true partners with design and construction professionals for the promotion of green design and construction and green materials
- Need for partnerships between design and construction professionals, material producers, material suppliers, and the media
- When they promoted construction projects, they tended to promote the design, and not the benefits of the properties of the chosen local green materials
- Need for journalists who are specifically trained in understanding local green materials
- Media should use all types of dissemination networks, especially radio and cell phones to help in the promotion of green design and construction, since a large majority of the population has access to radio and cell phones

- Media should partner with design and construction professionals to create their local architectural journals and magazines

In conclusion**,** participants felt that the government should be the driving force in the promotion of green design and construction in Burkina Faso. Overall, participants highlighted **governmental barriers**, **financial barriers**, the **limited access and high costs** of the local green materials, and the **limited access to educational resources** as the barriers which most affected the ability to attain sustainable construction in Burkina Faso.

5.2 Semi-structured interviews analysis

The second phase of this study collected qualitative data via semi-structured interviews, allowing the researcher to get more in-depth information on the participants' views of barriers to the adoption of green building materials and technologies.

A total of 20 rich semi-structured interviews were conducted from the participants from the questionnaire phase who indicated that they were interested in the follow-up interviews. The breakdown of the participants is shown in table 5.11 below.

Table 5.11: Demographic profile of the semi-structured interviews participants (N=20)

Characteristic	Frequency	Percentage
Professional body affiliation		
Architects	10	54.5
Contractor	1	2.29
Educator/researcher	1	4.58
Engineers	2	29.8
Government	2	1.37
Materials Suppliers	2	1.37
Planners	2	4.58

Source: (Nikyema, 2019)

At the completion of the analysis, over a **hundred themes and sub-themes** emerged to explain barriers to the adoption of green building materials and technologies in Burkina Faso. Some of these themes were themes found in phase 1 of the data collection (questionnaire), some were specific to phase 2 of the data collection, and some were found across both data collection phases as shown in table 5.12.

The semi-structured interviews found that the government administration, design and construction professionals (especially architects and engineers), and clients are the primary stakeholders who should have the most influence on green design projects in Burkina Faso.

Material suppliers, design and construction professionals (especially architects and engineers), and government administration have the most influence on the promotion of green materials and technologies in Burkina Faso. This study found that the construction industry in Burkina Faso is not performing efficiently in terms of sustainability. These findings suggest that it requires drastic change in order to actualize sustainable construction in Burkina Faso.

This study finds that green technology not only involves local materials and equipment, but also includes knowledge and skills. The majority of participants feel that there is a need to combine indigenous green materials (both in their traditional forms and re-imagined) as well as modern green building materials and technologies, in order to most effectively achieve sustainable construction in Burkina Faso.

In order to increase their rate of adoption, reforms must be instituted to increase the quantities and qualities of green materials and technologies on the markets in Burkina Faso. Their prices should be cheaper or within the range of non-green materials in order to increase their desirability. More research on green materials and technologies need to be carried out in order to develop norms and standards for these materials in Burkina to increase their popularity

Faso with the public and design and construction professionals. They tend to be seen as not being durable, as being materials for the poor, and due to memories of failed green projects in Burkina Faso.

Although prior studies have found that technology transfer of green materials and technologies was highly effective in the adoption of technologies for developing countries, this study found that it was not necessarily the case in Burkina Faso. Participants felt that the case of LOCOMAT (program focused on the development and promotion of local green materials) was a prime example of this.

It was a program which had been instituted in order to research local green materials, aid in the development of norms and standards, support their promotion, and disseminate the training to design and construction professionals. However, when the funding for this project ended, the developed local green materials and technologies were not necessarily transferred to the local population.

Therefore, a more participatory development and promotion of local green materials and technologies and involving all stakeholders in the public and private sectors, would be beneficial in the case of Burkina Faso.

5.3 Discussion of results for research question 1

Research question 1 asked: what are the barriers to green design and green materials implementation in Burkina Faso?

Based on the results of the online questionnaire and the semi-structured interviews, this study found a **total of 31 barriers** with **14 barriers specific** to Burkina Faso itself.

The advantage of the sequential mixed methods study design is shown in table 5.12. Some barriers were found exclusively in either the questionnaire or semi-structured interviews,

and some were found in both data collection phases, allowing for data triangulation. Please refer to chapter 7 for the detailed description for each barrier and the proposed guidelines.

Table 5.12. **Barriers found in this Study**

Barriers found from online questionnaire		Barriers found from semi-structured interviews		Barriers found from both methods	
7.1.5 9	Government	**7.1.2**	Government	**7.1.1**	Government
7.2.4	Human	**7.1.3**	Government	**7.1.4**	Government
7.2.5	Human	**7.2.1**	Human	**7.1.6**	Government
7.3.2	Knowledge	**7.3.4**	Knowledge	**7.1.7**	Government
7.3.5	Knowledge	**7.3.8**	Knowledge	**7.1.8**	Government
7.3.9	Knowledge			**7.2.2**	Human
7.4.4	Market			**7.2.3**	Human
7.5.2	Cost & risks			**7.2.6**	Human
				7.3.1	Knowledge
				7.3.3	Knowledge
				7.3.6	Knowledge
				7.3.10	Knowledge
				7.4.1	Market
				7.4.2	Market
				7.4.3	Market
				7.5.2	Cost & risks

Source: (Nikyema, 2020)

5.3.1 Actual versus perceived barriers

Even though this study did not measure the differences between actual and perceived barriers in Burkina Faso, it recognizes the need for a discussion on the subject. Actual and perceived barriers have been studied in a variety of fields, including in the field of design and construction. Barriers are defined as "things which impede or separate" (Webster's Dictionary, 2020).

The study of perceived barriers is rooted in self-regulation theories, health research, social cognitive theory, and social-ecological theory (Leventhal et al., 1991; Stokols, 2000;

Glanz et al., 2002; Locke et al., 2002; Glasgow, 2008). Perceived barriers as found in Glasgow (2008) could be defined as "a person's *estimation* of the level of challenge of social, personal, environmental, and economic obstacles to a specified behavior or their desired goal status on that behavior."

Glasgow (2008) finds this definition problematic due to the implication that an individual's judgement of the number and strengths of barriers is a cognitive process which may or may not be a close reflection of the actual measures of social, environmental, or economic barriers.

This is due to the fact that there are many factors influencing a person's perception of barriers, such as one's individual past history, risk of threat perceptions, perceived social support, and influence beliefs (Glasgow, 2008).

Figure 5.1 below is adapted from Glasgow (2008). His original diagram was drawn from the existing literature on perceived and other barriers. This adaptation reflects how the researcher perceives barriers and other factors impact our self-efficacy (the degree to which we can have agency and self-determination in our behaviors) and our problem-solving skills (Bandura, 1997; Williams et al., 1998). Those two factors have an impact on how we self-manage and adhere to our behaviors, which lead to consequences and experiences based on our behaviors.

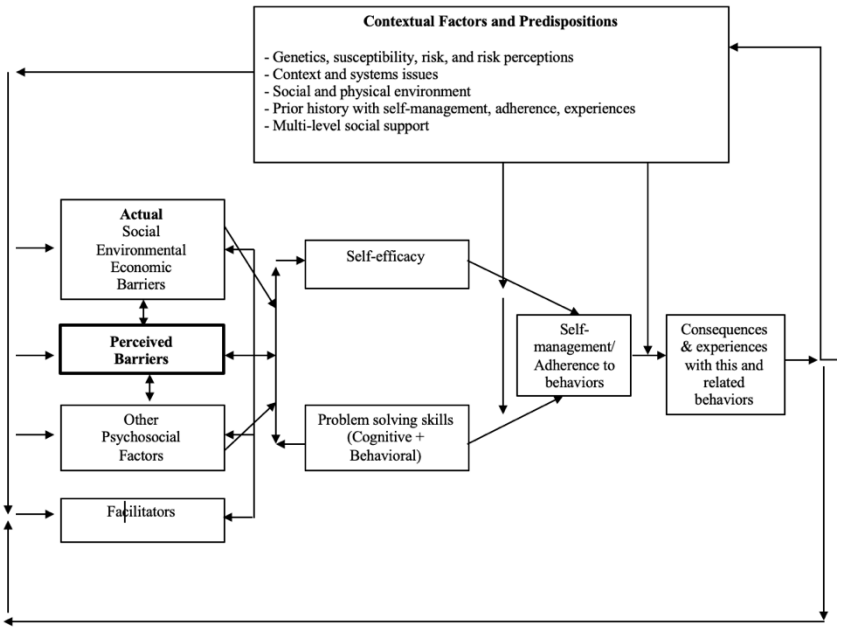


Figure 5.1: Logic Model of Role of Perceived Barriers and Related constructs
Source: (*Adapted from Glasgow, 2008)*

The manner in which we perceive our behavior and performance, influence how we perceive or adjust our perception of barriers; "perceived barriers are assumed to be malleable based on experience; different for different… behaviors; and influenced by, and in turn, influencing multiple factors" (Glasgow, 2008).

Contextual factors and predispositions impact our perceptions of barriers, our behaviors, and experiences. Due to this, **perceived barriers can be related to actual barriers**, meaning that they can reflect the actual barriers, but **they are not an actual or objective measurement of barriers** (Glasgow, 2008).

In the case of Burkina Faso for example, design and construction professionals perceived the government administration as not being actively involved in the promotion of local green materials and technologies, especially in their governmental projects. In actuality, the government has recently been implementing new construction projects, which use local green

materials, in different regions such as Gaoua. This shows that although the design and construction professionals' perceptions of the government administration's lack of involvement in the promotion of green materials might reflect actual barriers, they are not actual or objective measures of the existing barriers.

In this instance, their negative perceptions of the government administration of Burkina Faso as not being actively involved in the promotion of local green materials, might be influenced by their own perceptions and experiences, which in turn might lead them to overestimate the barrier, which serves to reinforce their own perceptions of being the only ones advocating for the promotion of green materials and technologies.

Future work could try to operationally measure the perception of barriers to the adoption of green building materials and technologies in Burkina Faso, in West Africa, and in developing countries in general.

5.4 Chapter 5 Summary

For the questionnaire section (phase 1), a total of **218** participants answered the questionnaire, and the response rate was **43%**.

For **government-related barriers**, participants felt that the **low awareness of government entities** of green design and construction, **lack of government supported practices** focused on green design and materials, **lack of government supported practices** focused on green design and materials, and lack of **government supported funding programs** for green design and construction were the most prevalent barriers.

For **human-related barriers**, participants felt that the **public's low awareness of the benefits** of green design and construction**, lack of effective initiatives** on green design and construction, the **public's resistance to change** towards green design and construction, and the **lack of public demand** were the most prevalent barriers.

For **knowledge-related barriers**, participants felt that **the lack of education opportunities** for design and construction professionals, **lack of access to financing** for education for design and construction professionals, that there is **not enough design and construction professionals knowledgeable** about green design and construction, and **the limited number of networking venues** focused on green design and technologies, were the most prevalent barriers.

For **market-related barriers**, participants felt that the **lack of green technologies available in the markets** and the **lack of supply networks for green technologies** were the most prevalent barriers.

For **cost and risk-related barriers**, participants felt that the **fear of increased financial risks** associated with sustainable technologies, the resistance to change and innovation creates an

increased fear of risk associated with green technologies, and the **uncertainty about the performance** green technologies were the most prevalent barriers.

For the semi-structured interview section (phase 2), a total of **20** participants were interviewed.

Some barriers were found to be specific to either the online questionnaire or the semi-structured interview phases, and some barriers were common to both.

This study found a **total of 31 barriers** with **14 barriers specific** to Burkina Faso itself.

CHAPTER SIX

COMPARISON WITH THE CASE OF THE UNITED STATES OF AMERICA

Chapter 6 discusses firstly the comparison of the study findings with the existing literature on barriers to the adoption of green building materials and technologies in developed and developing countries.

The second part of this chapter focuses on a discussion of RQ3, whether developing countries lag behind developed countries in the pursuit of green design using the cases of Burkina Faso and the United States of America.

6.1 Comparison of findings with existing literature

As outlined in Chapter 2 Literature Review, the existing literature on barriers to the adoption of green building materials and technologies were specific to the United States of America, to developed international countries (i.e. Australia, Singapore**)**, and to developing countries, as shown in table 6.1.

This study found barriers consistent with the existing literature with a total **31 barriers** found with **14 barriers specific** to Burkina Faso.

This means that this study **reaffirmed findings of prior studies**. As it also found barriers specific to Burkina Faso, this also reasserts the need for **context specific research** on barriers to the adoption of green building materials and technologies, in order to offer recommendations which best fit the existing context. Please refer back to chapter 5 for a description of the results and chapter 7 for guidelines for these barriers in Burkina Faso.

Table 6.1: Barriers found in the literature and in this study

Barriers found in U.S.A. studies	Barriers found in international developed studies	Barriers found in developing countries	Barriers found in this study in Burkina Faso
Cost	Lack of research on green design & technologies	Lack of green building practices & technologies' databases	**This study reaffirmed findings of prior studies** (U.S.; international developed studies; developing countries)
Limited users' knowledge and skills with green design & technologies	Lack of users', practitioners & market knowledge and interest in green design & technologies	Lack of available information on green design & technologies	**7.1.2** Lack of nationwide policy on green design & materials
High costs of green technologies	Uncertainty about the benefits & performance of green design & technologies	Cultural barriers	**7.1.3** Lack of green material definition in Code of Urban Planning & Construction
	Higher initial implementation costs in green design & technologies	Lack of transparency	**7.1.6** Administrative delays in CEFAC
	Lack of government support and incentives	Weak governance	**7.1.7** High costs of Urban Living Permit (PUH)
	Lack of building codes and regulations		**7.1.8** Lack of access to financing for construction
	Poor stakeholder relationships		**7.2.1** Lack of affordable real estate
			7.2.5 Lack of financing for construction for the public
			7.3.1 Limited educational access for design & construction professionals
			7.3.2 Limited financing for education for design & construction professionals
			7.3.4 Payment delays for construction projects
			7.3.5 Competition with foreign-owned construction companies (large projects)
			7.3.7 Limited number of architects
			7.3.8 Limited knowledge about the role of the architect
			7.3.10 Lack of trained media on green design & construction

Source: (Nikyema, 2020)

6.1.1 Do developing countries lag behind developed countries in terms of literature

Barriers to the adoption of green building materials and technologies occur in both developed and developing countries. A comparison of the barriers found in the existing literature as it pertains to research question 2, is proposed below using the case of Burkina Faso (representative of developing countries) and the United States of America (representative of developed countries).

If one counts the number of barriers found in the existing literature and in this study for Burkina Faso, then Burkina Faso could be said to be lagging behind the U.S.A. in terms of the literature, because it has **a greater number of barriers** (having barriers found in developed and developing countries, AND barriers specific to Burkina Faso).

On the other hand, if one argues that barriers found in developed and developing countries are universal to all countries, **then specific barriers are a better reflection of a country's state of** sustainability. Therefore, each country should be measured in how they meet their own goals, and not necessarily compared in how they compete globally with other countries.

6.2 Comparison of findings with performance indicators

The second part of this chapter compares the cases of Burkina Faso and the U.S.A. in terms of a series of performance indicators measuring a country's state of sustainability. This section will cover different performance indicators, and Burkina Faso's and the U.S.A.'s adherence to the UN's 17 Sustainable Development Goals (which include measures for decent work and economic growth, industry, innovation and infrastructure, sustainable cities and communities, responsible consumption and production, climate action, life below water and life on land).

6.2.1 Ecological footprint

The ecological footprint is an ecological accounting system, which measures how much nature is needed to support people. It compares how much biologically productive area is used by people for consumption to how much biologically productive area is available (biocapacity). Biocapacity is the productive area that can regenerate what people demand from nature. Footprint and biocapacity can be compared at the global, national, regional, or individual scale (Global Footprint Network National Footprint Accounts, 2019).

Ecological footprint analysis has been widely used as an indicator of environmental sustainability. It can measure and manage the use of resources throughout the economy and explores the sustainability of individual lifestyles, goods and services, organizations, industry sectors, neighborhoods, cities, regions and nations (Global Footprint Network National Footprint Accounts, 2019).

In Figure 6.1 below, the ecological footprint is measured by the number of global hectares impacted by humans per capita of each country. The lighter the orange shade, the smaller the smaller a country's ecological footprint per capita and the darker the orange shade, the higher the ecological footprint per capita. The total ecological footprint (global hectares affected by humans) is measured as a total of six factors: cropland footprint, grazing footprint, forest footprint, fishing ground footprint, carbon footprint and built-up land.

The world-average ecological footprint in 2016 was 2.75 global hectares per person (22.6 billion in total). With a world-average biocapacity of 1.63 global hectares (gha) per person (12.2 billion in total), the global ecological deficit was 1.1 global hectares per person (10.4 billion in total). Currently, less than 20 percent of the world's population is living in countries that can keep up with their own demands.

The United States of America's ecological footprint in 2016 was 8.1 gha per person (4.9 times more than the world's average biocapacity) as compared to Burkina Faso's which was 1.2 gha per person. For a more sustainable planet, there is a need for every country to have a footprint smaller than the planet's biocapacity. Any country which consumes more than the 1.63 global hectares per person has an unsustainable global resource. This doesn't mean that Burkina Faso, which has a footprint smaller than the 1.63 global hectares (gha) per person, is entirely more sustainable.

Ecological destruction may still occur due to the quality of the footprint. If a country doesn't have enough ecological resources within its own boundaries to meet its population's footprint, it runs an ecological deficit, and is therefore called **an ecological debtor. If it has an ecological reserve, it is then called an ecological creditor.**

The USA and Burkina Faso are both ecological debtors, even though the USA has a higher ecological debt (-4.5 gha) as compared to Burkina Faso which has an ecological debt of (-0.2 gha).

Therefore, both countries use more resources than their biocapacity. If both countries focus on implementing more sustainable policies, in term of ecological footprint, Burkina Faso might have to do less work in order to maintain and/or reduce its ecological footprint.

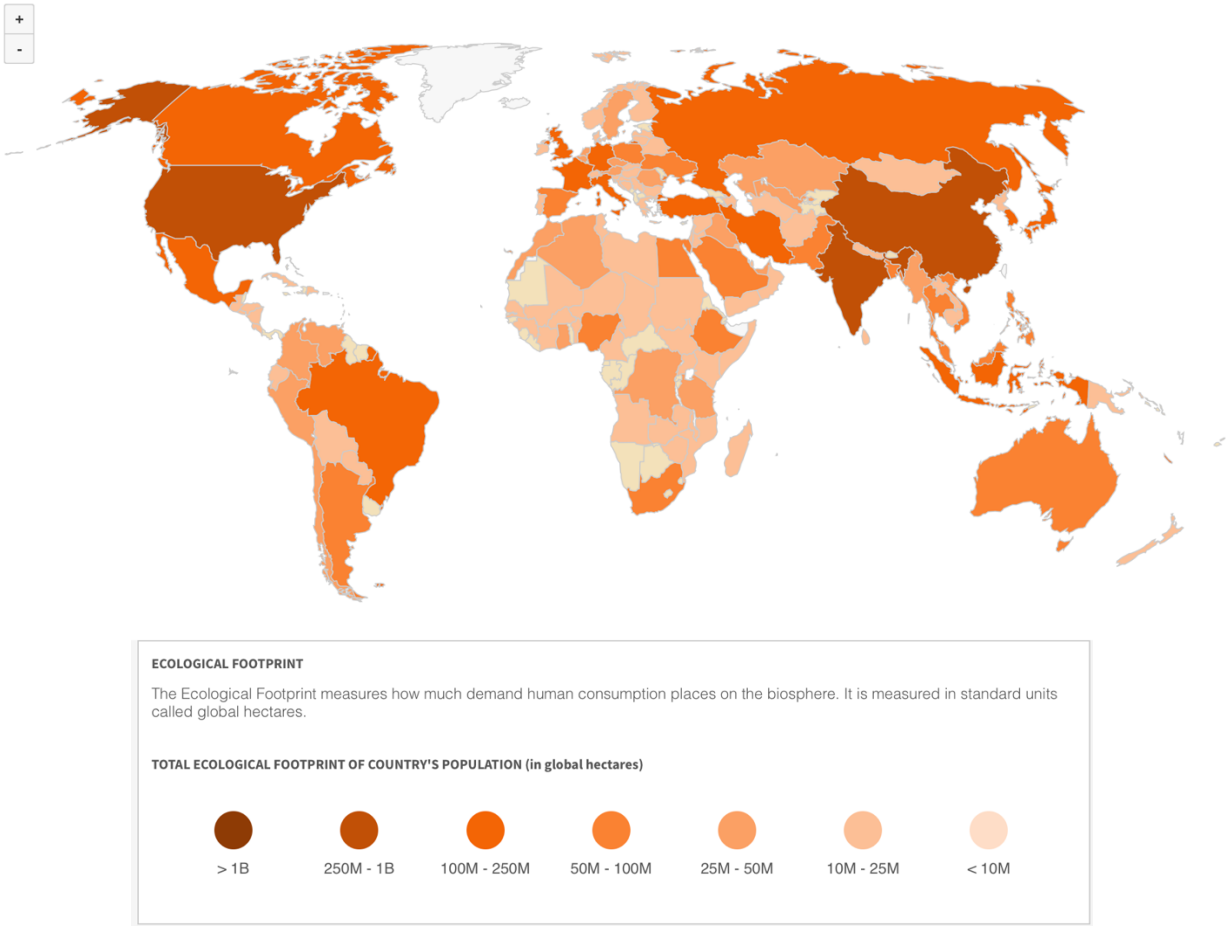


Figure 6.1: Global Ecological Footprint, 2016
Source: (Global Footprint Network National Footprint, 2019)

6.2.2 Global CO^2 emissions per capita

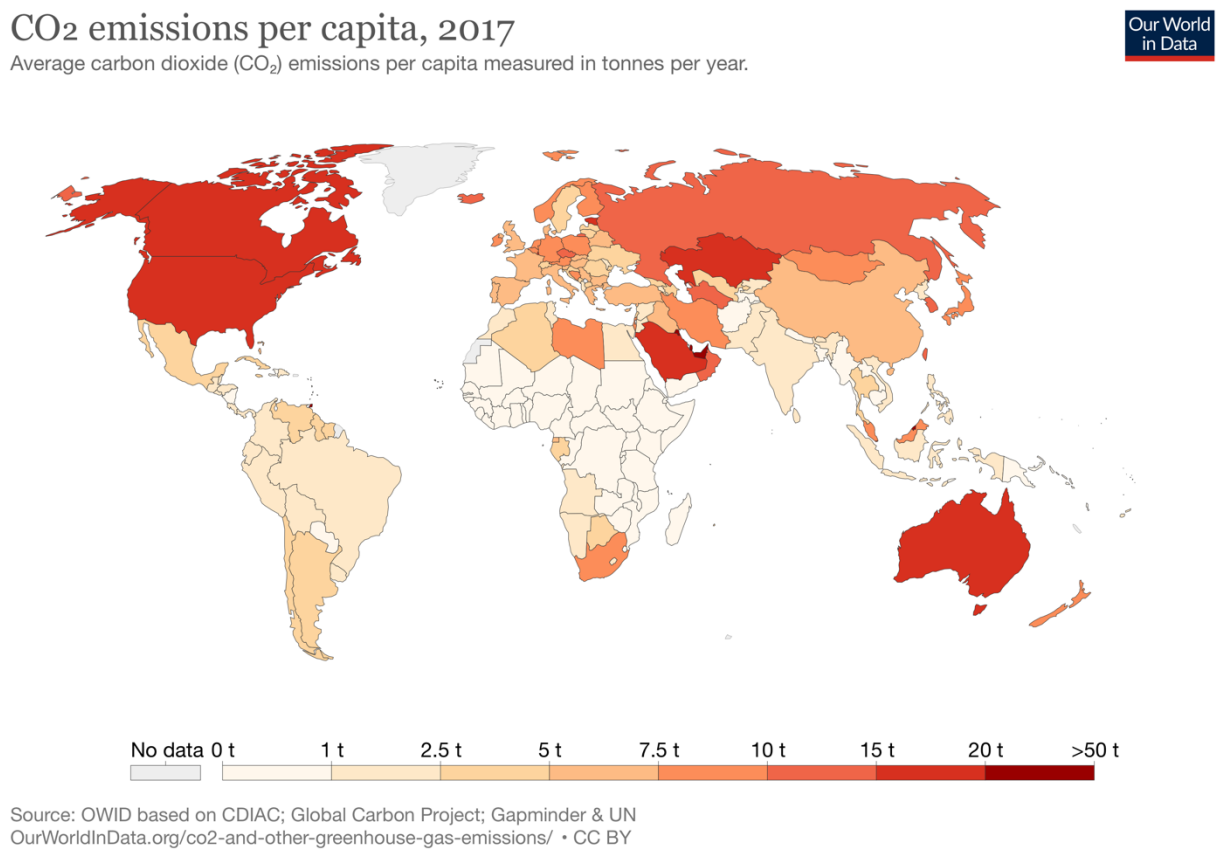


Figure 6.2: CO^2 emissions per capita, 2017
Source: (OWID based on CDIAC, Global Carbon Project, Gapminder & UN OurWorldInData.org)

Climate change is a global and pressing challenge (York et al., 2003; Ritchie & Roser, 2020). Research on climate change has led to a growing scientific consensus that climate change is occurring due to global warming (Parkinson & Cavalieri, 2002). Human emissions of greenhouse gases (carbon dioxide (CO2), nitrous oxide, methane, and others) have led to a global temperature increase of 1°C and more since the pre-industrial era (Qiancheng, 1998).

