University of the Witwatersrand. School of Architecture and Planning.

Policy responses to the escalating environmental impacts of the construction materials sector in Uganda. Case studies of burnt clay bricks and cement.

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand in partial fulfilment of the requirements for the degree of Masters of Architecture in Sustainable and Energy Efficient Cities.

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Declaration

I declare that this research report is my own unaided work. It is being submitted for the Degree of Masters of Architecture in Sustainable and Energy Efficient Cities to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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Abstract

The last two decades have witnessed the steady growth of the construction industry in Uganda and with it the increase in demand and supply of construction materials to support the industry. However, this trend in the two industries has been marred with escalating environmental impacts and high embodied energy along their life cycle processes. In addition, effective policies have not co-evolved fast enough towards facilitating the sustainable growth of the two sectors. This study aimed to investigate this scenario based on a qualitative study approach focusing on cement and burnt clay bricks as the two most extensively used and locally produced construction materials in Uganda. The study applies the concept of life cycle impact analysis based on the systems and processes adopted by two case study producers (Hima Cement Limited for cement and Butende Brick Works for burnt clay bricks) in order to assess the environmental impacts of the materials. This is followed by an assessment of how the respective policies have evolved towards ensuring the sustainable cradle to gate processes for the sector. Primary data from interviews and direct field observations were complemented with secondary data from statistics archives, policy documents, print media, and published academic articles on both sectors.

The study finds that the construction industry's contribution to the GDP grew from 800 million to 41 billion shillings over the 2001 to 2016 period while the respective production of brick and cement products grew by 94% over the same period. The accompanying environmental impacts findings indicate high GHG and particulate matter emissions, wastes and ecological habitat degradation as the critical ones for cement and high levels of deforestation as well as ecological habitat degradation for the bricks. Additionally, the data did not reveal any coordinated efforts towards incentivising the emergence and promotion of alternative materials. On the co-evolution of responsive policies, the study finds a pattern of fragmented and incoherently executed policy frameworks in spite of the reported evidence of the escalating negative impacts. The key recommendations include more systematic reporting and tracking of related growth and impacts, co-evolution of more coherent and systematic policy response, incentivising emergence of alternative materials as well as improved efficiencies across both production and use-disposal stages of both materials.

Key words: Uganda, construction materials sector, co-evolution of policies, burnt clay bricks, cement, life cycle impact assessment, embodied energy.

Dedicated to my late father Humphreys Wafula Fulani.

May you live on through my dreams and successes.

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ADA	Africa Development Associates
BBW	Butende Brick Works
BS EN	British adoption of European Standard
CO_2	Carbon Dioxide
EE	Embodied Energy
GDP	Gross Domestic Product
GHG	Greenhouse gas
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LCI	Life Cycle Inventory
MEMD	Ministry of Energy and Mineral Development
MoWT	Ministry of Transport and Works
MTIC	Ministry of Trade Industry and Cooperatives
MUK	Makerere University Kampala
NAPE	National Association of Professional Environmentalists
NCCP	National Climate Change Policy
NDP	National Development Plan
NEA	National Environment Act
NEMA	National Environment Management Agency
NEMP	National Environment Management Act
NFP	National Forestry Policy
NIP	National Industrial Policy
NISSP	National Industrial Sector Strategic Plan
NO_X	Nitrogen Oxide

NSQP	National Standards and Quality Policy
OECD	Organisation of Economic Co-operation and Development
SAPs	Structural Adjustment Programs
SEG-MUK	Society of Economic Geologists- Makerere University Kampala
SMM	Sustainable Materials Management
SO_2	Sulphur Oxide
UBOS	Uganda Bureau of Statistics
UIA	Uganda Investment Authority
UN	United Nations
UNDP	United Nations Development Program
UWA	Uganda Wildlife Act

Chapter 1 Introduction and motivation for the study

1.1 Overview

Following the political stability experienced since the late 1980s, Uganda's economy has steadily grown over the years guided by enabling government policies and incentives for private sector participation in economic development. Most of these policies supported the liberalisation of the economy through a massive privatisation drive and the attraction of both local and foreign investors in order to revive the economy. Among the key industries that benefited and grew as a result of these initiatives was the construction industry, so much so that it contributed to 7.3% of the total GDP in 2016 and grew by 6.3% between 2015 and 2016 (Uganda Bureau of Statistics (UBOS), 2016). Much of its growth has been attributed to the steady economic growth and high levels of urbanisation, accompanied by massive public investment in infrastructure as well as private and public investment in housing, institutional, commercial and industrial buildings. Consequently, this growth has influenced the increase in demand, production and consumption of construction materials and thus the steady growth of the construction materials sector in tandem within the last two decades.

According to UBOS (2016), cement, clay bricks and iron sheets are the predominantly used construction materials in Uganda for flooring, walling and roofing respectively especially in the urban areas. About 67% of dwellings have brick walls and 59% have cement floors. Other commonly used materials, especially in the rural areas, are thatched roofs, mud and poles as well as earth flooring. However, Hashemi, et al (2015: 7866) posit that, "low quality, high waste and energy intensive production methods as well as excessive soil extraction and deforestation" have characterised the construction industry and the construction materials sector and thus contributed to negative impacts on the environment. It was also noted that the sector lacks comprehensive data on its life cycle processes and inventories to allow for its effective governance.

This trend is reflected in the nature of policies and regulations that have been drafted or not yet drafted in response to the increasing environmental impacts of the construction materials sector and the construction industry at large. The UN Habitat (2010:87) argues that there are "weak, poorly enforced and not easily accessible" policies and regulations on materials and standards in Uganda. The policies that are relatively enforced are mainly the conventional ones focusing on the structural as well as health and safety properties of construction materials but not yet diversified to cover emerging issues such as embodied energy, thermal properties and similarly related sustainability requirements and standards.

On the overall, the government shows a commitment to promoting sustainable development through its National Development Plan (NDP) I and II and the National Climate Change Policy. However, the processes of streamlining the different regulations and standards to ensure integrated sector-wide sustainable growth, especially of high impact sectors like the construction materials sector, have been largely slow and happening in an ad hoc manner. It is important to note that the responsive adaption of national policies, building codes and specifications to the current growth trend of the construction materials sector would go a long way towards addressing resource efficiency, low embodied energy and environmental sustainability of buildings and the built environment in general.

1.2 Context of the construction materials sector in Uganda.

Uganda significantly benefits from the existence of naturally occurring limestone and clay deposits which have contributed to its materials and construction industry. The limestone deposits occur in Hima, Tororo and the recently explored deposits at Napak in Moroto District and Toror in Kotido District (Karamoja region to the North) (see Figure 1.1). The deposits at Tororo and Hima have largely provided the raw materials for Uganda's Portland cement industry since its inception in 1953. From the UBOS statistical abstract (2016), the annual production of limestone since 2011 has fluctuated over the years with the largest production recorded being approximately 1.2 Mta in 2016 which reflected an increase of about 22% from 2015 (see Table 2). The increase in limestone production in 2016 is due to the start in exploration of the new limestone deposits in Karamoja region. The other minerals used in the industry that are available locally are pozollana, iron ore and kaolin, among others (see Table 1.1).

Table 1.1. Annual mineral production in Uganda (Tonnes). Source Uganda Bureau of statistics (UBOS), 2006:196.

Mineral	2011	2012	2013	2014	2015	2016
Limestone	932,348.2	936,264.0	922,371.8	1,090,240.3	979,660.1	1,203,074
Pozollana	690,910.6	650,323.8	623,470.6	742,423.1	686,563.8	846,604
Kaolin		42,886	43,875	46,286	34,697	45,909

Iron ore		4,431	2,282	41,959	9,000	2,163

Furthermore, the existence of a vast clay resource base as well as the “favourable climatic and environmental conditions and the availability of labour” have also largely enabled the thriving of the burnt clay brick industry in Uganda (Africa Development Associates (ADA), 2017:4). The deposits occur mainly in the areas around L. Nalubaale and L. Kyoga basins as well as around L. Albert (see Figure 1.1) and have provided the essential raw materials to support the clay materials industry where products such as roofing tiles, facing bricks, ‘max spans’, pottery and ceramics are made.

Uganda’s cement market started with a sole company, Uganda Cement Industries, which was a government parastatal set up in 1953, nine years before the country’s independence. As part of its privatisation by the government in December 1994, it was split into Hima Cement Uganda and Tororo Cement which were separately owned by different investors. The production capacity of Uganda Cement Industries then was a paltry 70,000 tonnes of cement per annum. Currently, there are three operating cement manufacturing companies which are Hima Cement Limited (now subsidiary company of the global LafargeHolcim), Tororo Cement Limited and Kampala Cement Company Limited producing a combined output of approximately 3.7 million tonnes per annum. This sharp increase in production capacity was stimulated by increase in capital investment by the private investors, adoption of better production and management techniques and better policies that incentivised private sector investment over the respective period.