In Figure 6.2, the lighter the shade, the less CO^2 emissions per capita per year a country emits, and the darker the shade, the more CO^2 emissions per capita per year a country emits. Burkina Faso emitted 50.22 million tonnes of CO^2 in 2017, as compared to the U.S.A. which emitted 399.38 billion tonnes of CO^2 emissions.

Currently, China is the world's largest CO2 emitter; producing more than 1/4 of emissions. It is followed by the U.S.A (15%); EU-28 (10%); India (7%); and Russia (5%). The USA has contributed most of the global CO^2 emissions to date, accounting for 25% of cumulative emissions. It is followed by the EU-28 (22%); China (13%); Russia (6%) and Japan (4%) (Ritchie & Roser, 2020).

As Figure 6.2 shows, there are large inequalities in CO2 emissions. Developing countries such as Burkina Faso contribute less than 1% of emissions but will be the most impacted by climate change in the future.

6.2.3 GDP and GDP/Capita

The Gross Domestic Product (GDP) of an economy is a measure of its total production. "It is the monetary value of all goods and services produced within a country or region in a specific time period" (Ritchie & Roser, 2020). GDP per capita measures a country or region's economic prosperity. It can be defined as the "value of all goods and services produced by a country in one year divided by the country's population" (Ritchie & Roser, 2020). Finally, economic growth is the measure of the change of GDP from one year to the next.

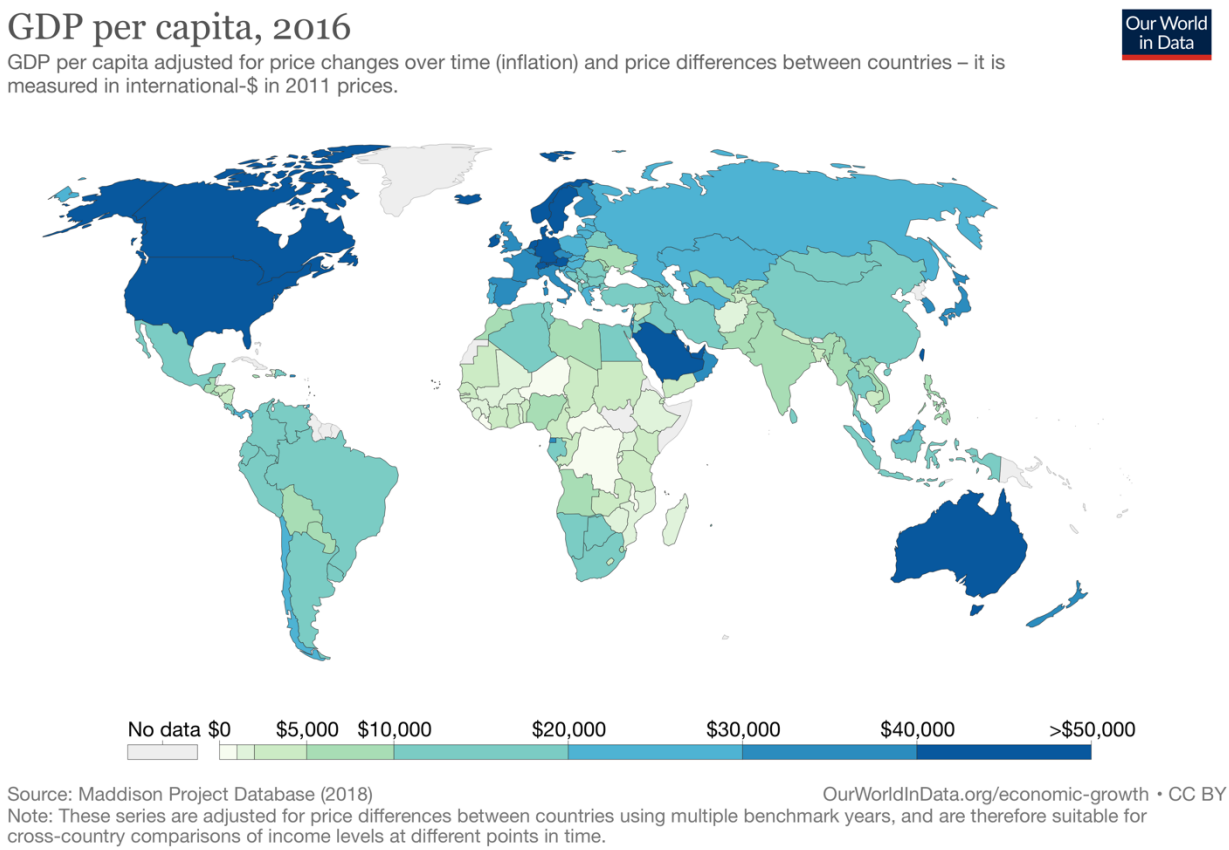


Figure 6.3: GDP per capita, 2016
Source: (Maddison Project Database, 2018)

In 1870, the global GDP per capita was estimated at around $1,263 per year. In 2016, the global average GDP per capita increased to $14,574, more than 10 times as in 1870 (Ritchie & Roser, 2020). This shows that on average, people are many times richer than their ancestors.

As is often the case, global development is not equal, and progress often creates inequality between countries. Figure 6.3 above shows a great disparity between the global GDP per capita. The U.S.A had a GDP per capita of $53,015 in 2016, as compared to Burkina Faso which had a GDP per capita of $1,561.

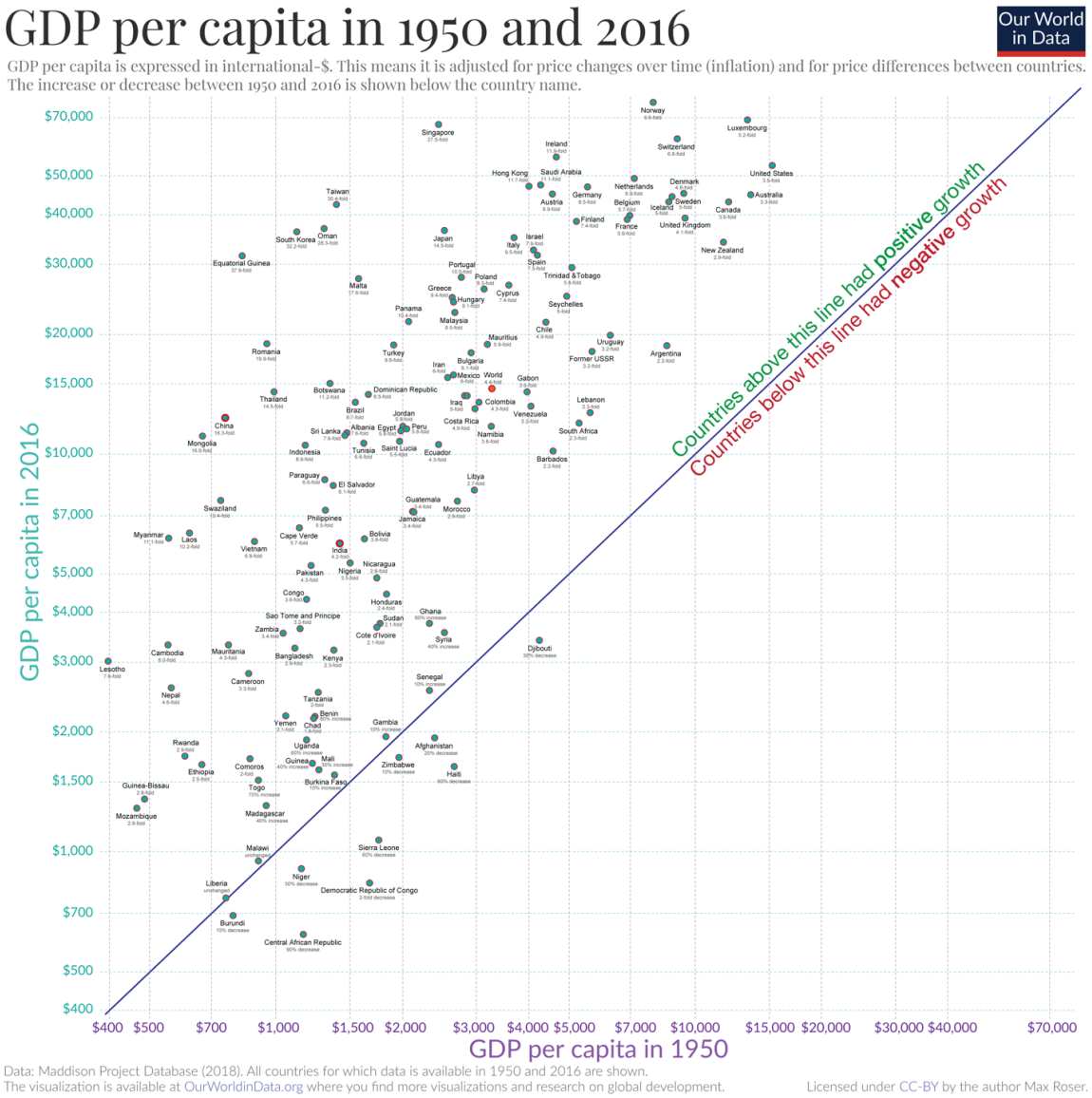


Figure 6.4: GDP per capita, in 1950 and 2016
Source: (Maddison Project Database, 2018)

Figure 6.4 shows a comparison of the GDP per capita between 1950 and 2016. Apart from 9 countries, every country is richer in 2016 than in 1950. The average global person is 4.4 times richer than in 1950, the average person in the U.S.A is 3.5 times richer, and the average person in Burkina Faso is 10 times richer (Ritchie & Roser, 2020).

Economic growth can have both positive and negative impacts. Positive impacts for example have led to increases in food access, technologies like solar technology, and better

infrastructures. On the other hand, there have been increasingly negative impacts on our environment as well as greater disparity in wealth and well-being between countries.

Economic growth is not the only metric which shows how well a country is doing. “The concern with GDP per capita is based on the idea that rising prosperity makes for a richer life” (Ritchie & Roser, 2020). This is not necessarily true, and the focus on GDP as an indicator of well-being, discounts other metrics which measure a country’s well-being. In the case of the U.S.A, it might be doing better on a GDP per capita scale than Burkina Faso, but the following section compares the UN’s SDG Index and Dashboards for both countries to see how the two countries compare in terms of other well-being indexes.

6.2.4 Sustainable development dashboards

The United Nation’s 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. “It provides a current and future shared blueprint for peace and prosperity for people and the planet” (UNDESA, 2016). A fundamental part of the Agenda is the 17 Sustainable Development Goals (SDGs), which are an urgent global call for action for all countries in a global partnership. It recognizes that all goals are interconnected, and that ending poverty and other deprivations must work in conjunction with improvements in health and education, inequality reduction, economic growth stimulation while mitigating climate change and preserving our natural resources such as oceans and forests (UNDESA, 2016).

The *Sustainable Development Report 2019* is the fourth edition of the annual review of countries’ performance on the 17 Sustainable Development Goals. It was jointly prepared by the Bertelsmann Stiftung and the Sustainable Development Solutions Network (SDSN). The Report covers all 193 UN member states and discusses their data based on changes over time in their

SDG indicators and their trajectories' calculations until 2030 (Sachs, Schmidt-Traub, et al., 2019).

The report found that four years since the adoption of the SDGs and the Paris Agreement, **no country is on track to meet all 17 SDGs**. It found that generally all countries have regressed in many areas, as found by recent reports of the Intergovernmental Panel on Climate Change (Masson- Delmotte et al. 2018) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES 2019). IPBES (2019) stated that "we are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide".

The report also found that many high-income countries, such as the U.S.A., perform well in areas such as economic development but have not achieved overall good SDG performances. This is because such countries face significant challenges in specific areas such as SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water) and SDG 15 (Life on Land).

Developing countries, including sub-Saharan Africa, are progressing rapidly towards ending poverty, but extreme poverty remains entrenched in some parts of the world. But such countries usually do better in SDGs 12 to 15.

Inequalities between countries is increasing globally, necessitating impactful and lasting policy changes for all countries. "As the IMF has recently noted, SDG-oriented public investments – financed through increased domestics resources and international development assistance – must rise sharply in most countries" (Gaspar et al. 2019).

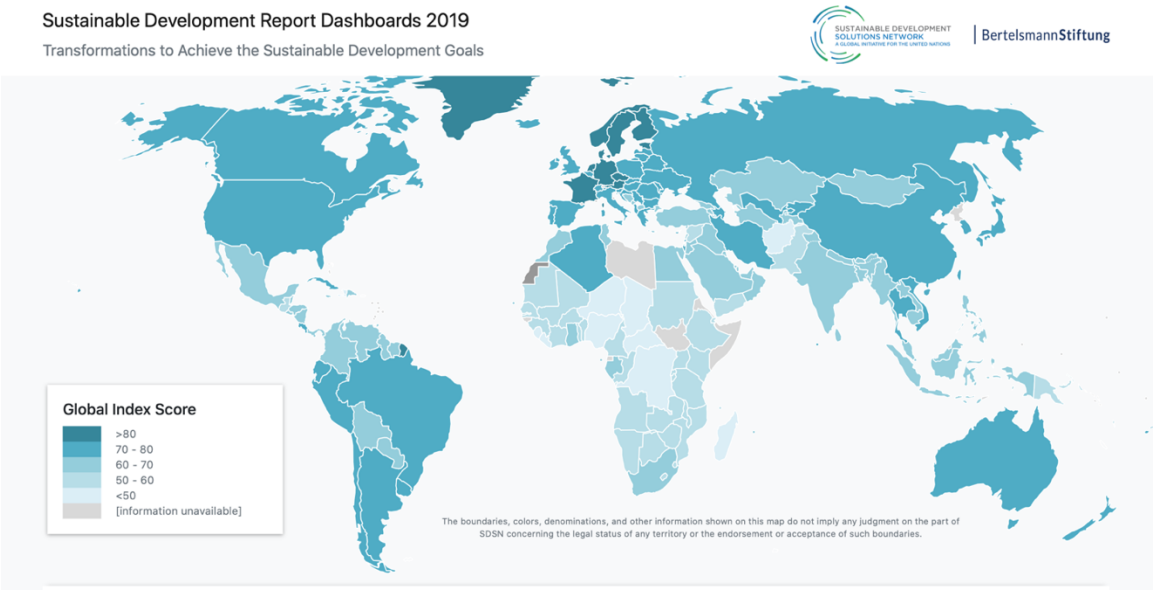


Figure 6.5: Sustainable Development Report Dashboards, 2019
Source: (Sachs, Schmidt-Traub, et al., 2019)

Figure 6.5 shows the global index ranking score of all countries. The darker the shading, the closer a country is to reaching all of their SDGs goals. The U.S.A. was ranked #35 out of 162 countries with an index score of 74.5, while Burkina Faso is ranked #141 out of 162 countries with an index score of 52.4 in 2019 (Sachs, Schmidt-Traub, et al., 2019). This means that the U.S.A.is on average 74.5% on the way to achieving its SDGs targets by 2030, while Burkina Faso is on average 52.4% on the way to achieving its targets.

It's not surprising that developing countries, such as Burkina Faso, are not ranked as high on the scale due to the fact that SDGs are demanding goals, such as ending extreme poverty and hunger, installing universal access to healthcare, education, safe water and sanitation, modern energy services, and decent work (Sachs, Schmidt-Traub, et al., 2019).

Despite Sweden being ranked #1 in terms of its global index ranking, even it is only 84.5% on the way to achieving its 2030 targets. The United States of America compared to other developed countries is not ranked in the top 20 list. It received its best scores on SDG 4 (Quality

Education), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth). But even for those SDGs, it didn't receive the green rating of SDG achieved, it received the yellow rating of Challenges remain.

Poverty, income inequalities, and universal access to healthcare and other public services remain important challenges which affect the U.S.A.'s performance on those SDGs (Sachs, Schmidt-Traub, et al., 2019).

As with other high-income countries, the U.S.A.'s high CO^2 emissions and other pollution and the threats to biodiversity found in such countries mean that they require considerable work in order to achieve their SDGs by 2030. The U.S.A. also generates significant negative environmental and security externalities (or spillovers) that undermine other countries' ability to achieve their SDGs (Sachs, Schmidt-Traub, et al., 2019).

6.2.4.1 Spillover score

Due to our global interconnectedness, all countries' actions have positive or negative effects on other countries' ability to achieve their SDGs, and these effects are called spillover effects. Spillover effect can be defined as "the impact of seemingly unrelated events in one nation having an impact on the economies of other nations. Such international "spillovers" are pervasive and have been growing fast with growth in trade exceeding the growth in world gross product" (Fischer- Kowalski et al., 2015).

For all countries to successfully meet their SDGs goals, positive and negative spillovers must be understood, measured, and carefully managed since all countries must do their part (Sachs, Schmidt-Traub, et al., 2019).

Spillovers can be categorized in three groupings:

- Environmental spillovers: deal with international spillover effects related to the use of natural resources and pollution. They are created by i) transboundary effects embodied in trade; ii) direct cross-border flows in air and water. The *Sustainable Development Report 2019* only includes indicators on environmental spillovers embodied in trade. More research is needed for global measures of cross- border.
- Economy, finance, and governance spillovers: deal with banking secrecy, international development finance (e.g. ODA), unfair tax competition, and international labor standards.
- Security spillovers: deal with negative factors such as arms trade, especially small arms (Adeniyi 2017) as well as organized international crime. Such spillovers can have an especially destabilizing impact on developing countries. The UN defines positive spillovers as for example conflict prevention and peacekeeping investments (Sachs, Schmidt-Traub, et al., 2019).

The report found that **high-income countries tended to generate larger negative spillover effects** than lower income countries. However, it also found that amongst countries with similar per capita income, there was a large variation in their spillovers. This suggests that countries can reduce their negative spillover effects without reducing their per capita incomes. On a per capita basis, small countries with large trade intensity – such as Luxembourg, Singapore and Switzerland – generated the highest negative spillover effects. (Sachs, Schmidt-Traub, et al., 2019).

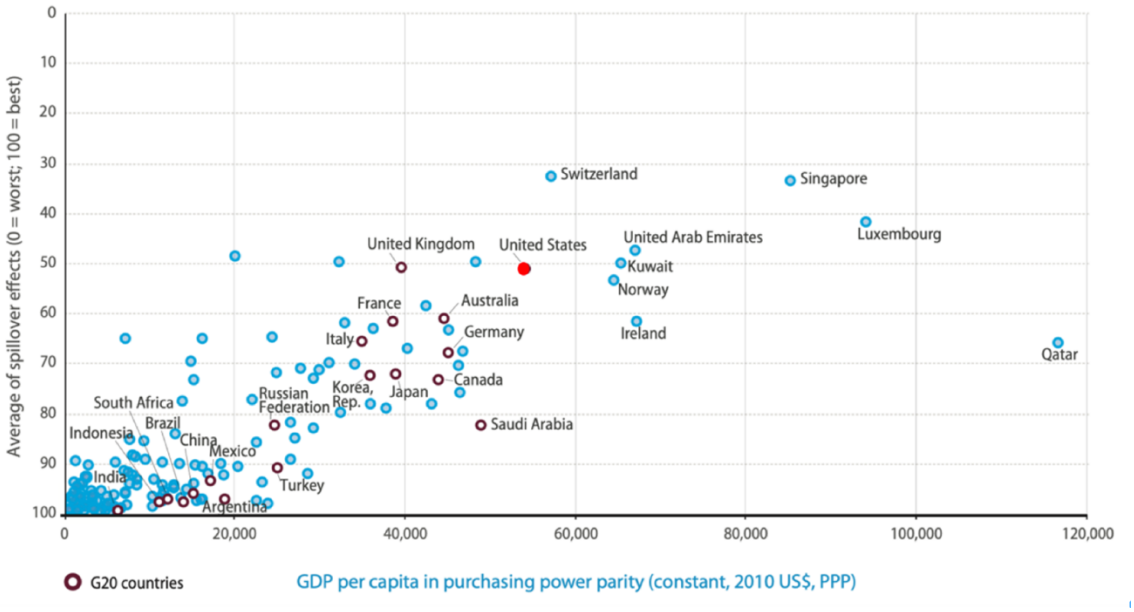


Figure 6.6: Average spillover score against Gross Domestic Product (GDP), per capita in purchasing power parity (PPP)
Source: (Sachs, Schmidt-Traub, et al., 2019)

Figure 6.6 show the countries with the highest average spillover scores. The closer a country is to 100, the less negative spillover they have on other countries.

Country	Rank	Spillover Score
United States	35	51.1
Burkina Faso	141	96.7

Table 6.2 Spillover Index Score (from 0 “worst” to 100 “best”)
Source: (Sachs, Schmidt-Traub, et al., 2019)

Table 6.2 shows that Burkina Faso has a negligible negative spillover and its actions has a negligible impact on other countries’ ability to achieve their SDGs. The U.S.A. has a much larger negative spillover effect, and its actions, therefore, have a significant impact on other

countries' ability to achieve their SDGs. The U.S.A. and other such countries need to reduce their negative spillovers so that all countries can reach their SDGs goals.

6.2.4.2 SDG Dashboards

The *Sustainable Development Report 2019* also features the SDG dashboards for each country, which display their individual strengths and weaknesses on the 17 SDGs based on performance indicators under each SDG. The dashboards focus on the two worst indicators under each goal. It also includes SDG Trends for each country, which can help countries categorize areas where their efforts are decreasing, stagnating, or moderately improving, areas where they are on track or maintaining their SDG achievement, and areas with no information or missing information on some or all metrics.

United States of America

Figure 6.7: SDG Dashboard for United States of America, 2019
Source: (Sachs, Schmidt-Traub, et al., 2019)

The United States received its best results on SDG 4 (Quality Education), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), SDG 14 (Life below Water), and SDG 15 (Life on Land). However, despite these best results, it only received the yellow rating of Challenges remain for many of its 17 SDGs. In areas dealing with consumption

and the environment, it received the red Major challenges rating for SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action).

Figure 6.8: SDG Trends for United States of America, 2019
Source: (Sachs, Schmidt-Traub, et al., 2019)

It is on track or maintaining SDG achievements in the areas of Quality Education (SDG 4), Decent Work and Economic Growth (SDG 8), and Industry, Innovation and Infrastructure (SDG 9). It is stagnating in the areas of Reduced Inequalities (SDG 10), Climate Action (SDG 13), Life Below Water (SDG 14), and Partnerships for the Goals (SDG 17).

Burkina Faso

Figure 6.9: SDG Dashboard for Burkina Faso, 2019
Source: (Sachs, Schmidt-Traub, et al., 2019)

Burkina Faso received its best result in SDG 15 (Life on Land) with its SDG achieved or on track to be achieved. It's next best results were in SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action). It received the worst ratings in areas dealing with

SDG 1 (No poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well Being), SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 9 (Industry, Innovation, and Infrastructure).

Figure 6.10: SDG Trends for Burkina Faso, 2019
Source: (Sachs, Schmidt-Traub, et al., 2019)

It is on track or maintaining SDG achievements in the areas of Climate Action (SDG 13), Life Below Water (SDG 14 based on available performance indicators not shown above but shown in detailed performance record in report), and Life on Land (SDG 15). It is stagnating in the areas of No Poverty (SDG 1), Gender Equality (SDG 5), Clean Water and Sanitation (SDG 6), Sustainable Cities and Communities (SDG 11) and Partnerships for the Goals (SDG 17).

6.2.4.3 Absolute performance gaps in G20 countries

G20 leaders reiterated their commitment to supporting the 2030 Agenda and the SDGs in their December 2018 declaration "Building Consensus for Fair and Sustainable Development". Their participation and commitment to the 2030 Agenda is necessary since G20 countries represent 2/3 of the world's population, 85% of global gross domestic product and over 75% of global trade. They also produce about 80% of global energy-related carbon dioxide emissions (Sachs, Schmidt-Traub, et al., 2019).

Figure 6.11 below estimates the absolute performance gaps (in %) for achieving each SDG, by showing the importance of the participation and commitment to the 2030 Agenda for G20 countries. Sub-Saharan Africa accounts for most of the achievement gaps only in SDG 1 (No Poverty) and SDG 4 (Quality Education).

Country	Spillovers	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
Argentina	0.2%	0.1%	0.5%	0.4%	0.2%	0.3%	0.4%	0.2%	0.7%	0.6%	0.8%	0.3%	0.7%	0.5%	0.7%	0.7%	0.6%	0.2%
Australia	1.5%	0.0%	0.4%	0.0%	0.1%	0.2%	0.0%	0.1%	0.3%	0.1%	0.2%	0.2%	1.1%	2.4%	0.3%	0.4%	0.1%	0.3%
Brazil	0.8%	1.8%	2.4%	2.1%	2.3%	2.2%	1.7%	0.6%	3.4%	2.4%	4.5%	1.8%	3.3%	2.6%	2.0%	2.8%	3.3%	1.7%
Canada	1.6%	0.0%	0.4%	0.1%	0.0%	0.2%	0.2%	0.1%	0.3%	0.2%	0.2%	0.3%	1.3%	1.7%	0.4%	0.5%	0.2%	0.4%
China	8.7%	2.2%	11.7%	11.4%	0.3%	10.5%	15.8%	15.7%	10.4%	12.1%	16.4%	14.0%	18.6%	16.6%	23.5%	18.1%	18.2%	22.9%
European Union	26.5%	0.3%	5.4%	1.5%	2.1%	3.6%	2.4%	1.7%	5.7%	3.5%	3.7%	2.9%	17.3%	9.1%	6.5%	3.5%	3.4%	5.7%
France	4.0%	0.0%	0.7%	0.2%	0.1%	0.3%	0.3%	0.1%	0.8%	0.4%	0.3%	0.3%	2.2%	1.3%	0.6%	0.5%	0.5%	0.5%
Germany	4.2%	0.0%	0.8%	0.2%	0.6%	0.6%	0.3%	0.3%	0.8%	0.4%	0.4%	0.3%	3.1%	1.2%	1.3%	0.5%	0.5%	0.4%
India	1.3%	23.7%	23.1%	23.9%	19.2%	28.5%	23.4%	22.7%	13.4%	21.8%	19.9%	26.6%	5.5%	11.1%	17.3%	22.9%	18.6%	15.0%
Indonesia	1.0%	4.2%	3.7%	4.2%	1.9%	3.3%	3.3%	3.4%	3.8%	4.0%	5.0%	3.5%	1.8%	2.1%	3.5%	5.4%	2.8%	4.6%
Italy	3.2%	0.1%	0.6%	0.1%	0.1%	0.5%	0.4%	0.2%	0.7%	0.5%	0.5%	0.6%	2.1%	1.3%	0.9%	0.3%	0.5%	0.7%
Japan	5.6%	0.1%	1.2%	0.3%	0.2%	1.6%	0.8%	0.4%	0.9%	0.6%	0.8%	1.2%	4.1%	1.8%	1.5%	1.3%	0.4%	1.4%
Korea, Rep.	2.2%	0.0%	0.3%	0.2%	0.2%	0.6%	0.4%	0.2%	0.4%	0.2%	0.2%	0.4%	1.4%	0.9%	0.6%	0.8%	0.4%	0.8%
Mexico	1.4%	1.0%	1.8%	1.0%	0.7%	0.9%	1.1%	0.9%	2.1%	1.9%	3.2%	1.0%	2.0%	1.8%	1.0%	2.4%	2.2%	1.7%
Russian Federation	4.0%	0.0%	2.3%	1.3%	0.3%	1.5%	0.6%	0.6%	2.1%	1.6%	1.9%	1.0%	3.2%	3.8%	2.1%	1.7%	2.5%	1.6%
Saudi Arabia	1.0%	0.1%	0.5%	0.3%	0.1%	0.6%	0.6%	0.2%	0.5%	0.3%	0.3%	0.8%	1.1%	2.0%	0.4%	0.6%	0.4%	0.3%
South Africa	0.3%	1.8%	0.8%	1.3%	0.9%	0.4%	0.8%	0.6%	1.3%	0.7%	1.7%	0.5%	1.3%	1.1%	0.7%	0.8%	0.9%	0.4%
Turkey	1.2%	0.0%	1.1%	0.6%	0.4%	1.4%	0.6%	0.4%	1.3%	1.0%	1.4%	1.0%	1.6%	1.2%	1.6%	1.3%	0.9%	0.8%
United Kingdom	5.2%	0.0%	0.7%	0.2%	0.0%	0.4%	0.1%	0.2%	0.7%	0.3%	0.5%	0.2%	2.8%	1.5%	0.7%	0.6%	0.3%	1.1%
United States	25.4%	0.2%	3.3%	1.5%	2.5%	2.7%	1.9%	1.1%	2.8%	1.2%	4.9%	2.3%	15.1%	16.4%	3.3%	2.6%	2.7%	4.6%
Total G20	87.9%	35.6%	59.6%	50.1%	31.3%	58.9%	54.1%	49.0%	50.2%	52.4%	65.6%	58.0%	82.1%	76.8%	66.2%	66.4%	58.0%	63.4%

>20% 10-20% 2-10% 0-2%

Figure 6.11: Absolute performance gaps for achieving SDGs, 2019
Source: (Sachs, Schmidt-Traub, et al., 2019)

Due to their large population, China, India, and the United States account for the largest shares of global SDG performance gaps. G20 countries represent roughly 50% or more of the total performance gaps for all the other goals. Brazil, China, India, Indonesia and the United States each represent more than 2% of the global achievement gaps for the majority of the Goals. Therefore, their lack of participation and commitment would deprive large shares of the world

population from sustainable development and improved living conditions (Sachs, Schmidt-Traub, et al., 2019).

Figure 6.11 shows that China and the United States of America alone represent **1/3 (33%) of the global performance gap on Goal 13 (Climate Action).** Using one of the underlying metrics, energy-related CO2 emissions, if China reduced its emissions to 2 tons of CO^2 per capita per year (equivalent to a total reduction in CO^2 emissions equivalent to 69.1% compared to current levels of emissions) the world would be 31.4% closer to achieving its SDG target on CO^2 emissions (Sachs, Schmidt-Traub, et al., 2019).

6.2.4.4 Conclusions

Going back to *RQ2, do developing countries lag behind developed countries in the pursuit of green design?* we can summarize the following conclusions.

- **Conclusions from the existing literature**

This study found a total of 31 barriers consistent with the existing literature on barriers to the adoption of green building materials and technologies, with 14 of the barriers specific to Burkina Faso.

In terms of the existing literature, **developing countries do not necessarily lag behind developed countries in the pursuit of green design and green materials implementation.** Each country, including Burkina Faso and the United States of America, has its own barriers to overcome which are specific to their contexts. We can learn from how other countries tackle their barriers, but barriers which are specific to each country require specific solutions to fit within the existing context.

- **Conclusions from performance indicators**

The 2030 Agenda for Sustainable Development provides a shared blueprint for the present and the future, with the 17 Sustainable Development Goals (SDGs), being a fundamental part of the Agenda. The Sustainable Development Report (20190 generally found that member countries in the Organization for Economic Co-operation and Development (OECD), including the United States, are not on track for achieving their SDGs.

Compared to non-OECD countries, OECD countries better perform on goals associated with socio-economic outcomes and basic infrastructures' access such as SDG 1 (No Poverty), SDG 3 (Good Health and Well-Being), SDG 6 (Clean Water and Sanitation) and SDG 7 (Affordable and Clean Energy), but they need to implement significant efforts on climate mitigation and biodiversity protection (SDG 12 to 15).

Their poor performance is driven by large ecological footprints, using more resources than their biocapacity, massive greenhouse gas emissions, biodiversity losses, and poor performance on spillover indicators. Based on available data, trends on SDG 13 (Climate Action) and SDG 14 (Life Below Water) are alarming in most OECD countries, including the United States (Sachs, Schmidt-Traub, et al., 2019). These countries need to design and implement policies in order to keep and/or increase their economic growth, while lowering negative environmental impacts.

The report also found that the degree of commitment and efforts towards achieving the SDGs differ widely from country to country. Based on a survey to gauge the strength of the SDGs integration into institutions and policy, the United States of America ranked at the bottom of OECD countries, just ahead of Russia. With changes in administration, the U.S.A. seems to be distancing itself from its adherence to its prior global goals, and it even withdrew from the UN's

Human rights Council (Sachs, Schmidt-Traub, et al., 2019). However, the report focuses on national-level progress, and doesn't reflect state and city level progresses. This is seen in the case of New York City which became the first city to report its progress on meeting its SDGs to the U.N. (Sachs, Schmidt-Traub, et al., 2019).

Developing countries, including Burkina Faso, face major challenges in achieving their SDGs, especially in areas dealing with socio-economic goals and basic access to services and infrastructure (SDG 1 to SDG 9). In some countries, including Burkina Faso, insecurity and conflict negatively impacts their performance in various goals such as SDG 16 (Peace, Justice and Strong Institutions) and SDG 17 (Partnerships for the Goals). In order to meet those goals, Burkina Faso needs to strengthen its institutions and increase its domestic resource mobilization (Sachs, Schmidt-Traub, et al., 2019).

It's relatively low consumption levels has allowed it to perform better on SDGs 12–15 (Responsible Consumption and production, Climate Action, Life Below Water, Life on Land and biodiversity protection). Unfortunately for most countries, including Burkina Faso, urban pollution trends (SDG 11 - Sustainable Cities and Communities), forest loss, and biodiversity protection (covered under SDG 15 - Life on Land) are not progressing, and in some countries are even regressing (Sachs, Schmidt-Traub, et al., 2019).

Therefore, in terms of its performance indicators, **the United States of America's poor performance,** driven by its large ecological footprints, its usage of resources greater than its biocapacity, its massive greenhouse gas emissions, its biodiversity losses, and its poor performance on spillover indicators, **could make it lag behind Burkina Faso in the pursuit of green design and construction.** For developing countries, such as Burkina Faso, it's degree of

development, inadequate infrastructures, and low GDP per Capita, makes it a longer road to travel in order to meet its SDGs.

Stronger efforts and commitment to meeting their SDGs is necessary for all countries, especially since no country has reached all their SDGs, and all countries have regressed in many areas. This is especially true for developing countries, such as Burkina Faso, which will be the most impacted by the effects of the rising climate change. Burkina Faso is also experiencing a rapid population growth which has been projected by the UN to increase from 20 million to 29 million between 2020 and 2030. Furthermore, most of this rapid population growth will occur in urban areas, and without specific urban planning, Burkina Faso will face an uncertain future.

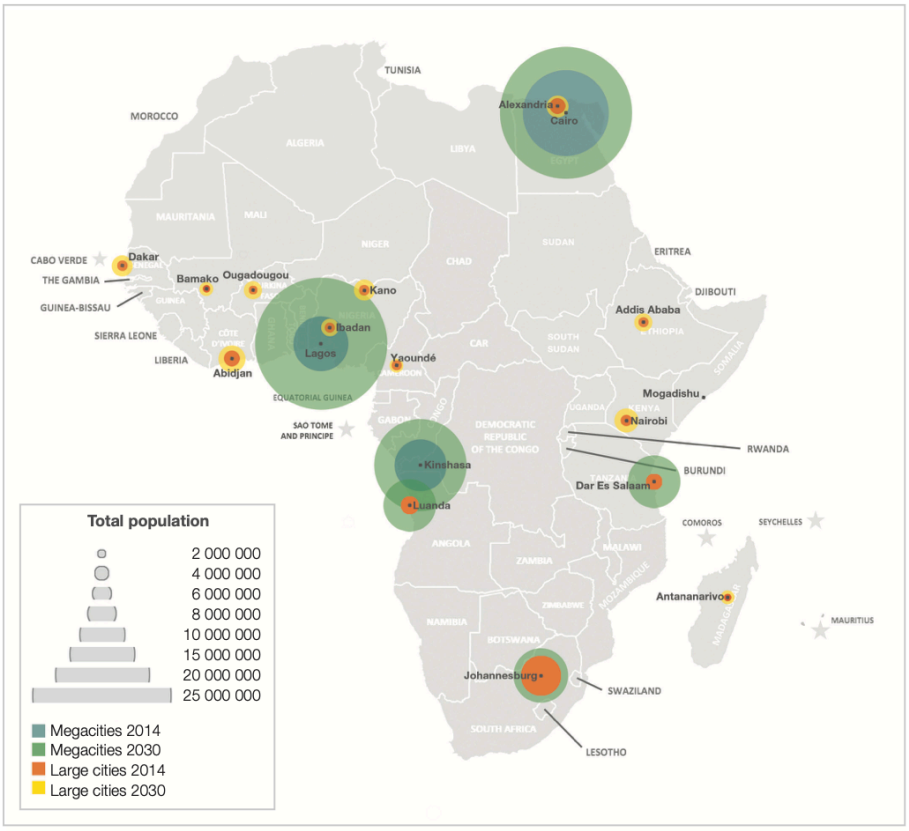
6.3 Planning for Africa's current and emerging megacities

By 2050, Africa is projected to have at least 14 megacities; almost five times as many as today, with 3 of the megacities in Nigeria (country with the largest current and expected future urban population in Africa) (Bello-Schünemann & Aucoin, 2016). Megacities are defined as cities with more than 10 million inhabitants and based on their economic activity concentration (UNDESA, 2016).

Currently, most of the world's existing and emerging megacities are in Asia. In Africa, only 3 cities, Cairo, Kinshasa and Lagos, can be presently defined as megacities. By 2025, Cairo and Lagos are projected to become meta- or hyper cities with populations greater than 20 million peoples (Bello-Schünemann & Aucoin, 2016). By 2030, 3 more African megacities are projected to emerge (Dar es Salaam, Johannesburg, Luanda) and Kinshasa is projected to approach the 20 million mark. In that same period, 13 new megacities are projected to emerge globally in less developed regions (UNDESA, 2014).

By 2040, Abidjan and Nairobi are projected to become megacities, and by 2050, 6 more megacities are projected to emerge: Addis Ababa, Bamako, Dakar, Ibadan and Kano (in Nigeria), and including **Ouagadougou, Burkina Faso** (Bello-Schünemann & Aucoin, 2016).

Figure 6.12 below shows Africa's cities in 2014 as well as the future emerging megacities by 2030. The average urban growth rates for large African cities is generally projected to decline over time, but some large cities are projected to grow even faster in the period of 2020 to 2025, meaning that their transition into large cities is still at the beginning stages. This is the case for Ibadan, Kano, and Addis Ababa. Between **2025 and 2030,** Bamako, Addis Ababa and **Ouagadougou** (from high to low) **are projected to have the highest annual average urban population growth rates, all above 4%** (Bello-Schünemann & Aucoin, 2016).



Source: City population data/estimates from UN DESA, urban population growth rates calculated by IFs version 7.22 and based on World Development Indicators.

Figure 6.12: Africa's current and emerging megacities and large cities 2014 versus 2030
Source: (Bello-Schünemann & Aucoin, 2016).

6.3.1 Drivers for Africa's current and emerging megacities

Compared to other continents, Africa is currently the least urbanized continent. Modern urbanization in Africa started late due to the vestiges of colonization, sustained low levels of food surplus, and disease constraints, leading to high mortality rates (Fox, 2011). Over time, increases in food surplus and institutional and technological changes increased life expectancy in urban areas. This in combination to high fertility rates led to an urban population boom (Mo Ibrahim Foundation, 2015).

The most important driver of Africa's rapid urban population growth is the natural urban population growth (predominance of births over deaths) (African Development Bank, OECD, & UNDP, 2016). It accounts for at least 60% of Africa's urban population growth, although the numbers differ between countries. Across projections, the rate of decrease in fertility rates in Africa's urban spaces as compared to national average and other global regions is hard to project (Bello-Schünemann & Aucoin, 2016).

Other drivers for urbanization include rural-urban migration (accounted for less than 1/3 of urban population growth between 2010 and 2015), annexation and reclassification of prior rural areas as urban areas, rural public services dissatisfaction, land pressures, natural disasters, weather impacts, cross-border inward migration, and conflicts (Bello-Schünemann & Aucoin, 2016).

Whichever driver(s) will motivate the migration towards urban centers, the exploding urban population will increase pressures on ageing infrastructures and services, job markets, housing and the environment if the future is not planned.

6.3.2 Urbanization and economic development

Urbanization is a complex phenomenon, but when implemented successfully, it leads to recognized benefits such as the high-density of economic activity, shorter trade links, utilization of human capital, shared infrastructure, and division of labor (Ciccone & Hall, 1993; Black & Henderson, 1999; Montgomery, Stren, et al., 2013; Ritchie & Roser, 2020). Urbanization has generally been understood as being reflected into higher living standards for the population, such as access to electricity, drinking water and sanitation, and improved nutrition. Globally, and especially in developing countries, these increased living standards have tended to occur more in urban areas than in rural areas.

The link between urbanization and economic growth has been well-documented (Bloom, Canning, & Fink, 2008; Henderson, 2003; Ritchie & Roser, 2020). Globally, higher levels of urbanization usually corresponded to higher levels of human development, and vice versa (AFDB, OECD, & UNDP; 2016).

In the case of Africa, including Burkina Faso, urbanization has not necessarily been a predictor of future economic growth and development, and structural transformation. This means that in the case of Sub-Saharan Africa, **"economic development has positive effects on urbanization dynamics, but urbanization can and does happen in contexts of low growth and/or low-income levels"** (Bello-Schünemann & Aucoin, 2016).

6.3.3 Challenges to planning for Africa's current and emerging megacities

Sustainable development is possible for all countries in Africa, but only if the following challenges are met, and Africa plans for its current and future megacities. Currently, Africa's **"rapid population growth is happening in the context of slow structural economic**

transformation, pervasive poverty, sharp inequalities, widespread socio-economic and spatial exclusion and environmental degradation" (Bello-Schünemann & Aucoin, 2016).