Due to the diverse scale and techniques of production, the burnt clay brick industry in Uganda is classified into three major categories which are artisan, small-scale and medium-scale production operations (UNDP, 1989). The first medium-scale brick manufacturing company in Uganda was Uganda Clays which was set up in 1950 at Kajjansi in central Uganda. Other medium sized industrial players that have emerged and grown over the years include Lweza Clays Ltd, Pan Uganda Ltd and HERM. Some of the small-scale producers are Butende Brick Works (BBW) and some brick production clusters in Kajjansi, Mbarara and Njeru. The artisan brick producers range from individual producers, to groups of 3- 5 people as well as families and they are widespread throughout the country especially where there are markets and clay deposits in close proximity. The quantities of bricks produced in the country have also greatly increased over the years especially due to the increasing levels of population growth and urbanisation that have led to an increase in demand for housing and related rural as well as urban infrastructure.

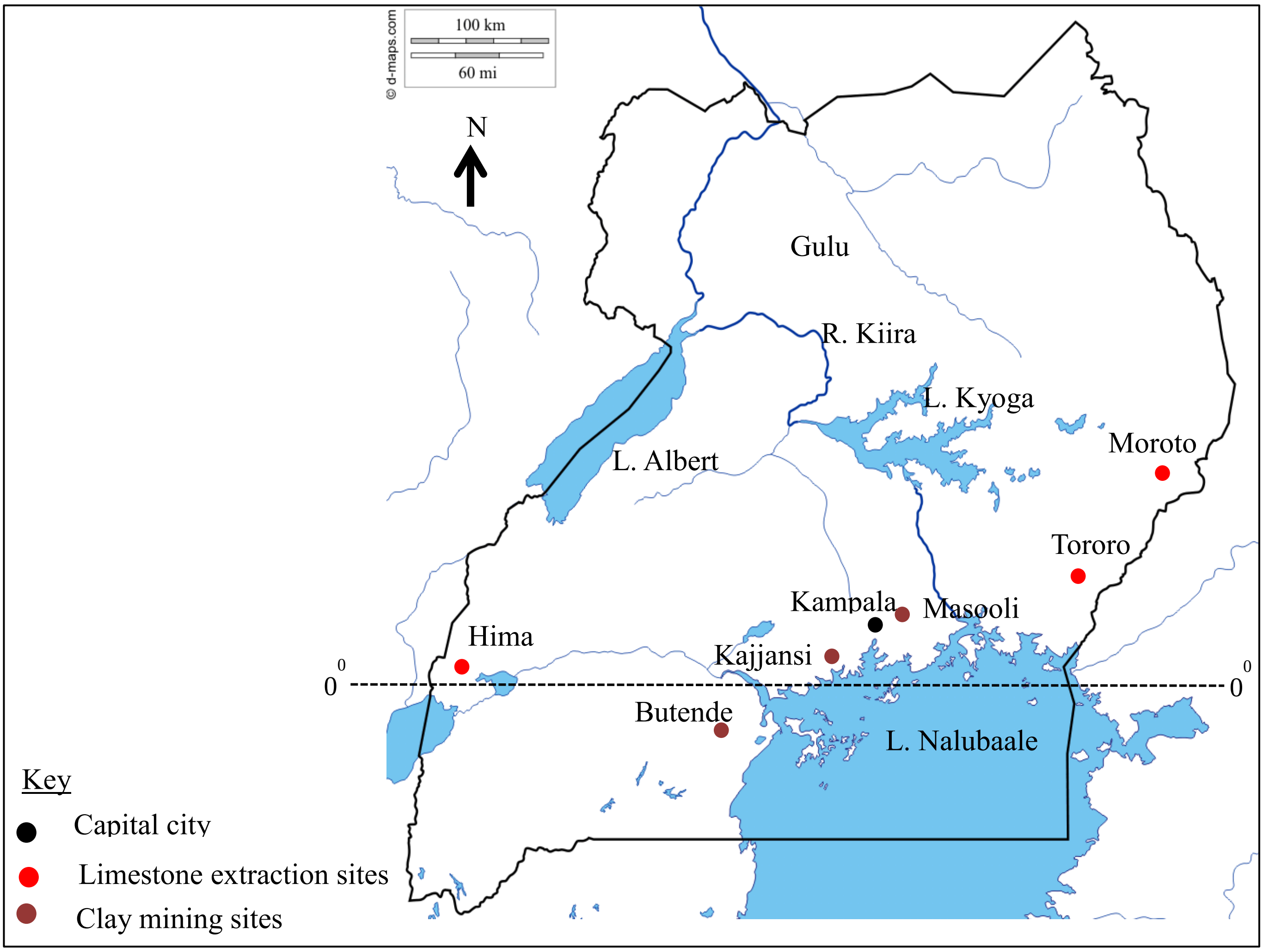


Figure 1.1. Map showing key areas of clay and limestone mining in Uganda. Source: d-maps.com.