This is reflected in most of Africa's urban problems, the lack of employment possibilities, ageing and/or inadequate infrastructures, informal settlements and urban slums, urban violence, inadequate access to urban services such as reliable electricity and improved water and sanitation. Additionally, Africa is expected to experience the direct and indirect effects of climate change such as food security, climate change migration and so on.

Raleigh (2015) found that urban poverty rather than rapid urbanization is the primary factor leading to the propagation of urban slums. The past and present underinvestment in infrastructures and housing, as well as poor or no planning have increased the problem of urban poverty.

This means that African governments need to increase their investments in infrastructures to meet the needs of the current rapidly increasing population as well as plan for the influx of population into cities over time. If they do not do so, the number of slums in urban settings will increase in the future.

6.3.4 Urban planning

Planning for the current and future African urbanization is a priority for all African countries, including Burkina Faso, especially as African countries attempt to repair the prior failures of urban planning.

Africa in general, and including Burkina Faso, needs to focus on both short term and long-term solutions. Short-term solutions are needed to tackle the more pressing issues such as meeting the growing demand for decent housing, job demands, service provisions, and lowering urban violence. These solutions need to be carefully planned in order to prevent long term

problems such as lack of inclusion and limited sustainability. Africa also "**needs strategic foresight and integrated long-term urban planning"** (Bello-Schünemann & Aucoin, 2016).

Africa, including Burkina Faso, relies heavily on the informal economy. Therefore, African countries need to utilize the power of the informal economy, while planning for their transformation into more formal structures (UK Aid and the African Center for Cities, 2015).

Although Africa can learn from the past and best practices in urban planning, the blueprint for urban planning for current and future needs must be context specific for each country. "It must be strategic and flexible, able to adapt to different urban and national contexts and requirements, it requires the participation of all stakeholders across all sectors and consider potential trade-offs" (Bello-Schünemann & Aucoin, 2016).

At the local scales, infrastructure and technology development plans need to focus on context- specific opportunities and requirements, such as the need for low-cost, decentralized solutions which can easily be implemented and maintained with low-skill levels and training. This will allow for services servicing the majority of the urban poor population. Additionally, African countries need to focus on bulk infrastructure projects, in order to meet the needs of informal settlements and slum dwellers (UN-Habitat, 2014).

National urban policies and strategies need to make sure that urban planning is an integral part of these policies and strategies, solutions need to be able to adaptable as well as meet the needs for both urban and rural settings (Parnell & Simon, 2014). Construction professionals need to be on the ground to implement these policies and strategies with the help of the local populations, therefore there is a need to increase the education and training of construction professionals.

Finally, African governments need to focus on mobilizing the necessary funds in order to finance urban policies and strategies. According to the African Economic Outlook 2016 report, **African governments and the private sector need to invest twice as much by 2050** as they have been investing to date. This requires a multi-stakeholder effort and public–private partnerships will be required, **with the government as the leader.** Based on the report, local taxes and government funding will generate the most revenue in terms of the scale and stability of the funding. Funding from external donors, land value capture mechanisms and public–private partnerships will also be other important revenue sources (Bello-Schünemann & Aucoin, 2016).

Researchers and experts have argued that due to Africa's urbanization being at its early stages, Africa, and including Burkina Faso, still have time to plan for this sustainable future. Leapfrogging, utilizing local materials, low-skill constructions, are some of the ways in which African countries can plan for their current and emerging megacities.

Even though a comparison of Burkina Faso and the United States of America was carried out in this study in terms of the literature and performance indicators as representative cases of a developing country and a developed country, Burkina Faso can look towards other African countries, with similar contexts and many of the same challenges, in order to plan for its sustainable future.

One example is Ethiopia which integrated its Millennium Development Goals (MDGs) into its national development frameworks for the period of 2000 to 2015 and was able to accomplish remarkable achievements. The MDGs were implemented via government leadership and the coordination of all stakeholders in an organized and structured manner throughout the country, for example in their Second Growth and Transformation Plan (GTP II).

In SDG 9 (Industry, Innovation, and Infrastructure), they have focused on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation as part of their vision of becoming an African leader in light manufacturing. They have made remarkable progress in the total length of their all-weather-roads, which increased from 110, 414 KMs in 2014/15 to 113,067 KMs in 2015/116, and the average time taken to access these roads was reduced to 1.6 hrs. in 2015/16. They have also made remarkable progresses towards their rail infrastructure development, digital infrastructure development, and air transport.

Another example is Rwanda which has also made remarkable progress towards meeting its sustainable goals. It set a target of becoming a green, climate resilient, and low carbon economy by 2050. Since 2012 it set up a specific green fund (FONERWA) in order to mobilize resources, and sustainable goals have been integrated in their policies at different levels. They became one of the more than 40 countries (including China, France and Italy) in the world who banned, restricted, or taxed the use of plastic bags except within specific industries like hospitals and pharmaceuticals.

Such countries show that for Burkina Faso, other African countries and developing countries, a sustainable future is positive if it planned for. Making such sweeping changes in order to meet their MDGs will require a certain degree of **rigor** on the part of all African governments, but this rigor must be tempered by training in sustainable measures, increasing the understanding of the benefits of green design and construction, by requiring the input and participation of all stakeholders (if they do not feel involved, such measures are doomed to fail in the long run), and through incentive measures to reward stakeholders for meeting sustainable goals.

6.4 Chapter 6 Summary

Barriers to the adoption of green building materials and technologies occur in both developed and developing countries. This study found **barriers consistent with the existing literature** for the case of Burkina Faso**,** as well as **barriers specific to the case of Burkina Faso.** This study therefore **reaffirmed findings of prior studies**, as well as added to the existing **body of knowledge**.

As it pertains to **research question 2**, in terms of the literature, if countries are assessed in the number of barriers they have, Burkina Faso could be said to lag behind developed countries in the pursuit of green design and construction. However, if barriers found in both developed and developing countries are universal to all countries, **then specific barriers are a better reflection of a country's state of sustainability**.

Therefore, each country should be measured in how they meet their own goals, and not necessarily in how competitive they are in meeting global goals.

The cases of Burkina Faso and the United States of America (U.S.A.) were compared using performance indicators. In terms of the Millennium Development Goals, OECD countries, including the U.S.A. are not on track for achieving their SDGs. They need to implement significant efforts on climate mitigation and biodiversity protection such as with SDGs 12 to 15. Their poor performance is driven by large ecological footprints, using more resources than their biocapacity, massive greenhouse gas emissions, biodiversity losses, and poor performance on spillover indicators.

Developing countries, including Burkina Faso, face major challenges in achieving their SDGs, especially (SDG 1 to SDG 9). However, Burkina Faso's relatively low consumption

levels has allowed it to have better performances on SDGs 12–15 (Responsible Consumption and production, Climate Action, Life Below Water, Life on Land) and biodiversity protection.

In terms of its performance indicators, **the United States' poor performance on performance indicators**, could make it lag behind Burkina Faso in the pursuit of green design and construction.

By 2050, Africa is projected to have at least 14 megacities; almost five times as many as today (Bello-Schünemann & Aucoin, 2016), including Ouagadougou, Burkina Faso. Between 2025 and 2030 Bamako, Addis Ababa and Ouagadougou are projected to have the highest annual average urban population growth rates, all above 4% (Bello-Schünemann & Aucoin, 2016). This migration towards urban centers, and the exploding urban population will **increase pressures on ageing infrastructures and services, job markets, housing and the environment** if the future is not planned.

Due to Africa's urbanization being in its early stages, Africa still has time to plan for this sustainable future. Leapfrogging, utilizing local materials, low-skill constructions, are some of the ways in which African countries can plan for their current and emerging megacities.

Burkina Faso can look towards other African countries, with similar contexts and many of the same challenges, in order to plan for its sustainable future, such as the cases of Ethiopia and Rwanda.

Such cases show that a sustainable future is positive if it planned for, but it will require **a certain degree of rigor on the part of all African governments**, but this rigor must be tempered by training in sustainable measures, increasing the understanding of the benefits of green design and construction, by requiring the input and participation of all stakeholders (if they

do not feel involved, such measures are doomed to fail in the long run), and through incentive measures to reward stakeholders for meeting sustainable goals.

CHAPTER SEVEN

RECOMMENDATION FOR STUDY FINDINGS

Chapter 7 outlines the implications and recommendations for the findings from chapter 5, along with a section on the connections (or deviations) to relevant literature on barriers to barriers to the adoption of green building materials and technologies. The findings for this chapter answer research question 3.

7.1 Barrier 1: Government-related barriers

This section focuses on the government barriers found in Burkina Faso in this study, and the researcher's proposed guidelines.

7.1.1 Lack of governmental leadership

The government is the biggest constructor in Burkina Faso. In the early 1980s the government focused on the usage local green materials, especially in social housing. It invested heavily at the time in research on those materials, such as in LOCOMAT, but due to lack of resources, there has been less emphasis on those local green materials or imported ones. There have been some recent implemented projects using local green materials in various regions in Burkina Faso, but they have not been part of a country wide focus.

Recommendation: The government should intensify its construction in local and imported green materials, especially in public buildings, to increase the local population's awareness of the benefits of such materials (for example in health centers, markets, social housing and schools).

Local green materials and technologies are usually produced by manually or mechanically at a small-production level, making them either unavailable on the market, limiting their availability, or only available seasonally.

Recommendation: The government should encourage the development of factories to mass-produce these local green materials and technologies, and to support private industries which want to mechanize such production (much of such efforts have been private efforts).

7.1.2 Lack of nationwide policy on green design and green materials

Municipalities should incorporate the usage of local and imported green materials and technologies within their communal development plans, especially in the construction of public buildings. This would significantly stimulate demand for those materials, and create local opportunities for training and employment, which in turn will fight against poverty.

Different regions have different types of local green materials and technologies. Therefore, within the nationwide policy, there should be individual policies for each region as to which local material to promote depending on their local availability. This will help preserve the local architectural styles of each region, as well as support materials which are readily available to the local populations of each region.

7.1.3 Lack of green materials definition in the Code of Urban Planning and Construction.

There is currently no specific section in the Code of Urban Planning and Construction which deals with the usage of green materials and technologies.

Recommendation: The government should put in place regulation to necessitates the usage of a certain percentage of green materials and technologies (e.g. 10%), especially in government construction and social housing.

Private operators who implement green materials and technologies could get incentives such as tax credits, or financial backing to build their projects. This will help in the vulgarization of these materials by increasing their demand, which in turn will help increase their production.

There should be uniformity in the application of these new laws on the usage of green materials and technologies across all concerned stakeholders within the design and construction industry, so that their application is efficient and harmonious.

The Code of Urban Planning and Construction needs to be updated, as the last time it was updated was in the 1990s. This would allow it to take into account changes within the design and construction industry such as with new green materials and technologies.

Recommendation: The government as well as concerned entities, such as the Orders of Architects and Engineers, are currently working on updating the Code of Urban Planning and Construction.

The government should establish certifications for infrastructures which incorporate green materials and technologies, which would stimulate their production and usage. They could start with local certifications which could evolve into international standards eventually.

7.1.4 Lack of research funding for green materials and technologies

When LOCOMAT was operating, it acted as a laboratory for research on local green materials. However, it was scaled down partly due to a lack of resources.

Recommendation: The government should set aside resources for research focusing on local green materials and technologies in order to gain a documented understanding of their properties, benefits, weaknesses, and where to best implement them. LOCOMAT, other research institutes, and other actors in the design and construction sectors and the private sector should be invited to participate.

The government should invest on mapping the locations and availability of local green materials available in Burkina Faso. There has been some mapping completed as well as studies focusing on such materials, but there is a need for more mapping. Having a complete, detailed

countrywide database of available green materials would help guide their production, implementation, and their usage countrywide.

7.1.5 Lack of or minimal local green materials norms and standards

Local norms and standards have been creased for some materials, such as the BLTs, BTCs. Other local green materials such as granite would benefit from more research on their properties, which lead to their standardization.

Currently, many of Burkina Faso's norms are modelled after French and international norms. It would be beneficial for the country to carry out research on standards and norms in order to see which ones best fit the local context, and which ones should be replaced (Sourdois & Traoré, 2013).

7.1.6 Administrative delays in the CEFAC

The construction sector in Burkina Faso used to be disorderly, and many of the constructions, especially in the private sector, used to be carried out without clients consulting design and construction professionals. This led to structures being built which did not conform to construction standards.

Another issue is that those who followed the formal process of construction, used to have to go through a lengthy and tiring process in order to get the necessary paperwork filed for construction, since the process was not centralized, engendering wastes of time, money, and energy.

The Center for Facilitation of Building Acts (CEFAC) was created in order to streamline and centralize the process. The compulsory construction authorization for any construction type in Burkina Faso now requires the Certificate of Urban Planning, Building Permit, Certificate of Conformity, and the Permit to Demolish.

Design and construction professionals such as architects, engineers, and technicians now play a central role in helping clients prepare their file for the CEFAC. The CEFAC works in conjunction with the government administration, the Ministry of Housing, the Town Hall, and the National Fire Brigade (BNSP) to make sure that any project is up to code. If their plans are not, they provide suggestions to correct those errors. The CEFAC's purpose is to curtail issues to do with incorrect and/or poor designs, as well as making sure that applicants have all the necessary documentation to get their permits. When the client's file is complete, the CEFAC forwards it to all the required offices and assists clients throughout the process. It usually takes the CEFAC 1-3 months to issue the Building permit once the file is ready.

Benefits of the CEFAC

- The CEFAC is helping regulate the construction industry by making sure that more buildings are up to code.
- It simplifies the process by centralizing it and acting as the middleman with the other 4 entities involved in the process.
- The CEFAC's biggest impact has been it making it compulsory to consult and get the signature of a registered architect before any files is accepted by the CEFAC. The reasons behind this lack of architects' consultation will be discussed in detail under Barrier 3: Knowledge.

Obstacles Pertaining to the CEFAC

- Delays in Obtaining the Building Permit

Although the CEFAC has a timeline of 1-3 months to review a file, design and construction professionals often complain that it takes longer than that, which could lead to project delays.

Interviewee 15 who works for the CEFAC stated that delays occur due to a variety of reasons, such as anomalies in the files (i.e. missing documents, errors in the plans, documents not signed by registered architects.) as well as for the reasons below.

"The biggest obstacle is time. All CEFAC structures meet every two weeks to review the files because we have a period of 1 to 3 months to examine a file. Having to work with different structures is sometimes difficult because the file must pass through the different structures, and therefore can be blocked at any level. One of the issues with everything being centralized with the CEFAC is that applicants blame the CEFAC for delays in the other structures."

Recommendation: The government has previously held a series of meetings between the various stakeholders involved in construction in Burkina Faso and the CEFAC to find solutions to processing delays.

In order to reduce anomalies in the files, the CEFAC should review their guidelines for file preparation, as well as hold workshops with pamphlets and instructional videos in order to better educate their clients in the proper file preparation and to answer questions they might have.

The government should review the list of required documents to see if any need to be modified or eliminated, as well as assess how to more efficiently get documents reviewed and returned to clients.

The government should evaluate whether the 1-3 months file review deadline is appropriate, with the option of increasing review time, or training additional personnel who could review the files at the CEFAC and/or the other three agencies involved in the process.

Interviewee 15 also mentioned that delays also occurred due to the file being reviewed by the three other agencies mentioned above. The government administration should access the

length of time it takes for a file to travel between the different agencies to identify where delays occur. This would help it target where to direct more resources or personnel to process files, or to create new departments within those agencies focused on file processing, or to even eliminate the need for the files to be examined by certain agencies.

7.1.6.1 Lack of follow though for Certificate of Conformity

Interviewees # 4 (architect) and 15 (CEFAC employee) stated that although the Certificate of Conformity is one of the necessary components of any construction project, there is unfortunately no consistent follow through to make sure that the construction follows the paperwork submitted to the CEFAC to receive the Construction Permit.

They both stated that this is due to the fact that there are not enough trained personnel who can visit construction projects to check for conformity. The Certificate of Conformity is part of the law, but its application has been sparse in many cases due to a lack of resources.

Recommendation: The government administration needs to allocate more resources to train more personnel for this process. Currently since the focus has currently been on increasing the number of clients who file for the Certificate of Urban Planning and Building Permit, it might not currently be currently feasible to train such personnel.

The government administration should then focus on incentivizing design and construction professionals to make sure that their submitted plans are up to code, as well as incentive builders to make sure that their construction follow the norms and standards. They could also give this function to another governmental agency which currently has the necessary personnel who could focus on this issue.

7.1.6.2 High costs of construction permits

Findings from this study as well as specific statements from interviewees # 4, 5, 11 (architects & contractor) and 15 (CEFAC employee) have found that design and construction professionals find the fees associated with the construction permit to be too high.

"Unfortunately, the cost of getting the Construction Permit discourages people. For a simple villa with only one level, in terms of expenses, you have the ground study which costs three hundred thousand francs CFA (about USD $500); fire safety costs a hundred thousand francs CFA (about USD $165); administrative documents cost one hundred thousand francs CFA (about USD $165), and you have to pay the CEFAC two hundred thousand francs CFA to process your file (about USD $330). This already adds up to seven hundred thousand francs CFA (about USD $1,168). You will spend roughly one million francs CFA total to get the Construction Permit (about USD $1670) on top of your construction costs; in addition to that you have to wait two to three months to get the Permit itself and be able to start construction. So, it's discouraging, people are not motivated and frankly do not have money." (Interviewee #7 Architect).

Studies such as (Benjamin and Mbaye, 2012; Traoré, 2013) have researched the reasons behind illicit and/or informal construction in Africa and in Burkina Faso. They found that one of the reasons why people do auto construction (the act of building one's house without any professional help), especially in residential construction, is that such citizens already have a hard time funding their construction. If they already cannot afford to go through the formal process to get the Construction Permit, they will most likely be inclined to build illegally.

Recommendation: When creating the CEFAC, the government administration had carried out an assessment study in order to fix fees schedule. They should perform another assessment

study to verify whether the fees associated with the various permits are really increasing the number of permits requested per year, or whether those fees should be reassessed.

The government administration should also review prior studies it had funded but which had not been implemented. Interviewee 20 (planner) had been commissioned by the government administration to research barriers pushing people towards auto construction.

Studies such as hers found that auto construction is a process in which homeowners start with a small temporary house usually built in adobe and mud, which gets upgraded and expanded as the homeowner gets more resources and culminating in a bigger house in hard materials(such as concrete, bricks, cement). The initial house and subsequent expansions get demolished and re-built numerous times throughout the process, until the final house in hard materials is erected.

Interviewee 20 had proposed creating structures which allowed clients to gradually work upwards from getting the Urban Living Permit (PUH) to the Construction Permit. She and her team designed a series of modular houses prototypes in a variety of materials (including local green materials) with the costs and benefits of each cladding. The houses prototypes being modular meant that it could be transformed and added to or subtracted from to accommodate the client's resources without the need to demolish the initial house.

A review of such studies could help the government administration see how to best implement such measures which formalize auto construction, promote the usage of local green materials, and help the average citizen be more inclined to follow the process of getting their Urban Living Permit (PUH) or Construction Permit.

Interviewee # 16 (government) stated that this is something that the Ministry of Architecture, Housing, and Construction is interested in working towards.

"80% of our housing stock in our different cities is built through self-construction, because we have distributed bare parcels to private individuals who are not construction professionals ... So, if we want results, we must provide technical assistance to those who purchase the land. For example, having standard housing plans that will serve as a support to promote all these materials. We offer them the choice of the same house which is designed in several materials. They will be able to make the choice on the cost, to have a cross reading on the questions of cost, performance, and aesthetics before making their choice. If this is successful, it could be of great interest for the promotion of sustainable materials.

7.1.7 High costs of Urban Living Permit (PUH).

The process to get the PUH is long and costly, especially for those who build on non-parceled (quartier non-lotti) land in the hopes of being incorporated in a subdivision in the future. In urban settings, Wyss & Suisse (2005) found that once the occupant's plot has been recognized by the government administration, they are given a temporary allocation of the plot for which they will now have to pay a tax based on the size of their allocated parcel in meter squared. They are then given roughly 5 years to invest in their parcel, through a process called "highlighting", which means that they must be able to build a wall fence around their parcel, a small house, and have an external bathroom. Once they have achieved this, they can now ask for their situation to be rectified in order for them to get their Urban Living Permit (PUH) (Permis Urbain d'Habiter).

Even for those who can afford to buy land, the process is usually lengthy and complicated to get their land registered. CAHF (2019) found that it takes four procedures and roughly 67 days to be able to register one's property in Burkina Faso, as compared to an average of 53.9 days in Sub-Sahara Africa and 20.1 days in high income countries that are part of the Economic Co-operation and Development (OECD). Registration also requires 12 percent of the total property

value in Burkina Faso as compared to an average of 7.6 percent in Sub-Saharan Africa and 4.2 percent in OECD high income countries.

Recommendation**:** In terms of the PUH, the government administration could look into strategies to make it easier for its citizens, especially low-income citizens, to get access to their PUH. Studies such as (Wyss & Suisse, 2005; Traoré, 2013) have recommended for governments, especially in developing countries, to simplify their land regulations, lower plot prices, increase their social housing and to set up simple parcel files, instead of land registers, in order to meet the growing needs of the population.

7.1.8 Lack of access to financing for construction

Studies such as (Turin, 1973; World Bank, 1984; Wells, 1986; Bon, 1992; Tokuori, 2010; Bagaya & Song, 2016) as well as policy makers have recognized the important role that the construction industry plays in a country's economic growth, especially in the case of developing countries. One of the findings of these studies is that the lack of access to capital was one of the primary barriers hindering construction projects, especially for small and medium construction companies. In terms of Burkina Faso, only 4% of its population has access to microfinancing services (World Bank, 2003). Due to this, a significant share of these small and medium sized companies' investments and working capital are still self-financed.

The construction sector in Burkina Faso has benefited from a boom in recent years due to donor and government financed infrastructural projects which have included several large-scale and small scale earth dams projects using voluntary local labor, and road building and water supply projects (as part of the government administration's priority). In the private sector, construction companies profited from the increasing demand for hotel accommodation in Ouagadougou, which frequently hosts regional conferences (Economist Intelligence Unit, 2001).

This current trend of international aid and government backed projects has increased the financial aid to assist in developing the infrastructure of Burkina Faso, and it can be assumed that such foreign assistance will continue to contribute to Burkina Faso's economy.

Small and medium sized construction companies don't often receive access to such financing, or are not often included in those large-scale projects, despite laws in Burkina Faso calling for the use of local construction professionals for such projects. There is therefore a need to promote the participation and growth of small and medium sized construction companies in Burkina Faso.

Recommendation: An increase of Public-Private Partnerships (PPPs) could be a way to foster that participation. In terms of big construction projects, PPPs would allow the financially resourceful private sector (both local and/or foreign) to fund construction projects in Burkina Faso. Studies like (Tokuori, 2010; Traoré, 2013; Bagaya & Song, 2016) have found that although the government's financial motivations in using PPPs was a primary factor, other benefits of PPPs included attracting sustained private investment in infrastructure development, the ability to better identify potential risks in projects, and the sharing of those risks between the private and public sectors.

However, for PPPs to be successful, the government administration should make sure to provide the proper policy frameworks at the national and local levels. This would ensure that the terms and conditions of contracts for construction projects are carefully implemented in order to make sure that contract award and management are conducted with transparency and accountability (Tokuori, 2010; Traoré, 2013; Bagaya & Song, 2016).

For scale projects, the government administration of Burkina Faso should increase its support of the construction activities of private and voluntary initiatives, as well as NGOs,

especially for small-scale community-driven infrastructure projects by minimizing the bureaucracy which often makes it difficult for such projects to be implemented.

These types of strategies would also encourage international construction firms to want to participate in joint venture projects with their local colleagues, or to extend their involvement through sub-contracting and other supply chain mechanisms which would contribute to the development of the local construction capability of Burkina Faso.

7.2 Barrier 2: Human-related barriers

Section 7.2 describes human-related barriers found in this study, as well as the researcher's proposed guidelines for these barriers.

7.2.1 Lack of affordable real estate (especially in urban areas)

Access to real estate in Burkina Faso is hindered by citizens' low purchasing power, increasing land prices, real estate companies and promoters dominating the property market of Burkina Faso and fixing outrageous land prices, and a lack of available information tracking and regulation of land prices (Carbonell, 2018; Le Fou, 2018; Banque Mondiale, 2018; Zouré, 2019).

Recommendation: Recommendations 7.1.6 and 7.1.7 would also be recommended for this barrier. The government administration should also review land prices fixed by real estate companies and promoters in order to set up policies to reduce price volatility and decrease land prices. It should also continue in its work of increasing the number of social housing, as well as more strictly applying its zoning laws in order to reduce urban sprawl.

7.2.2 Negative perception of local materials as not durable

Citizens of Burkina Faso living in unparcelled land (quartier non-lotti), especially in urban areas, generally have turn to adobe and mud bricks for their construction, not to their sustainability but due to the precariousness of their situation. Wyss & Suisse (2005) found that

the precariousness of their situation has an immediate effect on the choice of building materials for these citizens. Until they become integrated into a subdivision and get their Urban Living Permit (PUH), these citizens have to live in a house with the bare minimum. They feel that they should not invest too much in a house which runs the risk of being torn down if they are evicted.

"*Theft and aggression are daily concerns; the inhabitants suffer from permanent insecurity. In such a context of "forced misery", it is not surprising that the material associated with this situation, land, is considered to be "provisional", "unsustainable" and "for the poor"* (Wyss & Suisse, 2005).

It generally takes them between 5-8 years to get their PUH, and when they can afford to build their final durable house, they will turn to durable materials such as concrete, cement, and bricks (which are considered hard, durable and definitive) to show that they have achieved their dream of owning a house and are no longer poor.

Another reason for these citizens to turn towards such hard materials, instead local green materials such as adobe which is more sustainable but less durable without upkeep, is that concrete, cement, and bricks can be stored and built with over time based on their available resources. Wyss & Suisse (2005) found that such citizens see cement, concrete, and bricks as materials which don't require further maintenance. Furthermore, as their house plan will evolve over time depending on their available resources, cement, concrete and bricks are seen as being more flexible to modification as compared to materials such as adobe and mud.

Recommendation: There needs to be more information diffusion networks geared towards the public to change their negative perception of local green materials as not being durable or being seen as materials for the poor. As mentioned by Interviewee 20 (planner) there is a need for flexible design and construction projects that incorporate local green materials

which can be allow the homeowner to phase out their construction over time depending on their available resources as they work towards getting their PUH. Such model houses would show them a more efficient way of building while promoting the use of local green materials as durable materials which can be as competitive as other hard materials such as cement, concrete, and bricks.

7.2.3 Negative perception of local materials due to bad memories

Although Burkina Faso's vernacular architecture is characterized by using mud and adobe bricks, in modern times this architecture has often been seen by the local population as being outdated, not durable, and for the poor. Often large scale modern projects, such as the Cissin operation, the ADAUA project, or the LOCOMAT project, using local materials ended up failing due to lack of technical skills of the construction professionals, designs not adapted to the climate, using materials which were not mixed properly or which had not been treated for termites, etc. Therefore, a lot of the negative perceptions of local materials could been tied to those failed projects (Gilbert & Koala, 1997), as well as the limited follow through in applying the results of research on those materials.

Recommendation: There is a need for modern large-scale projects using local materials which have learned from the failures of the above projects, and which could show the local population that local materials construction is aesthetically pleasing, modern, and durable. One area where this could be applied is in social housing. The Burkinabe government had been building with local materials for their social housing, especially during the Revolution years. They could make it part of their policy to use local materials when relevant to show that local materials can be used in such projects.

Interviewee 9 (architect) stated “Modern earth architecture is not well known in Burkina, either by the population, or even construction professionals such as architects or engineers. For Burkinabe, earth architecture means vernacular architecture. The architect Kéré has built using local materials, like his Gando school, but his projects are more well-known in Europe than in Burkina, which is sad to see”.

Another stakeholder group which could help improve the public’s bad memories of the construction with local materials, is for more residential luxury construction using local materials.

7.2.4 Lack of awareness of the benefits of sustainable construction

This low awareness of the benefits of sustainable construction from the public stem from the barriers highlighted under #2 and 3 above, but also due to the ineffective information diffusion networks on sustainable construction geared towards them. If they do not see a lot of sustainable construction in their surroundings, as well as not seeing their promotion via information diffusion networks such as on the television or the radio, their awareness will remain low. A large section of the population, even in remote rural areas, have access to a cell phone and/or a radio. Therefore, it would be beneficial for more promotion of such materials and sustainable construction to be diffused via television, radio, and podcasts which would be listened to on their cell phones.

Recommendation: Construction professionals do their part in using local materials in their construction projects, the government would do its part in creating and implementing policies to promote their utilization, but other stakeholders also need to step up, especially the media. In order to do that, journalists and communicators specialized in the promotion of technological innovation would need to participate.

This means that such media would need to be trained in the benefits of sustainable construction in order to better promote them. This could be fairly quickly done by adapting appropriate modules in journalism programs at the universities in Burkina Faso, or specific training modules could also be designed and offered to those already on the labor market. Design and construction firms could also either liaison with media agencies in order to have special programs focused on sustainable promotion or create social media job postings at their companies in order to better promote their utilization of local materials in their projects both locally and internationally.

7.2.5 Lack of financing for construction for the public

Access to financial funding for construction projects is still a major issue in Burkina Faso. The World Bank estimates that only 28% percent of the population of Burkina Faso has access to financial services as compared to 93.5% of Americans in the United States of America (U.S.A.). Additionally, despite good bank capitalization, interest rates are still considered high, at about 10 to 12 percent (CAHF, 2018) as compared to the U.S.A. which has an interest rate of 2.5 to 4 percent (USEPA, 2016).

The Banque Centrale des États de l'Afrique de l'Ouest (BCEAO) estimated that 15 commercial banks and four credit institutions (établissements financiers) were operating in Burkina Faso as of June 2019. Housing loans are available in the country but require collateral which the average citizen of Burkina Faso doesn't have.

Recommendation: The Banque de l'Habitat du Burkina Faso (BHBF) (Housing Bank of Burkina Faso) was a specialized bank founded in 2005 with the specific goal of dealing with the issue of housing finance. Critiques of the BHBF have argued that it has failed in its mission of providing adequate financing for construction projects. The takeover of BHBF by private

shareholders has opened new perspectives. Under the new leadership it hopes to become a modern, efficient, and competitive universal bank. This is why it was renamed the International Business Bank (IB bank) in order to meets its vision of having international standing (IB Bank, 2019). Time will tell if this takeover will improve access to financing for construction for the citizens of Burkina Faso.

More micro-financing as well as big scale financing should be developed in Burkina Faso in order to improve access to financing for construction, as well as to increase the development of green practices and technologies in Burkina Faso. More promotion of available financial services should be performed to increase the public's knowledge of them. One solution to increase the number of people who have access to banking services is to use the cell phone, which is becoming increasingly popular even in remote places in Burkina Faso. The average citizen of Burkina Faso is already used to sending money and paying bills using cell phone applications. Therefore, this is an opportunity to increase mobile banking, especially in areas which are hampered by transportation and other infrastructure limitations.

7.2.6 Limited user knowledge of green materials and technologies

The population of Burkina Faso having limited knowledge regarding the benefits of green materials and technologies was also a barrier. Many green materials and technologies are not widely used in design and construction projects, are often seen being trustworthy than non-green materials is a barrier found both in developed and developing countries. This reluctance to use such materials and technologies is exacerbated if the users feel that they have to be trained in their usage (DuBose & al., 2007; Du & al., 2014; Chan & Darko, 2017). In the case of Burkina Faso, minimal knowledge about green practices and technologies and lack of financial funding

geared towards construction created more of a barrier than the resistance to change on the part of the public towards green design and technologies.

7.3 Barrier 3: Knowledge-related barriers

Section 7.3 focus on barriers related to knowledge as well as the researcher's proposed guidelines for these barriers.

7.3.1 *Lack of educational access for design and construction professionals*

Burkina Faso has a few public universities such as the University of Ouagadougou, University Ouaga II, Université Polytechnique de Bobo-Dioulasso, Université Norbert Zongo, Institut Polytechnique Africain, Centre Universitaire Polytechnique de Dédougou, Centre Universitaire polytechnique de Ouahigouya, and the Centre Universitaire polytechnique de Kaya.

Unfortunately, there is a need for more public universities to meet the demand for higher education. Public universities are also vulnerable to strikes which can lead to students' studies being delayed. For example, in 2008, the University of Ouagadougou was closed for 2 months due to students protesting work conditions, delayed grant and benefit payments, and budget cuts which had led to a lack of available educators.

Citizens of Burkina Faso who can afford to send their children to private universities often do so due to the belief that private universities offer better education and are less prone to strikes. This has increased the number of private universities operating in Burkina Faso such as: Fondation 2iE, Université Aube Nouvelle, Université Saint Thomas d'Aquin, Université Privée de Ouagadougou, Université Libre du Burkina, Université Ouaga 3S, University of United Popular Nations, Institut Sciences Campus, Université du Faso, Institut privé des hautes Etudes Cheick Modibo Diarra, and Université Catholique de l'Afrique de l'Ouest.

Although these private universities increase the number of available higher learning institutions, there is a need to regulate the quality of the education offered.

- *No state architecture school in Burkina.*

Burkina Faso doesn't currently have a state architecture school. The West African countries joined together and created a regional architecture school in Togo and there is another regional architecture school in the planning stages in Ivory Coast.

There are a few private architecture schools in Burkina Faso, but they can generally be characterized in the following manner. Some are schools which used to form architectural technicians, which saw the potential to fill the gap in the lack of local architecture schools, and which reformatted themselves as architecture schools. Unfortunately, their curricula were not updated, and although their graduates call themselves architect, their formation is more on par with architectural technicians. Others have the adequate curriculum but are not accredited with any accreditation bodies.

Engineers and contractors on the other hand have access to public and private local engineering schools and training programs which are accredited. However, there also exist engineering schools and training programs which are not accredited. Planners and interior designers need to travel abroad in order to gain access to education in their fields.

Recommendation: The increase of local private school can be considered positive since it's helping meet the demand for higher education. Nonetheless there is a need for policies to regulate education curriculums for design and construction professionals especially for private institutions, as well as policies to assess the degree of knowledge of design and construction professionals who have studied overseas and who have returned to practice in Burkina Faso.

The Orders of Architects and Engineers have been trying to assess the degree of knowledge of such graduates (from local and international institutions) at their levels, and to provide additional training when necessary in order to fill gaps in their education. However, such measures can only be applied to design and construction professionals who get registered with the Orders, meaning that some professionals are not being assessed. There is a need for the government administration to work in partnership with these Orders to regulate design and construction professionals at a larger scale.

7.3.2 Lack of financing for education for design and construction professionals

The government administration of Burkina Faso currently offers some scholarships for design and construction education, but they are not sufficient to meet the demand for scholarships. One of the government agencies in charge of providing loans and grants for students of Burkina Faso is the Fonds national pour l'Education et la Recherche (FONER – French acronym – National Fund for Education and Research). New graduates, students, teachers and researchers, local authorities, partners in education, and pre-school to secondary schools, technical, and professional training institutions can benefit from loans and grants from FONER (Van Lill & Gaillard, 2014).

Although FONER is in charge of funding both education and research, the majority of its budget is used for study grants due to the need to support students. Since 1994, approximately 60,000 loans have been allocated to students. The rate of net reimbursement is relatively low (10-15%). Due to this, funding has yet to be used to create infrastructure or research (Van Lill & Gaillard, 2014).

FONER is funded by a variety of resources such as state and local grants, financial institutions and national and international contributions, and funding from private companies.

There is a need for increases of FONER and funding from the government administration in order to meet the demands for scholarships. Currently, Burkina Faso is trying to increase access to basic education for all, therefore less focus is given to improving higher education. Therefore, there is a need to to attract more funding from a broader range of donors and funding sources in Burkina Faso.

7.3.3 Limited users' knowledge and skills about green design (subcontractors & technicians)

This barrier deals with poor subcontractors' performance. The practice of subcontracting is an integral part of the Burkinabe construction industry. When it is well regulated, it is beneficial to the clients, contractors, and subcontractors, as well as increasing the efficiency of the industry as a whole. When it is not well regulated, poor subcontractors' performance can lead to scheduling delays and construction projects which do not meet adequate standards. Having a high degree of quality control and supervision is beneficial to both client and contractor, preventing extra costs and mismanagement.

Recommendation: Studies like Bagaya (2016) found that many projects in Burkina Faso are often awarded to the lowest bidder who may lack the technical competence to successfully complete the project. The government administration of Burkina Faso should set up fair bidding procedures: (i) promptly remove corruption and cumbersome obstacles in the bidding process, (ii) assess contractor's technical capability, experience and manpower based on his production of certificates of completion, and (iii) estimate contractor's financial strengths by means of annual turnover and profit (Bagaya, 2016).

In order to do so, the following actions must be carried out: (i) strict compliance with contractual deadlines, if failing, the full application of penalties, (ii) the construction projects must be efficiently monitored by both government engineers and private credible consulting

firms, and (iii) the systematic and technical control of the contractor's materials and machinery upon delivery and at the construction site (Bagaya, 2016).

- *Poor technicians' performance*

This section deals with poor technicians' performance, where their lack of skills generally has to do with inadequate or non-existent vocational training programs. Wyss & Suisse (2005) found that poor technicians' performance was also the consequence of an education and training system which puts a lot of weight on the acquisition of general culture, and which neglects to a certain extent the acquisition of practical know-how, as highlighted by the training of Masons at the level of the Certificate of Professional Aptitude (CAP).

They recommended a new axis of vocational training, the dual training, as a way to mitigate this issue at the artisan level. In their model, the apprentice mason works with a contractor who frees up part of his working time to follow theoretical training given by existing vocational training centers.

The dual training experience of the CAFP in Koudougou which was piloted between 1998 and 2001 showed that this model performance was very encouraging, as technical high schools were already sufficiently equipped to offer their services in this regard.

As with many such endeavors, financing is the problem as it requires entrepreneurs to finance the training of their apprentices through the chamber of trades or their unions. Wyss & Suisse (2005) found that clients could play a major role in this by requiring that workers employed on their site have certified training, forcing contractors to follow this formal system. This would allow the certification of skills to become a marketing tool at the company level. In this way, they could target their biggest customers, donors and the government administration of Burkina Faso.

The downside to this model is that it is a first step, and therefore cannot reach all apprentice masons, especially those who are not part of any structures or are in the informal sector. Another issue is that due to the lack of trained technicians, CAP masons often prefer to stop their training in order to work as technicians. This is a double problem because in stopping their training, they are poor supervisors for the unskilled labor, and on the other hand, although they are successful as technicians, they don't go beyond this level since they have stopped their training.

There is a need for training and supervision of all design and construction professionals at all levels, but this recommendation will have to implemented gradually. Reinforcing technical training which already exists in high schools could help speed up the process. There is also a need for the creation of new training centers. Wyss & Suisse (2005) found that in this aspect, the government administration of Burkina Faso is active, such as with the Provincial Technical High School of Fada N'Gourma, although additional work and funding is necessary.

This also provides the possibility to implement training in the use of local green materials for all stakeholders (such as architects, engineers, technicians, masons) by introducing this training in the educational curriculum of schools and vocational programs.

7.3.4 Payment delays for construction projects

Issues with payment delays is prevalent in many sectors in Burkina Faso, including the construction sector, with many professionals and subcontractors needing advance payments in order to buy supplies and hire workers for a construction job. Payment delays propagate further delays in the start and completion of construction projects, as well as in the quality of the chosen materials, since construction professionals and subcontractors might be tempted to buy inferior materials in order to save money.

Studies such as (Fugar & Agyakwah-baah, 2003; Tokuori, 2006; Bagaya, 2016) found that in the case of government projects, "payment delays can create cash-flow problems within the construction industry on a vertical progression". This means that since the government administration of Burkina Faso is one of the primary builders, delays at that level have a significant impact on the construction industry since the government administration is in charge of the management of national budget funds and/or foreign investment funds. Such delays also occur with private clients and smaller projects.

Interviewee #11 (contractor) detailed this barrier in the following manner: *"A lot of time, we builders are on standby. It's expensive to keep a lot of workers on standby if we don't have a project. So, we have to recruit when we need them... It's also hard for us small companies to keep a lot of materials in stock because you have to hire a watchman to make sure the materials are not stolen, and that can be wasting money. Most clients don't want to pay us for the whole project, or they pay us as they get money. The hard part about our job is that you have to often chase the client when you finish the project to be able to get all your money. This means that you waste time, money, and gas trying to get your money."*

Recommendation: Studies like (Tokuori, 2006; Bagaya, 2016) have suggested the following recommendations. Firstly, use contractual incentives in order to motivate contractors to meet their clients' project objectives. If they are rewarded to finish projects on time or ahead of schedule, they will be more apt to reduce delays in their construction projects.

Clients also need to do their part by making sure that they have the resources available for the projects before they commission them. Additionally, such studies have suggested that if the government effectively impose penalties for scheduling delays, this could reinforce the public treasury, as well as motivate design and construction professionals to meet their deadlines.

7.3.5 Competition with foreign-owned construction companies (large projects)

This study found that design and construction professionals in Burkina Faso didn't feel that they competed with foreign design and construction firms in small scale construction projects.

For large-scale construction projects, small to medium sized design and construction companies were not able to effectively compete with large sized companies, and therefore did not have the capacity to implement large scale projects without external financial and physical support. For such projects, design and construction professionals in Burkina Faso felt that there were more foreign design and construction firms participating since they had the means to fund such projects alone or in partnership with the government administration of Burkina Faso.

Recommendation: The need for more Public-Private Partnerships (PPPs) is again recommended for this barrier. In terms of big construction projects, PPPs would allow the financially resourceful private sector (both local and/or foreign) to fund construction projects in Burkina Faso. For PPPs to be successful, the government administration of Burkina Faso should provide the proper policy frameworks at the national and local levels to ensure that terms and conditions of contracts for construction projects are carefully implemented so that the tasks of contract award and contract management are conducted with transparency and accountability (Tokuori, 2010; Traoré, 2013; Bagaya & Song, 2016).

Such strategies would also encourage international construction firms to be more willing to participate in joint venture projects with their local colleagues, or to extend their involvement through sub-contracting and other supply chain mechanisms which would contribute to the development of the local construction capability of Burkina Faso.

7.3.6 Limited construction professionals' knowledge and skills of green materials and technologies

This barrier can be broken down into two broad categories:

i) Design and construction professionals (especially architects) who have limited knowledge about local green materials and technologies, and who are not convinced about their performance or their advantage over non-green materials and technologies.

ii) Design and construction professionals (especially architects) who are knowledgeable about local green materials and technologies, and who believe in their performance and advantage over non-green design materials and technologies.

Design and construction professionals in the first category have either rarely or never worked such materials and technologies, who see them as materials for the poor or as antiquated and/or not durable materials, who have bad memories of failed projects using such materials, and who do not believe in their properties or performance over non-green materials and technologies.

Design and construction professionals in the second category have learned about these emerging green materials and technologies and are convinced in the need to incorporate them in construction projects. However, when they enter the work force, they are confronted with the realities of the minimal availability of local green materials and technologies in the Burkinabe market and with the minimal client demand for such materials. For these reasons, they often fall back to using non-green materials instead of innovating, and as such become complacent.

Recommendation: Design and construction professionals are necessary for the promotion and utilization of green materials and technologies. The government administration of Burkina Faso can aid in the promotion of such materials via the creation and implementation of policies

geared towards the promotion of their utilization such as being rewarded with incentives for using a set percentage of green materials and technologies.

7.3.7 Limited number of architects

In the past, Burkina Faso had more trained engineers than architects, and engineers and draftsmen did the work of architects. Currently, the number of architects has increased, although there is a need for more trained architects, especially in the provinces. Some participants stated that some conflicts between architects and engineers have occurred, with architects feeling that engineers are taking over their functions, and engineers complaining that architects are dominating the construction market (despite their smaller numbers) and blocking them from participating in construction projects.

Interviewee # 7 (architect) stated: *"Unfortunately, our texts date from the 1990s, and at that time, there were no more than 20 architects in Burkina, so other disciplines played the role of architects. Now we are at least 200, so I hope things will change, and start to influence the field of construction. We still don't have enough architects and engineers in Burkina, especially in the provinces… Things have gotten better but compared to our neighboring countries, we need a lot more. Engineers in Burkina are around 500 or more but like architects, they are mainly concentrated in the capital and Bobo Dioulasso."*

7.3.8 Limited knowledge about the role of the architect

Due to the limited number of architects in the past, the population of Burkina Faso has gotten used to turning to engineers and draftsmen for their construction projects. This means that the role of the architect is not well understood by the average population of Burkina Faso.