Uganda's construction industry is one of the sectors that has steadily grown since the early 1990s. The Uganda Bureau of Statistic (UBOS) (2016:4) highlights the fact that growth in the construction industry has been mainly propelled by "private investment in real estate and public investments in civil works". Its activities are carried out by both formal and informal actors and the informal players account for the majority share at 70% (UN Habitat, 2010). The formal actors are mainly comprised of small and medium scale firms with a few registered international companies. However, the UN Habitat report (ibid) highlights the fact that the construction industry in the country is poorly organised and coordinated and this has greatly contributed to the high levels of wastefulness and inefficiencies associated with the sector. Additionally, Hashemi et al (2015:7871) add that "the major limitations of the construction industries in African countries are high costs and limited access to good quality materials whether imported or produced locally". These limitations point out the fact that whereas the contribution of the construction industry to overall GDP of the country is steadily growing, it is still grappling with organisational and operational challenges that need to be addressed in order to allow for its sustainable advancement.

1.3 Background of the study

Uganda's increasing levels of urbanisation at 5.43% per annum and rapid population growth rate at 3.6% per annum have led to a huge infrastructure and housing backlog (UBOS, 2016). For example, the housing backlog is currently estimated at 0.7 million units and that of tarmacked road infrastructure is at 16,600 Km (ibid). This means that if these needs are to be met systematically by the government and the private sector, the construction industry shall rapidly grow to address the infrastructural requirements and consequently influence the rapid increase in production and consumption of construction materials. This is already happening with the increase in the cement production capacity of Uganda since 2010 so as to supply material to the government civil works projects such as dams, roads and the railway and the steady increase in the number of residential building plans being submitted for approval at the various town councils throughout the country.

Whereas the construction industry and the construction materials sector are promising a vibrant growth, they are also faced with major challenges such as poor organisation, ineffective regulations as well as a lack of quality building materials and skilled labour, all of which are affecting their ability to develop in a sustainable manner with minimal environmental impacts (UN Habitat, 2010). Additionally, Hashemi et al (2015:7872) highlight the fact that the production and construction with the most prevalent materials such as burnt clay bricks and cement is characterised by "inefficient, wasteful and energy intensive" processes especially in the low-income housing sub-sector. All of this is happening within a "weak, fragmented" and unsupportive legal and regulatory framework (UN Habitat, 2010: 89).

Furthermore, Uganda became a party to the Kyoto Protocol in 1998 and therefore made a commitment to reducing its quantified emissions through formulating enabling policies for promoting energy efficiency practices, use of renewable energy, protecting and enhancing the natural environment and research in better and appropriate technologies and improvement in inter-sectoral coordination. It was also around the same period (in 1997) that the country started experiencing some of the most devastating effects of climate change such as extensive drought period that affected the water levels and consequently hydro-power generation and increase in temperatures in areas such as Rakai and Busembatia where massive deforestation was happening. This was mainly attributed to the high levels of population growth and urbanisation as well as the energy demands of the country at that time that were being met by biomass fuels (over 90% (MEMD, 2000)). However, even with the factors mentioned above, the level of formulation, implementation and revision of policies/regulations (to curb the trend of environmental degradation and promote sustainable growth in accordance with the Kyoto protocol and the sustainability development goals) has remained very low. This means that environmentally degrading and high carbon growth trends have gradually increased amidst lax policy frameworks.

This study investigates the environmental impacts of the cement and burnt clay bricks sub-sectors along their life cycle. These are two of the predominantly used construction materials locally processed and extensively used in Uganda (especially in the urban areas) and therefore could give a general picture of the overall trends within the industry. The study particularly focuses on the product systems along the life cycle processes and inventory of two case-study producers, one for cement (Hima Cement Limited) and the other one for burnt clay bricks (Butende Brick Works) (see Figure 1.2). It also investigates the regulatory framework within which the construction materials sector operates and how the different sectoral policies are evolving in order to guide the sustainable growth or development of the sector. Therefore, the aim is not so much as to emphasize the quantitative inventory aspects of the LCA but more on the qualitative and quantitative aspects of the impact assessment that could guide policy direction for comprehensive green growth.