Interviewee # 7 (architect) described this situation in the following manner: *"Architecture is a profession in reality that has existed for a long time but is unfortunately badly*

perceived and misunderstood here in Burkina. At first, architects were described as wealthy, untouchable, and in general, architects were perceived as not affordable based on our fees.

Overall, we realized that people are more used to old practices. They call on a bricklayer to come and do their project without knowing that there is a thinker ...[architect] who is there, who can help them reduce costs and have exactly what they want. It's a long-term battle that the architects have to lead, and it's a major difficulty. We can say that it is a matter of habit that people prefer to resort to a draftsman rather than an architect. When they like a building they see, and they will duplicate it without turning to an architect who might be able to propose a better plan to them".

Interviewee # 6 (architect) stated: "*the first difficulty that we can talk about is the lack of knowledge of the public, their ignorance in terms of architecture. The profession of architect is nowadays, unknown. It takes patience, information, awareness. Even educated Burkinabe do not know what the architectural profession is. When one looks at the practical organization of the profession, at the institutional level, there is the Order of the Architects who organize the architects. But the governors, those who are at the head of the country and who make the decisions, have a hard understanding that the architectural profession needs a strict organization, therefore we have not been able to make either the public or the government understand our profession".*

- *Architects are seen as being too expensive*

Interviewee #15 (government) suggested: "*another issue with the low consultation of architects and other construction professionals for plans, are their fees. There are no real regulation of architects and other construction professionals' fees, and we have had clients*

complain that consulting fees were too high on some construction projects, they can go between 20-40% of the total costs of the project".

Interviewee # 6 (architect) stated that "*for green materials, we need to adapt the architects' schedule of services…they don't take into account the costs related to specific requirements of those materials, such as BTC"*.

Interviewee # 14 (engineer) described it as a problem in all levels of the construction field: *"In terms of the cost of services of the different parties, whether for the company, the architect, or the engineer, clients find their costs as too high because they do not understand what we do. Clients do not see the purpose of paying dearly for an architect or engineer to just think. They are just interested in having their houses built cheaply".*

Recommendation: In terms of architects feeling that other professions (such as engineers, draftsmen, and surveyors) are taking their jobs, the Order of Architects, the Order of Engineers, and the Order of Surveyors of Burkina Faso are currently working on updating and modernizing the construction laws in Burkina Faso, and better communication and cooperation between the different branches of design and construction industry in Burkina Faso is one area that they are focusing on.

Regarding the need to make the population of Burkina Faso understand the role of architects, the Order of Architects of Burkina Faso has a series of planned events such as the Journey of the Architect, in which they promote architects, explain to the public what their job entails, and why using them for plans is necessary. They also breakdown their duties and costs for the public.

Partnering with the media to disseminate the above information beyond the Journey of Architects and to a broader audience would be beneficial. They could also partner with the CEFAC in their training programs in order to increase clients' understanding of their role.

Interviewee # 7 (architect) also proposed that the government administration of Burkina Faso could lower taxes for architects to make it more feasible for them to decrease their fees which could increase the number of clients making use of their services. *"In Burkina, the architect is not busy because before the CEFAC, arrangements were not made to get people to resort to an architect. You need laws, you need information, you have to educate people. By lowering taxes this could minimize the amount of the architect's fees and push clients to seek the architect's expertise. In addition, we could also get more young people to want to become architects".*

7.3.9 Lack of green building databases and access to information venues

This study found that a large amount of the research performed in Burkina Faso, especially in the area of green practices and technologies, was not well disseminated. They either did not go beyond the research phase into dissemination, or their findings remained unknown to a large portion of the population due to their lack of digitization.

This study also found that access to digitized information necessary for this research was more readily available in international databases than in local databases which were limited in numbers.

Interviewee #19 (Planner) stated "*we tried to push for the digitization of our work, especially when using local materials for social housing, and we outlined how we could do it. But like many things in Burkina, it only takes one regime change, for good ideas to get forgotten, and money put aside for particular projects get shifted to projects favored by the new regime*".

Burkina Faso has the available structures to facilitate and disseminate research as shown in section 3.3.3, so why does this barrier still occur?

Studies like (Butare, 2014) as well as interviews with the heads of institutions and researchers have shown that those structures often do not have a clear vision of their missions, do not firmly apply dissemination plans, or rarely evaluate results and performances.

Institutions and researchers also tend to focus more on the research phase of their projects and less on the promotion and dissemination phases such as with publications. There is also the culture of secrecy playing a role in this barrier in Burkina Faso, where some researchers prefer not promoting information, especially when it's a negative assessment of their profession or if it could jeopardize their job.

Interviewee #12 (educator/researcher) stated: "*there is often a level of distrust in research…everyone is competing to rise in the company, and it's often more who you know than your hard work which pushes you forward. So good research gets put in a drawer, and nothing gets done, and then it gets forgotten*".

Studies like (Butare, 2014) also found that few researchers were aware of patent research and exploitation, especially when they are aware of the long and difficult path that new inventions go through in order to reach the Burkinabe market. However, this barrier is not specific to Burkina Faso and does occur in developed and developing countries.

Furthermore, many researchers find the idea of commercializing their research findings as totally foreign. The current laws of Burkina Faso are also not currently set up for royalties collection in case of sales of patents. Lawyers in Burkina Faso also need additional training in matters of intellectual property.

Recommendation: Studies like (Butare, 2014) have recommended the following policy for the promotion and dissemination of research results.

- *Revisit the missions of the research structures and review financing methods*

Revisiting the missions of the research structures will ensure that structures are meeting their missions, are applying dissemination plans, and are evaluating results and performances. Reviewing financing methods, will allow research structures to assess where resources are concentrated, that research funding is efficiently effected, and that all aspects from funding research to disseminating research is carried out.

- *Motivate researchers to incorporate promotion and dissemination of research*

Studies like (Butare & Zoundi, 2005) have recommended that additional investments should be allocated for the promotion and dissemination of research results by supporting scientific publications in specialized journals, in online databases, at conferences and seminars, the dissemination of results in public or private print media, on the radio, and on the television. Furthermore, research institutions should develop a corporate culture where researchers are accountable for results dissemination.

- *Establish consultation frameworks to increase the volume of research commissioned by the private sector and civil society*

Stakeholders in the private sector and civil society should participate in research to increase the volume of commissioned research, to facilitate the dissemination of research, and ensuring that it moves from research into implementation (Fabrizio, 2006; Butare, 2014).

- *Train journalists in the popularization of research and in technological innovation*

The media in Burkina Faso should be trained in the benefits of green design and green materials and technologies to better promote them. This could be implemented fairly rapidly by

adapting appropriate modules in journalism programs at the universities in Burkina Faso or designing specialized training modules for those already in the job market. Design and construction firms could also either partner with media agencies to develop programs focused on the promotion of green design and green materials and technologies or create social media openings at their companies focused on the promotion of their green design projects.

7.3.10 Lack of trained media on green design and green materials

Knowledge production is important in the construction industry since it can promote and find solutions for "the need to effectively deal with complex projects; the effective use of new, innovative building materials, systems, services; managing change (both project change and organizational change); coping with the uniqueness of projects; and managing team member interfaces (e.g., consultant-contractor)" (Egbu, 2006).

Studies such as (Frenken, 2002; Onyancha & Ocholla, 2007; Abramo et al., 2009; Hoekman et al., 2009; Klitkou et al., 2009; Sooryamoorthy, 2009) found that research collaboration increased researchers' ability to share knowledge, skills and techniques. This increased the transfer of tacit knowledge, created knowledge communities between the collaborating researchers, and connected them to the wider scientific community by increasing the visibility of their research.

Onyancha & Maluleka (2011) found that the African countries in their study, benefitted from their collaboration with their African colleagues in the increase in the number of their publications, although the degree to which the number of publications increased differed. In the case of Burkina Faso which had a minimal number of available publications, its publications increased by 35.98% with its collaborations with its African colleagues.

Therefore, research as well as collaborative research and knowledge sharing should be encouraged in sub-Saharan Africa and Burkina Faso, in Africa as a whole, and globally.

Recommendation: Researcher networks should be encouraged between Burkina Faso and its neighbors in sub-Saharan Africa, common subjects or topics should be identified and explored for possible collaborative research; regional conferences for networking and scholarly exchanges should be organized frequently; and funding for research and collaborative research should be prioritized (Onyancha & Maluleka, 2011).

Interviewee # 7 (Architect) stated: "*The government should be the leader in organizing conferences, because it would be too expensive for the Order of Architects or private entities to organize them themselves, especially if the government doesn't help. If the government is at the forefront, it makes these conferences more legitimate, because organizations often do not trust the individual or a group of individuals. For the private individual, you can register for training workshops and conferences, but it's often hard to get invitations to participate without the backing of the government."*

7.4 Barrier 4: Market-related barriers

This section focuses on the market related barriers found in this study in Burkina Faso, and the researcher's proposed guidelines.

7.4.1 Limited users' knowledge about local green materials and their properties

- *Definition of local materials*

Green materials are generally called "local materials" in the context of Burkina Faso, but the definition of a local material has evolved and changed over time. According to Burkina's LOCOMAT (National Strategy on Local Building Materials), local materials are defined as "being **produced locally**, **from domestic raw materials** (or resources) **specific to a country**

with the aim **of minimizing its cost,** are **environmentally friendly**, and have a **positive macroeconomic impac**t on the national level" (Wyss & Suisse, 2005).

This study reaffirmed the above definition in both the Qualtrics questionnaire and in the semi-structured interviews. As discussed under Barriers 1 and 2, the population in Burkina Faso as well as some design and construction professional generally perceives local green materials negatively as being materials for the poor (especially adobe and mud bricks), issues in their durability, memories of failed projects using such materials, bad materials quality (i.e. earth of poor quality, quarries of bad quality), badly stabilized structures, inadequate designs and not fitting the local climate.

- *Ignorance about local materials*

This ignorance of the benefits of local green materials and technologies can be categorized in the following manner:

- Technical aspects: such as mechanical, static, water, physical and qualitative characteristics.
- Economic aspects: such as cost of production by piece, cost of production by volume, production cost per technical unit, economic threshold, financial immobilization.
- Health and environmental aspects: such as chemical components, gas emission, susceptibility to insect hosting.
- Ecological aspects: such as deforestation, disembowelment of the hills, production of wastes.
- Institutional aspects: such as legislation, insurance, development policy, standard and standards. (Nko'o, 2006)

Recommendation: There is a need to understand the benefits and properties of local green materials and technologies in order to better promote them. Promoting them via well-built large scale projects especially governmental projects will enhance their visibility as well as speak to their durability and sustainability.

There is a need for more research detailing their properties in order to develop norms and standards in order to commercialize them, and to increase their availably in the market of Burkina Faso. There is also a need for more training on local green materials and technologies, especially in design and construction professionals programs, vocational training, conferences, and the media.

7.4.2 Lack of availability of green materials and technologies on the market

Section 3.3 details some of the available green materials in Burkina Faso, and despite Burkina Faso having a variety of such materials available in the country, they are not sufficiently accessible on the market.

- *Informal supply chains*

The limited availability of these local green materials on the market in Burkina Faso has led to the development of informal supply chains such as with solar panels. These informal supply networks help meet the demand for such materials in the market, but this creates a loss in revenue for the economy due to lack of taxation on these products. The government administration of Burkina Faso could develop incentives to help formalize these informal networks.

- *Focus of local materials development has mainly occurred in urban areas*

The promotion of local green materials and technologies in Burkina Faso has largely been limited to urban areas due to the fact that much of the infrastructure development has been

concentrated in areas where large population hubs are grouped, even though the majority of the citizens of Burkina Faso live in rural areas. This is despite the fact that there are minimal available materials quarries around the capital of Ouagadougou. This means that many of the local green materials need to be transported from different regions in Burkina Faso, which increases their initial costs due to the addition of transportation costs.

Recommendation: As mentioned under Barrier 1, the government administration of Burkina Faso needs to inventory the available local green materials. Burkina Faso also has a variety of vernacular architecture, consequently there is an opportunity to promote the local architecture of the different regions with specific policies for the usage of locally available green materials alongside the uniform policy on their usage across the whole territory of Burkina Faso.

7.4.3 High labor cost for local materials

Construction using local materials such as BTC is currently very expensive as compared to using non-green materials and technologies, which tends to discourage the majority of the population of Burkina Faso. This is due to the fact that there are few skilled masons knowledgeable about construction using local green materials, increasing their labor cost.

Additionally, such masons are usually based near the quarries where they work. In order for them to work in other regions, they need to be recompensed with travel costs and accommodations in additional to their salaries. This additional cost is then reflected on the already high initial costs of local green materials and technologies which in turn decreases their demand.

Recommendation: In order to increase the number of masons capable of working with specific green materials, there needs to be specialized training in different regions around Burkina Faso.

Mechanizing some of the production and manufacturing of green materials will increase their availability on the market by minimizing their production time, increasing their manufacturing output, which will in turn will decrease their prices. If there is an increase in the usage of such materials in conjunction with more specialized training in such materials, it will increase the demand for trained masons and decrease their labor costs.

A drawback of increased mechanization, especially if it requires the usage of electricity, is that it would increase the strain on the electrical grid which already cannot meet the demand of the population in Burkina Faso . Electricity production in Burkina Faso is still considered low, according to INSD (2011), in urban areas, only 13.7% of the total population has access to electricity.

Wyss & Suisse (2005) recommended the following 6 interventions to increase the production of local green materials in Burkina Faso.

- **Industrialize** the green materials production sector in order to produce high quality materials quality and to increase their availability
- **Formalize** the informal materials production networks, whether manual or industrial
- **Standardize** and classify products so that their quality is guaranteed
- **Increase research and categorization** of those local green materials
- **Train** stonecutters, masons and designers in the production of local green materials to increase knowledge and reinforce demand

7.4.4 Limited local green materials norms and standards

Norms and standards for green materials are necessary to ensure that they are available in the market in Burkina Faso in consistently good quality. Some materials in Burkina Faso such as

the cut laterite block (BLT) have benefited from the development of norms and standards, while others such as the granite do not currently have a standard size.

There has not been a wide usage of local green materials partly due to the available technical references not being sufficiently disseminated. The lack of standardization might make some clients and design and construction professionals be reticent to choose such materials since this would increases their risk in the eyes of insurance companies and banks who might not want to finance "unproven" materials and technologies. There is therefore a need for more research on local green materials to develop norms and standards to increase their usage and to decrease the perception of their risks.

7.4.5 Limited training on local green materials and technologies

Research and projects using local materials in Burkina Faso has been carried out for years in Burkina Faso, and enthusiasm for the usage of local materials has peaked and waned depending on the government administration in place. Research projects such as LOCOMAT and the PAB used to provide training for workers on construction sites as well as for producers of those materials. With the closure or scaling down of such projects, training for local green materials has either diminished or disappeared completely.

Based on Burkina Faso's *Inventory of technical and didactic resources available for the promotion of local building materials in Burkina Faso* Report (2009), the government administration of Burkina Faso outlined a comprehensive plan for the training of local materials.

What training on local materials?

- **Advocate** for the need to include content on local building materials in training courses with institutional actors of education and training;

- Focus on **initial training** by ensuring that technical and vocational training curricula incorporate content related to local materials and technologies from Burkina Faso;
- Develop **continuous training** at all levels for local materials and technologies;
- Develop **the training of endogenous trainers**. Building professionals (craftsmen, technicians) could be trained to serve as relays in each region of the country on materials;
- **Promote** and increase the placement of trainees and students in building and public works, in engineering, and architecture offices and on construction sites favoring the use of local materials and technologies;

Train on what and why?

- The **capitalized experience of LOCOMAT** in order to reinforce and sustain the gains;
- On the **popularization** of FASONORM **technical standards** to ensure harmonized productions, quality, and appropriate constructions;
- The **results of the research** carried out by Project BKF92 / 008 on substances materials and building materials in Burkina Faso to promote and disseminate them.
- Based on research, there is unanimity on the quality of the **BLT and BTC.** Comprehensive skills baselines for these materials need to be put in place for transfer of skills for **adequate production, implementation and maintenance**;
- **Accentuate research on other types of materials** (i.e. banco or earth) for experience and highlight their durability and aesthetics.

Who provides the training?

- Independent trainers: make a directory of training skills on local building materials

- Technical and vocational education and training institutions: to finance and ensure the development of content complementary to the teaching and training programs on the subject in agreement with the MESSRS, the JEM.
- Artisanal professionals: support the emergence of professional artisans trainers to make skills available and accessible in all regions, according to existing potential, and at an affordable cost.

Who to train?

All links in the chain must be involved in the training to ensure that there is a real transfer of knowledge on the subject. To do this, the following target audiences must be targeted:

- Teachers and trainers: in public and private education and vocational training institutions;
- Active professionals: (masons, workers, workmen, technicians and engineers of construction companies) to be extension agents and endogenous trainers in construction companies;
- The craft professionals of the corporation: to make them endogenous trainers within their professional organizations;
- The municipal agents of the local authorities concerned;
- The personnel (middle management and senior management) of the administrations, organizations, projects and programs, NGOs and associations involved in the design, implementation and monitoring of construction work;
- Individual and organized beneficiaries, communities;

The establishment of an effective training device and the pedagogical methods of its implementation is intimately linked to the concepts of local materials, the environment and the

possible uses. In other words, **training can only be designed and developed on the basis of clear objectives in terms of what types of local materials for which type of habitat and in which environment**.

The training actions to be developed on housing and community-based facilities using local building materials will have to consider two dimensions:

- The rural environment;
- The urban environment.

The existing technical and didactic resources inventoried in the report, must be re-read, completed, and adapted to each context in order to make the training close to reality and to bring about change at the level of the individuals and communities.

While the involvement of the State in the valuation of local building materials is necessary, it is equally important that private stakeholders get involved. The synergy of state / private action is therefore required to give a chance of survival to local building materials.

Here are some points on which the Private sector must play its score:

- Create an organization responsible for putting the community in order (specifications to be filled out before carrying out the activity);
- Promoters of technical schools and universities must integrate local materials into their training curriculum;
- Ensure the formation of all links in the chain (designers, material producers, masons, laborers, formers etc.);
- Communicate for a change of mentality on local materials through information documents (production, implementation and maintenance) on each type of local material;

- Make infrastructure achievements with materials adapted to each locality (for example: BTC and Adobes for the Sahel and the BLT for the South).
- Architects must be aware of and advise people on the advantages to be built with local materials;

This report was an important first step towards creating a comprehensive plan for the training of local green materials. But work still need to be done in order to mobilize resources and to implement this strategy plan at all levels of society in Burkina Faso.

7.5 Barrier 5: Cost and risks-related barriers

Section 7.5 describes cost and risk-related barriers found in this study, as well as the researcher's proposed guidelines for these barriers.

7.5.1 High cost of local green materials

Green materials tend to be **initially more expensive** than non-green materials due to their initial and installation **costs**, even though they may pay for themselves quickly. This is exacerbated when you add **importation costs.** This is in addition to other negative perceptions of such materials, such as being seen as **materials for the poor** (especially adobe and mud bricks), lack of **durability**, **bad projects examples**, **bad quality (**i.e. earth of poor quality, quarries of bad quality etc.), **badly stabilized structures**, **inadequate designs**, not fitting the **climate** etc.) increases their costs in the eyes of potential users.

Recommendation: The more government administration of Burkina Faso and other agencies promote green materials and technologies, the more access to financial loans and incentives will increase, the more green design projects will be implemented, the more the demand for green materials will increase, which will decrease their importation costs and increase their local manufacturing.

7.5.2 Fear of increased financial risks associated with green materials and technologies

Owning one's house in final hard materials serves as a form of security and a guarantee with a bank, since it allows the homeowner access to credit by using the house as collateral. "The acquisition of a habitat allows the owner to access all kinds of services for which he is sidelined as a tenant" (Wyss & Suisse, 2005).

Due to local green materials not being sufficiently available in the markets in Burkina Faso and of constant good quality, some design and construction professionals and promoters are not convinced of their benefits in the context of Burkina Faso. Their quality is variable and the management of the producers is complicated. Although there are some producers who are well organized, the production remains semi-artisanal and the diversification of these materials on the market is still limited.

Due to these factors, many banks refuse to give homeowners access to credit for houses built with local green materials, since those houses are considered temporary dwellings in the eyes of the banks.

Therefore, as with the recommendation above, the more promotion of green materials and technologies, the more standards and norms will be applied which will guarantee products with constant good quality, the more they will decrease in risk in the eyes of promoters, design and construction professionals, and financial institutions.

7.6 Barriers, costs and benefits table

Chapter 7 discussed the barriers found in this study in Burkina Faso, as well as proposed recommendations and guidelines to mitigate these barriers. The findings for this chapter answer research question 3.

In order to implement recommendations, one must confront the difficulties of implementing them, the cost engendered by their implementation, as well as the benefits stemming from those recommendations.

The degree of success of those recommendations will require a balance between costs and benefits, where the benefits must be equal or outweigh the costs, and the costs must be low.

The path towards sustainability in Burkina will be multi-phase, necessitating both short and long term solutions. The first phase of implementing such guidelines is to rank them in terms of their ease of implementation as it contrasts to their costs and benefits as shown in table 7.1 below.

This dissertation due to its exploratory nature did not try to provide practical action items for implementing the proposed guidelines. Future work will entail translating the proposed guidelines into practice, and this translation will be data driven by the stakeholders to estimate the impact of these implementations.

The scale used in table 7.1 ranges from **0 (less difficult to implement) to 10 (most difficult to implement)**. This scale although subjective, was driven by the data gathered in this dissertation, such as the repeating themes revealed by the different stakeholders.

Table 7.1: Barriers, direct costs, and benefits for Burkina Faso

Barrier Category	Barrier	Difficulty of Implementation	Direct Costs	Benefits
Knowledge	7.3.8 (Misunderstood architectural role)	2	Cost to client: ***Permit fees***	Regulated construction; regulated city planning; safer buildings; green buildings
Government	7.1.3 (Lack of green definition in code)	3	Cost to government/ construction industry: ***Legislation costs***	Healthy environment; financial benefits; competition with other countries in sustainability
Knowledge	7.3.5 (Competition with foreign firms)	3	Cost to design & construction industry: ***Income loss; loss of bids*** Cost to government: ***Training costs***	Better construction projects quality; competition in design & construction industry
Government	7.1.5 (Lack of green norms/ standards)	4	Cost to CEFAC/government: ***Staff training, job creation; loss of efficiency***	Regulated construction; regulated city planning; safer buildings; green buildings
Government	7.1.6 to 7.1.7 (CEFAC administrative delays)	4	Cost to government / architects: ***Revenue loss***	Regulated construction; regulated city planning; safer buildings; green buildings; law abiding citizens

Table 7.1: Barriers, direct costs, and benefits for Burkina Faso (continued)

Barrier Category	Barrier	Difficulty of Implementation	Direct Costs	Benefits
Knowledge	7.3.9 (Lack of green databases/ access venues)	5	Cost to government / construction industry: ***Staff training; digitization costs (equipment, servers, internet); downtime; efficiency; electricity***	Increased information access/sharing; promotion of sustainability; research; intellectual property; revenue generation
Knowledge	7.3.10 (Lack of trained media)	5	Cost to government/ construction industry: ***Training; wages; facilities; promotion costs; time/down time***	Educated construction professional and population; information sharing; sustainability promotion; safer buildings; healthier environment; healthier population
Knowledge	7.3.4 (Payment delays)	6	Cost to government/ construction industry: ***Labor costs; equipment costs; materials costs; overtime pay; efficiency; revenue loss (incentives)***	Economy; sustainable development; construction; scheduling delays; newer/ faster infrastructure development
Market	7.4.2 (Lack of green materials variety)	7	Cost to government/ construction industry/other industries: ***Revenue standards/ norms costs; training costs; construction costs; factories; electricity***	Green materials availability; cheaper prices; safer/ healthier buildings; sustainability promotion; healthier environment & population; increased market size/ share; competition; economy
Government	7.1.1 (Lack of government leadership)	8	Cost to society in: ***Failure to meet policy goals; owe donor money; increased business costs; reputation damage; loss of knowledge; productivity loss***	Revenue increase; healthier environment; healthier population; sustainability promotion; safer buildings; attract businesses
Government	7.1.2 (Lack of green nationwide policy)	8	Cost to government/ construction field/industries in: ***Revenue (incentives)***	Healthier environment; healthier population; economy; design & construction industry

Table 7.1: Barriers, direct costs, and benefits for Burkina Faso (continued)

Barrier Category	Barrier	Difficulty of Implementation	Direct Costs	Benefits
Knowledge	7.3.7 (Limited number of architects)	8	Cost to government in: ***Training; wages; facilities; promotion costs; time/down time from training; books*** Cost to architects in: ***Loss of revenue; reputation***	Better design projects; construction quality; economy; construction industry; sustainability promotion
Cost & risks	7.5.2 (Increased financial risks of green materials)	8	Cost to society due to: ***Legal liability; credit risks; performance failure costs; failure due to lack of experience; certification costs; new materials liability; assessment tools; training; financial risks***	Healthy environment; water and energy savings; increased productivity; operational savings; maintenance savings
Government	7.1.4 (Lack of research funding)	9	Cost to society due to: ***Failure to meet research/ funding goals; loss of revenue; loss of knowledge; increased stress to meet goals***	Healthy environment; healthy population; revenue from patents/ research; business; economy

Source: (Nikyema, 2020)

7.7 Chapter 7 Summary

Chapter 7 discusses the barriers found in this study and proposes recommendations and guidelines driven by the literature, archival data, and the findings of the study. The findings for this chapter answer research question 3. Below are the barriers which were found for the case of Burkina Faso under the government, human, knowledge, market, and cost and risks related barriers.

7.1 Barrier 1: government-related barriers

7.1.1 Lack of leadership of government
7.1.2 Lack of nationwide policy on green design and materials
7.1.3 Lack of green materials definition in Code of Urban Planning and Construction
7.1.4 Lack of research funding for green materials
7.1.5 Lack of/minimal local green materials norms and standards
7.1.6 Administrative delays at CEFAC
7.1.7 High costs of PUH
7.1.8 Lack of access to financing for construction industry

7.2 Barrier 2: human-related barriers

7.2.2 Lack of affordable real estate in urban settings
7.2.3 Negative perceptions of local materials (as not durable)
7.2.4 Negative perceptions of local materials
7.2.5 Lack of awareness of the benefits of green design and materials
7.2.6 Lack of financing for construction for public
7.2.6 Limited users' knowledge about green design and materials

7.3 Barrier 3: knowledge-related barriers

7.3.2 Lack of educational access for design and construction professionals
7.3.3 Lack of financing for education for design and construction professionals
7.3.3 Limited users' knowledge and skills about green design (subcontractors, technicians)
7.3.4 Payment delays for construction projects
7.3.5 Competition with foreign construction firms (large scale projects)
7.3.6 Limited construction professionals' knowledge and skills with green design and materials
7.3.7 Limited number of architects
7.3.8 Minimal knowledge about the role of architects (perceptions of being expensive)

7.3.9 Lack of green building databases and information access venues
7.3.10 Lack of trained media in green design and materials

7.4 Barrier 4: market-related barriers

7.4.1 Limited users' knowledge about green materials and technologies
7.4.2 Lack of green materials variety in the local markets
7.4.3 High cost of labor and materials for local green materials
7.4.4 Lack of/limited green materials and technologies' norms and standards
7.4.5 Lack of training on green materials and technologies

7.5 Barrier 5: cost and risks-related barriers

7.5.1 High costs of green materials and technologies
7.5.2 Fear of increased financial risks associated with green materials and technologies

The path towards sustainability in Burkina will be multi-phase, necessitating both short and long term solutions. The first phase of implementing such guidelines is to rank them in terms of their ease of implementation as it contrasts to their costs and benefits as shown in table 7.1 below.

This dissertation due to its exploratory nature did not try to provide practical action items for implementing the proposed guidelines. Future work will entail translating the proposed guidelines into practice, and this translation will be data driven by the stakeholders to estimate the impact of these implementations.

The scale used in table 7.1 ranges from **0 (less difficult to implement) to 10 (most difficult to implement)**. This scale although subjective, was driven by the data gathered in this dissertation, such as the repeating themes revealed by the different stakeholders.

CHAPTER EIGHT

CONCLUSION

This chapter summarizes the findings of the study and present the conclusions, recommendations and the suggestion for further research.

8.1 Summary

The purpose for this study was to investigate the barriers to the adoption of green design and green materials and technologies in developing countries, using the case of Burkina Faso. The input of all concerned stakeholders within the design and construction industry in Burkina Faso were invited, and architects, contractors, educators, engineers, members of the government who work in the Ministry of Architecture and CEFAC, material suppliers, planners, and researchers were sought. The findings of this study are presented based on the research questions. The research questions investigated in this study were:

- **RQ1**. What are the barriers to green design and green materials implementation in Burkina Faso?
- **RQ2**. Do developing countries lag behind developed countries in the pursuit of green design using the cases of Burkina Faso and the United States of America?
- **RQ3.** What are the lessons and guidelines learned from this study? How can they be disseminated to facilitate green design and construction?

The study adopted a sequential exploratory mixed method design with three consecutive data collecting phases (online Qualtrics questionnaire, semi-structured interviews, comparative analysis).

This study found that the majority of the design and construction professionals were university graduates, (majority holding Master's Degrees and Bachelor degrees), and the

majority of them had 20+ years of experience. They worked primarily in medium to small companies, and their projects were usually residential and commercial construction projects.

The study established that the majority of participants defined themselves as being somewhat knowledgeable about green design and construction (38.07%), followed by very knowledgeable (29.35%).

Design and construction professionals worked primarily with simpler green materials and technologies such as green roofs (defined primarily as vernacular straw roofs), natural light and ventilation, passive design techniques, and green materials such as (adobe, BTC, BLT, cut stones) which are local and specific to Burkina. The majority of participants felt that green buildings had an advantage over traditional buildings in environmental benefits, occupants' health and comfort, and operating costs.

The biggest challenges to the implementation of green design and construction in Burkina Faso were client demand, lack of stakeholder awareness, lack of green technologies, and lack of stakeholder involvement.

The most important considerations when considering green design and construction in Burkina Faso were minimizing construction & operating costs, affordable construction, environmental preservation, and cultural heritage.

For **government**-related barriers, participants felt that the low awareness of government entities of green design and construction, lack of government supported practices focused on green design and materials, lack of government supported practices focused on green design and materials, and lack of government supported funding programs for green design and construction were the most prevalent barriers.

For **human**-related barriers, participants felt that the public's low awareness of the benefits of green design and construction, lack of effective initiatives on green design and construction, the public's resistance to change towards green design and construction, and the lack of public demand for green design and materials were the most prevalent barriers.

For **knowledge**-related barriers, participants felt that the lack of education opportunities for design and construction professionals, lack of access to financing for education for design and construction professionals, that there is not enough design and construction professionals knowledgeable about green design and construction, and the limited number of networking venues focused on green design and technologies, were the most prevalent barriers.

For **market**-related barriers, participants felt that the lack of green technologies available in the markets and the lack of supply networks for green technologies were the most prevalent barriers.

For **cost and risk**-related barriers, participants felt that the fear of increased financial risks associated with sustainable technologies, the resistance to change and innovation creates an increased fear of risk associated with green technologies, and the uncertainty about the performance green technologies were the most prevalent barriers.

Overall, the majority of the total participants saw the future was **positive**. This study found a **total of 31 barriers** with **14 barriers specific** to Burkina Faso itself.

In conclusion**,** participants felt that the government should be the driving force in terms of pushing policies for green design and green materials implementation in Burkina Faso, as well as be the leader in building with green design and local green materials

The qualitative phase found that the government, design professionals (especially architects and engineers), and clients were the major stakeholders who had the most influenced

the degree of sustainability in the construction industry in the country. Material suppliers, design professionals (especially architects and engineers), and local authorities had the most influence on the promotion of green materials and technologies in Burkina. This study found that the construction industry in Burkina Faso was not performing efficiently in terms of sustainability. These findings suggest that the construction industry requires drastic change in order to actualize sustainable construction in the country.

This study found that green technology not only involved local materials and equipment, but also included knowledge and skills. The majority of participants felt that there was a need to combine indigenous green materials (both in their traditional forms and re-imagined) as well as more modern green building technologies in order to most effectively achieve sustainable construction in Burkina Faso.

But in order to make their adoption more effective, work needs to be done in order to increase their quality and availability on the markets in Burkina Faso. If the population of Burkina Faso is not shown that local green materials and technologies can be competitively priced compared to non-green materials, and that they can be as durable as building with non-green materials such as concrete, and that local green materials are not materials for the poor, then their adoption will not be as successful in Burkina Faso.

Although studies have found that technology transfer of technologies was highly effective in the adoption of technologies for developing countries, this study found that it was not necessarily the case in Burkina Faso. Participants felt that the case of LOCOMAT (program focused on the development and promotion of local green materials) was a prime example of this. When funding for this project ended, the technologies developed were not necessarily transferred to the local population. Therefore, a more participatory development and promotion

of local green materials and technologies, involving all stakeholders in the public and private sectors would be more beneficial in the case of Burkina Faso.

The study established that different stakeholders influenced the adoption of green design and green materials in different ways. These include:

1. **Government (**National, Regional/Provincial, Local/Municipal)

Government policies are necessary to implement sustainable projects. Government entities often look towards the corporate and professional bodies to help them craft more efficient policies, as such their knowledge of sustainable design practices is low-medium. However, the impact of their policies on green buildings and infrastructures can either be positive or negative, as such, all other stakeholders should do their part to inform them of their needs

The government influence the adoption of green design and green materials in terms of policies, regulatory programs, incentives such as taxes and credits, education, green construction projects, institutional development, and investments.

2. **Design and construction professionals**

These members often go through formal and intense training on green design practices, making their knowledge of them as high. During the design and implementation process, their job is to guide their clients, corporate, and government entities about sustainability practices as well as translate their clients' needs into concrete projects. As such, they can be considered as sustainability leaders.

3. **Private sector businesses (**Transnational, National, Local/micro-enterprises)

They influence the adoption of green materials and technologies via their capital investments, technologies' research, development, and commercialization, development of

marketing skills and capabilities, lending and or credit policies, and technology selection in terms of distributors and the end users.

4. **Financial and international development institutions** (Multilateral banks**,** aid agencies, United Nations World Trade Organization)

These institutions influence green materials and technology adoption via research and development, research funding, recommendations of policies, technology commercialization, and technology transfer.

5. **Media and community groups** (NGOs, community groups, newspapers, radio, television, schools)

These institutions influence the adoption of green materials and technologies via promotion and advertising, educational and community programs, lobbying for community resources, and information dissemination especially to the consumers.

6. **Individual consumers** (Rural, Urban)

Rural and urban consumers influence green materials and technologies adoption via their selection of these materials, their purchases, as well as learning and applying knowledge of these materials and technologies in their environments.

Some of the most prevalent key barriers which had an impact on green materials and technologies transfer found in this study were users and design and construction professionals' bad perception of green materials and technologies, lack of understanding of the properties of green materials and technologies, the perceived risk of using these new materials and technologies, the difficulty of measuring effectiveness without norms and standards, and the high costs of new materials and technologies.

In terms of consumers' barriers to green materials and technologies implementations, this study found negative experiences and memories about local green material being transferred into a reluctance to take risks with such materials, their unfamiliarity with such materials' properties leading to bad applications in their usage, and the current high costs of green materials due to importation costs, minimal availability on the market, and limited supply chains. These negative perceptions could be positively influenced via media and community groups' promotion of these materials, educational and community programs, and seeing model projects at the governmental scale and in luxury neighborhoods.

Research based barriers include the low investment in education, training, research and development especially for consumers and design professionals, the poor linkage between research and application of green materials and technologies, the lack of dissemination of research findings.

The predominant artisanal extraction and manufacturing of local green materials, their minimal mechanized industrialization, and the low number of trained masons, the non-standardized and variable quality of local materials, and their high costs as compared to non-green materials, have a significant impact on the adoption of green design and green materials in Burkina Faso.

Although for some materials (BTC and BLT) have had norms and standards established, many other local green materials such as granite have not sufficiently been researched. Without a way to document their properties and performance, they will still be considered as having high risk and low desirability, and therefore they will not be successfully used. Financial institutions regard houses built with local green materials as less valuable than those built with concrete cement and temporary dwellings. They do not accept them as collateral, making such houses less

desirable for the population. With more promotion of such materials, they might become the norm, which might change their designation as temporary dwellings.

The findings show that there is a need for more research, development and promotion, and training of local green design and construction professionals, as they had a significant impact on the adoption of green design and green materials in Burkina Faso.

Among the recommendations to promote green materials and technologies in Burkina Faso, the need for the involvement of the government through infrastructure development, the need for policies and regulations focused on green materials implementation, the implementation of existing policies and regulations, the dissemination of these materials and technologies via culturally appropriate and technologically sound sustainable construction projects, the dissemination of existing research on green materials and technologies and their increased industrialization and distribution on the market, were proposed.

8.2 Study limitation

A review of studies on barriers to the adoption of green design and green materials showed that few of these studies were carried out in developing countries as compared to developed countries. When they occurred in developing countries, the majority of them occurred in Asia in countries such as China and Malaysia. Even fewer studies focused on Africa, or West Africa where Burkina Faso is located. The 2015 study by Aktas & Ozorhon stressed the importance of country specific studies on barriers to the adoption of green building practices and technologies in order to best identify local solutions to encourage the adoption of green building practices and technologies.

The choice of the case study design in developing countries with few easily accessible digitized databases, and limited experiences with such studies, led to the following limitations.

Few databases were easily accessible on the internet, and the ability to gain access to them depended on the use of gatekeepers. The researcher often encountered suspicion from organizations and stakeholders when contacting them by e-mail or by phone regarding access to the databases or for wanting to use information gained from design and construction professionals in her research, especially for professionals who worked in the government. Due to this, the researcher had to reduce the scope of her study from multiple cases in West Africa, to the one case of Burkina Faso as a representative case in West Africa with multiple embedded units of analysis.

Gaining access to databases on the stakeholders' information was also a limitation, necessitating snowball and convenience sampling, or procuring access to the databases via gatekeepers. The pool of potential design and construction professionals was limited since not all design and construction professionals in Burkina Faso are registered with professional organizations such as the Order of Architects of Burkina Faso or the Order of Engineers of Burkina Faso. But without any other online databases such as a yellow book of design and construction professionals, the researcher had to limit herself to this small pool of participants.

The researcher also found that many potential participants had not updated their e-mail within the databases, or they found the e-mail suspicious as the researcher was contacting them from an American university, and the majority of participants felt more comfortable with phone or in person contact. Due to this, they responded more readily to the paper version of the study or preferred to orally relate their answers to the researcher to transcribe.

Conducting the questionnaire portion over the phone or conducting the in person or over the phone interviews with the design and construction professionals involved adherence to the case study protocol, which on one hand helped make this study replicable, but on the other hand,

was also time consuming due to having to schedule them around the participants' busy schedules. However, this limitation was overcome via constant follow-ups, and respondents agreeing to over the phone interviews when in person interviews were not possible.

Despite these limitations, this study provided rich findings which will add to the existing body of knowledge, as well as guiding the researcher towards areas of future research.

8.3 Study significance

The adoption of green design and green materials and technology is **projected to continue growing** in Burkina Faso, and in Africa at large. This study makes the following contributions:

- **Policy:** It has identified barriers to the adoption of green design, and green materials and technologies in Burkina Faso. Knowledge on the barriers to the adoption is the first step in providing guidelines and policy to foster environmentally sustainable design practices in Burkina Faso, and West Africa in general. Future work will entail translating the proposed guidelines of this study into practice.
- **Practice:** This study will encourage design and construction professionals to be more aware of local green materials and technologies and to promote their adoption in the design and construction fields
- **Future Research:** This study will influence further empirical studies on barriers to the adoption of green design and green materials in developing countries.

8.4 Overall recommendations

This study has identified 31 barriers to the adoption of green design and green materials in Burkina Faso. Based on the study findings and conclusions, the following recommendations are proposed to improve green design and green materials adoption in Burkina Faso.

The majority of these recommendations will require the government to be the driving force behind their implementation with the help of professional institutions. As highlighted by the existing research and via the findings of this study, all concerned stakeholders in the design and construction industry need to actively participate in these recommendations.

1) The government must play an active role in the design and implementation of an improved agenda of strategies:
    a. Deliberate national funding should be invested to improve research and development on green materials and improvement of these materials which respect the environment and the cultural background of the population. In the process, definitions of green design, green materials, must be normalized.
    b. A review of existing regulatory frameworks should be undertaken to accommodate emerging green technologies.
    c. Exchanges between Burkina Faso and neighboring or other African countries with similarities should be promoted to learn from others and reinforce national policies and strategies
    d. Guidelines on green design and materials should be promulgated to guide the construction industry and its professionals. The guidelines will be based on the findings of the research and development and adapted from the international norms to the national economic and cultural realities of Burkina Faso.

e. Education and training: government policies should guide the curriculum of schools and institutions of the professionals (architects, engineers, masons)
f. Lead by example: Government projects should deliberately be promoting green design and green materials. Building of school infrastructures, government office buildings in urban and rural areas have to be showcasing green design and materials. This will reinforce population positive perception, create and sustain demands for green design and materials.
g. Choosing the appropriate green material and technologies should follow specific policies and guidelines to choose the most appropriate materials and technologies. Burkina Faso has a rich and diverse vernacular architecture, and although there should be an overall policy for the usage of green materials and technologies, it should also detail how to most appropriately use them in each region. The criteria to consider when laying out such policies should include availability, environmental impact, durability, culture, maintenance, and costs.

2) All concerned stakeholders, design and construction professionals, must be committed
   a. to promote construction that are based on green design and using green materials.
   b. To provide clients with clear costs and benefits on using green materials and technologies and hence contribute to public education.
   c. In the process of their works they are in a better position to advice governments on the implementation of policies and guidelines and necessary amendments
3) Research institutes and higher education institutions must partner with government and with design and construction professionals:

a. in research and development of local green materials and technologies, and the publication and dissemination of the findings.
b. Development of norms and standards by testing the performance and effectiveness of those materials.
c. Providing relevant courses and training on green design, local green materials and technologies; this include the promotion of emerging green materials and technologies.

8.5 Recommendations for future research

Barriers to the adoption of green building materials and technologies has not been widely researched in Burkina Faso and in West Africa in general. Based on the findings of this study, there are a few areas of further research.

1) Although this study allowed for the collecting of perspectives from a variety of stakeholders in the design and construction sector in Burkina Faso (Architects, contractors, educators, engineers, engineers, government, materials suppliers, planners, and researchers), some of the samples within the groups were small. Therefore, further research could allow to the researcher to spend more time in the field, and based on the limitations of this study, she would be able to format her study further to target those stakeholders who did not participate as much as compared to other stakeholder groups.
2) Other concerned stakeholders such as members of the private sector, financial and international development institutions, members of the media and community groups, and individual customers were not part of the study due to the limitations of the scope

of this study. However, as concerned stakeholders, their voices should be heard, and further research would allow for this.

3) Although this study assumes that research findings of this study are applicable for similar countries in West Africa, in further research, the researcher would like to go in the field in other countries in West Africa in order to get the perspectives of other design and construction professionals in West Africa.
4) This research can be said to have investigated barriers to green design and green materials implementation from the perspective of the formal sector, since the participants were members of professional organizations. However, the informal sector plays a large role in the design and construction sector in Burkina Faso, therefore further research is needed to investigate their role and contribution to the design and construction industry, and their perspectives and uses of local green materials and technologies.
5) This dissertation due to its exploratory nature did not try to provide practical action items for implementing the proposed guidelines. Future work will entail translating the proposed guidelines into practice, and this translation will be data driven by the stakeholder to estimate the impact of these implementations.

8.6 Dissemination of research findings

Part of this dissertation was presented at the SBE19 Thessaloniki conference and via the following paper:

Nikyema, G. A., Blouin, Y.V. (2019). Barriers to the adoption of green building materials and technologies in developing countries: The case of Burkina Faso. Thessaloniki, Book of Abstracts (2019), pg. 31.

Results of this dissertation will be shared via papers and conferences. Another important dissemination component will be to share the findings of this dissertation with the government administration of Burkina Faso in the hopes that it will help guide future sustainable development plans, as well participate in the promotion of adoption of green materials and technologies in Burkina Faso.

Future research which could be done in conjunction with the government administration of Burkina Faso would be to translate the proposed guidelines of this dissertation into practical applications and solutions which will be data driven by the concerned stakeholders in order to estimate and implement these guidelines into action.

Overall, promoting sustainability must be made part of the political agenda of Burkina Faso, if it wants to mitigate rising environmental problems, the forecasted large impact of climate change on developing countries including Burkina Faso even though their carbon footprint is currently smaller than developed countries, and the forecasted exploding population in Africa and Burkina Faso with 60% of the population living in ageing urban settings by 2030 if new urban plans are not implemented.

Africa and Burkina Faso have the potential to mitigate these effects through strong policy and utilization of green design and green materials in design and construction projects. Burkina Faso can look towards other African countries who have made remarkable strive on the road towards sustainability, such as Ethiopia and Rwanda.

As interviewee #7 (architect) said *" ...the government should see through this a new possibility that will lead the population to live better by choosing sustainable construction, reorient the policy, take laws; to give facilities and to lead people little by little towards sustainable constructions. The most essential element is to set an example".*

APPENDICES

Appendix A

Information about Being in a Research Study
Clemson University

Sustainability in West Africa and the United States of America. : A Comparison of Barriers to Green Design and Green Materials Implementation in Burkina Faso

KEY INFORMATION ABOUT THE RESEARCH STUDY

Voluntary Consent: Dr. Vincent Blouin, along with Goulwendin Alexia Nikyema are inviting you to take part in a research study. Dr. Vincent Blouin is a professor at Clemson University in Clemson, South Carolina, United States of America. Goulwendin Alexia Nikyema is a student in the Planning, Design and Built Environment program at Clemson University, running this study with the help of Dr. Vincent Blouin.

You may choose not to take part and you may choose to stop taking part at any time. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study.

Alternative to Participation: Participation is voluntary and the only alternative is to not participate.

Study Purpose: The purpose of this research is to discover and understand the barriers to green design and green materials implementation in West Africa. Despite increases in sustainability locally and globally, there still exist barriers which impede its widespread propagation.

Activities and Procedures: Your part in the study will be to report on your perceptions of those barriers to green design and construction. Via an online questionnaire and a follow-up over the phone semi-structured interview, you will share your perceptions, thoughts, and experiences towards those barriers in your country, as well as suggestions on how to improve green design and construction in your country and globally.

Participation Time: The questionnaire will take 30 minutes, while the interview will take 30-60 minutes. Therefore, it will take you about 60-90 minutes of total participation to be in this study.

Risks and Discomforts: We do not know of any risk or discomforts to you in this study. As a participant, you will be allowed to not answer any question in the questionnaire and semi-structured interview which make you uncomfortable.

Possible Benefits: You will not receive any personal benefits beyond your valuable input assisting the study, as well as possibly benefiting green design and construction professionals and local communities pursuing green design implementation.

AUDIO/VIDEO RECORDING AND PHOTOGRAPHS

Participants who have indicated in the questionnaire that they want to participate in the follow-up phone interview will be contacted by the co-investigator via a phone call or e-mail. At the beginning of the individual interview, the co-investigator will re-iterate to the participant the

purpose of the study, explain the measures which will be taken to protect the identity and confidentiality of the participants, and ask their permission to be audio recorded.

After getting the oral confirmation from the participants, the co-investigator will start the interview regarding their perceptions on barriers to green design and green materials implementation in West Africa.

Participants will be assigned a numerical identifier for the questionnaire as well as a fictious name for the interview in order to protect their identify. Only the transcripts of the recorded data will be used in the study, and the recorded data will not be used publicly.

EQUIPMENT AND DEVICES THAT WILL BE USED IN RESEARCH STUDY

An encrypted Qualtrics questionnaire link will be used for the questionnaire part of the study, and each participant will receive an individual link to the questionnaire. For the interview portion of the study, the co-investigator will use her personal cell phone, Viber, and What's App (based on participants' preference) to call the participants and a digital audio recorder to record the interviews.

All data from this study (questionnaire results, audio recordings, and transcripts of audio recordings) will be strictly kept in the co-investigator's computer and back up hard drive which are both equipped with passwords. When not in use, they will be kept in a locked drawer of the co-investigator's desk within her locked office.

No one beside the PI and the co-investigator will be allowed to see the participants' answers.

PROTECTION OF PRIVACY AND CONFIDENTIALITY

The results of this study may be published in scientific journals, professional publications, or educational presentations.

Identifiable information collected during the study will be removed and the de-identified information could be used for future research studies or distributed to another investigator for future research studies without additional informed consent from the participants or legally authorized representative.

CONTACT INFORMATION

If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC's toll-free number, 866-297-3071. The Clemson IRB will not be able to answer some study-specific questions. However, you may contact the Clemson IRB if the research staff cannot be reached or if you wish to speak with someone other than the research staff.

If you have any study related questions or if any problems arise, please contact Goulwendin Alexia Nikyema at Clemson University

CONSENT

By participating in the study, you indicate that you have read the information written above, been allowed to ask any questions, and you are voluntarily choosing to take part in this research. You do not give up any legal rights by taking part in this research study.

A copy of this form will be given to you.

Appendix B

Qualtrics Questionnaire

Informed Consent

My name is Goulwendin Alexia Nikyema. I am a PhD candidate from Burkina Faso studying at Clemson University, in Clemson, South Carolina, United States of America. My dissertation examines barriers to green design and green materials implementation in Burkina Faso. You have been selected as a leader in a position to report on your perceptions of barriers to green design and construction. The objective of this questionnaire is to understand your perceptions, thoughts, and experiences towards this topic, as well as your suggestions on how to improve green design and construction. As such, your input and experiences are critical to the success of this study. Please be assured that your responses will be kept completely confidential.

The questionnaire should take you around **30 minutes** to complete. Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice. If you would like to contact the Principal Investigator in the study to discuss this research, please e-mail Goulwendin Alexia Nikyema at gnikyem@clemson.edu. By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason. Please note that this questionnaire will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

○ I CONSENT, begin questionnaire

○ I do NOT CONSENT, end questionnaire

I: Introductory Questions

Q1. How many architectural related employees (full-time and part-time) does your company employ?

☐ 1 to 4 employees
☐ 5 to 9 employees
☐ 10 to 19 employees
☐ 20 to 99 employees
☐ 100 employees or more

Q2. What types of buildings do you or your firm work on in general? (*Please mark all that apply).*

☐ Residential (single, multi-family)
☐ Commercial buildings (e.g. offices, restaurants, retail stores, hotels, etc.)
☐ Governmental buildings (e.g. city halls, courthouses, embassies, etc.)
☐ Educational buildings (e.g. schools, universities, libraries, etc.)
☐ Other (please specify): ……

Q3. How knowledgeable are you about green design and construction? (Drop down menu)

1. Extremely knowledgeable 2. Very knowledgeable 3. Somewhat knowledgeable 4. Not very knowledgeable 5. Not at all knowledgeable

Q4. How often do you incorporate the following green technologies in your projects?

	Always use	Frequently use	Sometimes use	Rarely use	Never use
Green roofs					
Natural light					
Natural Ventilation					
Passive design					
Reduce energy consumption (e.g. low-energy, zero-energy etc.)					
Renewable energy sources (e.g. solar, wind, geothermal etc.)					
Smart appliances and energy efficient appliances					
Sustainable Materials (e.g. biodegradable, locally sourced, recycled, low VOC, smart glass etc.)					
Water treatment/conservation (e.g. Rainwater collection)					
Waste reduction					

Others ……

II: General Perceptions about Green Buildings

Q5. Rate how much you agree that green buildings have an advantage over traditional buildings in the following categories.

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
Building performance					

Environmental benefits					
Design & Construction costs					
Operating Costs					
Durability					
Marketability					
Occupants' Health and comfort					

Others ……

Q6. Rate to what degree you agree that the following aspects pose a challenge in the implementation of green design and construction in your country.

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
Lack of stakeholder awareness					
Lack of stakeholder involvement					
Lack of adequate policies					
Lack of green technologies					
Lack of technical knowhow					
Client demand					

Others ……

Q7. How important are the following aspects when considering green design and construction in your country?

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
Affordable construction					
Cultural heritage					
Cutting edge design and innovation					

Environmental preservation					
Minimizing construction and operating costs					
Minimizing payback period					
Prestige					

Others ……

III: Role of the government in green building practices.

Q8. Rate how much you agree with the following statements concerning government influence in green design and construction in your country.

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
Government entities have a low awareness of green design and construction.					
There is a lack of government supported practices focused on green design and construction.					
There is a lack of government supported programs (ex. training, education programs etc. concerning green design					

and construction.					
Green design and construction standards are not adapted to fit local needs.					
There is a lack of government supported funding programs (ex. tax incentives, funding) focused on green design and construction.					
There is a high degree of international donors participation in green design and construction.					

Q9. Please list any other governmental related barriers to green design and construction.
……
……
……

IV: Human Barriers to Green Design and Construction.

Q10. Rate how much you agree with the following statements concerning human related barriers to green design and construction in your country.

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
The public has a low awareness of the benefits of green design and construction.					
There is a lack of effective educational initiatives on green design and construction geared towards the public.					
There is resistance to change on the part of the public towards green design and construction.					
The public fears losing their cultural identity due to green design and construction being chosen instead of traditional design and construction methods. .					

There is a lack of demand from the public for green design and construction.					

Q11. Please list any other human related barriers to green design and construction.
……
……
……

V: Knowledge Related Barriers to Green Design and Construction.

Q12. Rate how much you agree with the following statements concerning professional knowledge related barriers to green design and construction in your country.

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
There is a lack of education opportunities (government supported or private) for design and construction professionals.					
There is a lack of access to funding opportunities for education (formal and informal) for design and construction professionals.					
There are not enough design and construction					

professionals knowledgeable about green design and construction.					
There is a high degree of participation of international design firms in the country.					
There is a high degree of participation of international construction firms in the country.					
There are limited networking venues on green design and technologies (e.g. conferences,					

Q13. Please list any other knowledge related barriers to green design and construction.
……
……
……

VI: Market Related Barriers to Green Design and Construction

Q14. Rate how much you agree with the following statements concerning market related forces impacting the decision-making process related to green design and construction in your country.

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know

There is a lack of green technologies available in the markets in the country.					
There is a lack of supply networks for green technologies in the country.					
Design and construction markets are generally resistant to change and innovation.					

Q15. Please list any other Market-related barriers to green design and construction.
……
……
……

VII: Cost and Risk Related Barriers to Green Design and Construction

Q16. Rate how much you agree with the following statements regarding the level of influence that cost and risk-related barriers have on the following statements regarding green design and construction in your country.

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
There is a concern for financial risks and increased costs associated with					

green technologies.					
Resistance to change and innovation in the design and construction markets create an increased fear of risk associated with green technologies.					
Uncertainty about the performance of existing and/or emerging green technologies has an impact on the adoption and implementation of green design and construction.					
Fear of litigation due to existing and/or emerging green technologies' failures has an impact on the adoption and implementation of green design and construction.					

Q17. Please list any other cost and risk-related barriers and to green design and construction.
……

……
……

VIII: Final Thoughts

Q18. What do you foresee is the future of green design in your country?
……
……
……

Q19. What do you think is the role of the media in promoting green design and construction in your country?
……
……
……

Q20. Please provide any additional factors influencing barriers to green design and construction.
……
……
……

Q21. Please provide any additional factors influencing motivators to green design and construction.
……
……
……

IX. Respondent Biographical Information:

Q22. Please state your years of experience as a design or construction professional/

- ☐ 0 to 5 years
- ☐ 6 to 10 years
- ☐ 11 to 15 years
- ☐ 16 to 20 years
- ☐ 20+ years

Q23. Please state the country you work in primarily.

Q24. Please state your Occupation/Job Title.

Q25. Please state your formal education level.

- ☐ Diploma/technical degree
- ☐ Bachelor degree
- ☐ Master degree
- ☐ PhD degree

Thank you for your participation in this questionnaire.

Please indicate if you would be interested in participating in a follow-up 30-minute interview by phone regarding the barriers to green design and green materials implementation in Burkina Faso. Your name will not appear in the final transcripts of the interviews.

If yes, please enter your name and e-mail below.
Name:……
E-mail address:……
If no, questionnaire will close.

Appendix C

Interview Guide
Clemson University

Sustainability in West Africa and the United States of America. : A Comparison of Barriers to Green Design and Green Materials Implementation in Burkina Faso

Supplies

- Information consent form
- Notebook and pen
- Voice recording device

Preparation

- Be well rested
- Be open and ready to listen
- Ask questions to engage participant in sharing his/her perceptions regarding his/her experiences with sustainable projects and green materials in his/her country.

Setting up the Interview

- Take detailed field notes
- Make a note during the interview of: participant's openness, willingness to share, tone, attitudes towards questions, atmosphere etc. and modify the questions accordingly.
- Set up and make sure the recording device works in order to record the interview.

Next Steps

- Thank participant
- Explain the research
- Read out the information consent form to the participant
- Ask the participant if he/she is willing to be recorded.
- Ask the participant if he/she understands the information consent form or has any questions
- Get his/her verbal agreement that he/she is willing to be interviewed

Information to Be Obtained

- What sustainability practices have been adopted by the participant and/or his/her organization and why?

- What mechanisms are in place in his/her country to support sustainable projects and green materials implementation
- What barriers exist in his/her country which hinder or promote green design and green materials implementation in his/her country.
- What is the future of green design and construction in his/her country?

Interview Protocol Form
Clemson University

Sustainability in West Africa and the United States of America. : A Comparison of Barriers to Green Design and Green Materials Implementation in Burkina Faso

Interview Protocol

Location: _____

Interviewee (Name and Title):_____

Interviewer:_____

Date and Time: _____

Introductory Protocol and Consent

My name is Goulwendin Alexia Nikyema, and I am conducting research on barriers to green design and green materials implementation in Burkina Faso. You have been selected as a leader in a position to report on your perception of barriers to green design and construction. The objective of this interview is to delve deeper into your perceptions, thoughts, and experiences towards barriers to green design and construction, as well as your suggestions on how to improve sustainability in the built environment. Your participation in this interview is the second phase of this research, and you have indicated in the online questionnaire during the first phase that you are willing to be participate in a more in-depth interview.

This informal interview will last between 30-60 minutes. Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice. This research has no known risks. Your valuable input is appreciated and will assist both sustainability professionals and local communities in their pursuits to sustain environmental, economic, and societal resources.

Please know that I will do everything possible to protect your privacy. All notes and audio recordings will be stored in a locked and secure location. Would it be all right if I audiotaped our interview? Saying no to audio recording will have no effect on the interview. Additionally, you may choose not to answer any questions. Do you have any questions before we get started?

A) Introductory questions:

Icebreaker: You have stated in the earlier questionnaire that you have worked x___ years in this position? Please elaborate on your specific role.

1) Can you tell me about your company have a clear policy on sustainability? Or please elaborate on your company's policy on sustainability?

2a) You mentioned this significant sustainable project that you worked on in your questionnaire, please elaborate on what this project meant to you as a designer.

2b) OR, have you worked on a sustainable project? Why do you think that you or your company have worked with few/ not worked with any non-traditional green materials?

3) You stated that you had this_____ degree of knowledge on sustainable design. What do you think could improve your knowledge and/or utilization of sustainable design practices in your projects?

4) Who is in charge of researching non-traditional materials? Are employees encouraged to research new materials? Why are more traditional construction materials still more popular than green materials?

2) Questions related to Sustainable Design

5. What do you think are the biggest challenges in the implementation of sustainable design and construction in your country, if any?

Follow up:

- Do you think the concept of sustainable design and construction is important to your country?
- In your opinion, does the construction industry implement the concepts of sustainable design and construction in your country?

6. In your questionnaire you mentioned that these considerations were the most important to sustainable design and construction in your country. Why is that?

7. In your questionnaire you mentioned that these **government related** barriers were the most striking? Please expand on those. Are there any strategies currently in place to mitigate these barriers?

8. In your questionnaire you mentioned that these **human related** barriers were the most striking? Please expand on those. Are there any strategies currently in place to mitigate these barriers?

9. In your questionnaire you mentioned that these **knowledge related** barriers were the most striking? Please expand on those. Are there any strategies currently in place to mitigate these barriers?

10. In your questionnaire you mentioned that these **market related** barriers were the most striking? Please expand on those. Are there any strategies currently in place to mitigate these barriers?

11. In your questionnaire you mentioned that these **cost and risk related** were the most striking? Please expand on those. Are there any strategies currently in place to mitigate these barriers?

12. Are there any other barriers which were not mentioned which you can think of?

3) Questions related to the future of Sustainable Design

13. In your opinion, what does the future hold for environmentally sustainable building design practices in the construction industry? How should the design and construction industry promote sustainable design and construction in your country?

14. What do you think is the role of the media in propagating sustainable design and construction in your country?

A15. Do you have any additional comments on barriers to green design and construction in your country?

Closing statement for all interviewees

Thank you very much for your time and your participation in this interview. Your responses will help further research on barriers to green design and green materials implementation in West Africa. Do you have any further questions that I may answer for you? If not, thank you again for you time.

Appendix D

Table 1. Frequency Table for Government Barrier Questionnaire Responses

	Gov1		Gov2		Gov3	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Agree	35	16.1	70	32.1	59	27.1
Agree	101	46.3	110	50.5	112	51.4
Disagree	59	27.1	27	12.4	32	14.7
Strongly Disagree	15	6.9	3	1.4	4	1.8
I don't Know	8	3.7	8	3.7	11	5

	Gov4		Gov5		Gov6	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Agree	23	10.6	103	47.2	17	7.8
Agree	86	39.4	91	41.7	62	28.4
Disagree	58	26.6	19	8.7	76	34.9
Strongly Disagree	23	10.6	3	1.4	40	18.3
I don't Know	28	12.8	2	0.9	23	10.6

Appendix E

Table 2. Frequency Table for Human Barrier Questionnaire Responses

	Hum1		Hum2		Hum3	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Agree	55	25.2	71	32.6	30	13.8
Agree	143	65.6	121	55.5	52	23.9
Disagree	17	7.8	9	4.1	82	37.6
Strongly Disagree	3	1.4	0	0	43	19.7
I don't Know	0	0	17	7.8	11	5
Total	**218**	**100**	**218**	**100**	**218**	**100**

	Hum4		Hum5	
	Frequency	Percent	Frequency	Percent
Strongly Agree	13	6	47	21.6
Agree	40	18.3	101	46.3
Disagree	55	25.2	55	25.2
Strongly Disagree	87	39.9	12	5.5
I don't Know	23	10.6	3	1.4
Total	**218**	**100**	**218**	**100**

Appendix F

Table 3. Frequency Table for Knowledge Barrier Questionnaire Responses

	Kno1		Kno2		Kno3	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Agree	68	31.2	111	50.9	70	32.1
Agree	119	54.6	101	46.3	99	45.4
Disagree	26	11.9	4	1.8	39	17.9
Strongly Disagree	1	0.5	0	0	2	0.9
I don't Know	4	1.8	2	0.9	8	3.7
Total	**218**	**100**	**218**	**100**	**218**	**100**

	Kno4		Kno5		Kno6	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Agree	14	6.4	9	4.1	49	22.5
Agree	32	14.7	44	20.2	125	57.3
Disagree	83	38.1	85	39.0	25	11.5
Strongly Disagree	66	30.3	57	26.1	6	2.8
I don't Know	23	10.6	23	10.6	13	6.0
Total	**218**	**100**	**218**	**100**	**218**	**100**

Appendix G

Table 4. Frequency Table for Market Barrier Questionnaire Responses

	Mar1		Mar2		Mar3	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Agree	34	15.6	94	43.1	23	10.6
Agree	112	51.4	113	51.8	90	41.3
Disagree	46	21.1	10	4.6	56	25.7
Strongly Disagree	25	11.5	1	0.5	36	16.5
I don't Know	1	0.5	0	0	13	6.0
Total	**218**	**100**	**218**	**100**	**218**	**100**

Appendix H

Table 2. Frequency Table for Cost and Risk Barrier Questionnaire Responses

	Cos1		Cos2		Cos3	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Agree	82	37.6	41	18.8	79	36.2
Agree	121	55.5	77	35.3	84	38.5
Disagree	9	4.1	61	28.0	30	13.8
Strongly Disagree	1	0.5	20	9.2	12	5.5
I don't Know	5	2.3	19	8.7	13	6.0
Total	**218**	**100**	**218**	**100**	**218**	**100**

	Cos	
	Frequency	Percent
Strongly Agree	8	3.7
Agree	33	15.1
Disagree	38	17.4
Strongly Disagree	119	54.6
I don't Know	20	9.2
Total	**218**	**100**

Appendix I

Question 18 Burkina Faso Future Descriptors

Table 5.4: Negative future descriptors (N=46)

Description	Number of respondents
Negative	14
Dark	10
Not very bright	9
Not promising	5
Sad	5
Depressing	2
Bleak	1

Source: (Nikyema, 2019)

Table 5.5: Neutral future descriptors (N=66)

Description	Number of respondents
Neutral	16
Could be better	13
Work in progress	11
Future is not clear	10
Getting better	7
Stagnating	5
Slow	3
Have no choice but to move forward	1

Source: (Nikyema, 2019)

Appendix J

Coding Example From Data Analysis

Characteristic	Sources	References
Understanding Sustainability		
Experience	12	27
Definition of sustainability in Burkina Faso	6	12
History	4	7
Learning	20	5
Memory	13	8
Design and construction roles	3	15
Training	10	8
Local green materials	20	30
Contextual Characteristics		
Culture	4	9
Awareness	10	10
Attitude	6	3
Vernacular architecture	2	4
Local materials	20	30
Public	14	10
Needs	1	5
Priorities	4	6
Sustainability Barriers		
Government	15	20
Human	11	13
Knowledge	8	8
Market	9	7
Cost and risks	12	3
Financing	19	17
Poverty	5	8
Recommendations		
Best practice	10	12
Cost savings	18	7
Technology	4	6
Research	16	11
Green materials	18	23
Norms and legislations	5	14
Clients	2	7

Source: (Nikyema, 2020)

Appendix K

Example of subcategories/Nodes

Burkina Faso	51
Financing	46
Learning from the past	42
Sustainability mechanisms	41
Sustainability barriers	39
Government influence	37
Design and construction groups	33
Money	32
Future	24
Profitability	23
Responsibility	21
Beliefs	18
Definition of sustainability	17
Definition green materials in Burkina Faso	15
Failed projects	14
Environmental stewardship	13
Green materials and technology product	13
Sustainability education	13
Social housing	13
Education	13
Type of construction	12
Bad memories	12
Costs of construction	12
Number of years with company	12
Design industry	11
Construction industry	10
Green roofs	10
Environment	10
Cost of green materials	10
Stagnating	10
Experience	9
Solar energy	8
Green markets	8

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