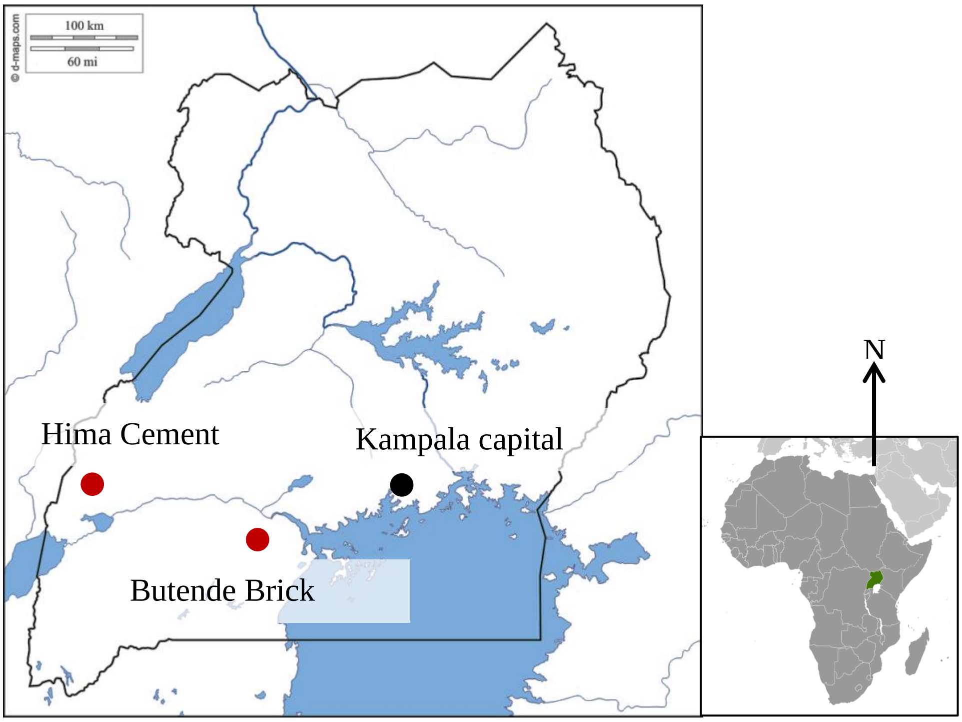


Figure 1.2. Map showing the location of the two case studies: Hima Cement Limited and Butende Brick Works. Source: d-maps.com.

There is therefore a need for guiding policy and regulation process, especially for a developing nation like Uganda, in line with the articles of the Kyoto protocol and the millennium development goals for sustainable development. There is also a need to understand the current policies as regards the major construction materials and how they can evolve in order to address the mitigation of environmental impacts and embodied energy as a way of contributing to sustainable and resource efficient life cycle processes of the construction materials sector as well as the construction industry in general.

1.4 Rationale for the study

The proposed study contributes to a deeper understanding of the product systems surrounding the life cycle processes of burnt clay bricks and cement in Uganda and similar low income countries in order to guide sustainable materials production and management as well as use within the construction industry and eventually the disposal or recycling of resultant waste. The study is also expected to aid policy makers in formulating new laws and regulations or amending the existing ones in order to enable the development and adoption of sustainable material practices for a more sustainable construction industry in the country.

1.5 Problem statement

The gradually increasing levels of urbanisation in Uganda with the associated increase in infrastructure and housing projects by both government and the private sector have led to the steady growth of the construction industry as well as the increase in demand and supply of construction materials especially burnt clay bricks and cement. However the current growth trend of the construction materials sector is marred with organisational and operational inefficiencies along the life cycle of these materials all of which is happening within an ad hoc policy framework that cannot effectively guide its sustainable growth.

Furthermore, most studies and policies on construction materials are mainly focused on their mechanical, structural, health and safety properties with minor concern on their embodied energy and environmental impacts. Construction materials can have negative environmental impacts across their life cycle from extraction, processing, use and disposal of such materials especially due to embodied energy intensities and environmental degradation associated with different life cycle processes. This study will substantiate on the environmental impacts of two major construction materials in Uganda (burnt clay bricks and cement) alongside responsive policy co-evolution as an enabling factor towards a sustainable construction materials sector in the country.

1.6 Objectives

The main object of this study is to increase awareness on the environmental impact of two key locally-produced and extensively-consumed construction materials in Uganda (that is, burnt clay bricks and cement) among policy makers and civil society. According to BS EN 15978:2011 (Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method) guidelines, this entailed examining their production techniques, construction methods, use stage and end of life stage. In addition, it focuses on the current policies and regulatory framework such as the Building Control Act, National Construction Industry Policy and Ministry of Works and Transport Standard Specifications, among other policies, in relation to regulating the environmental impact of the construction materials sector. Furthermore, the study also explores ways in which Uganda’s policies could evolve in order to promote sustainable extraction, production, utilisation and also possibly incentivise alternatives to the commonly used construction materials in order to ensure effective mitigation of their escalating environmental impacts.

1.7 Main research question

The key research question which guided the study can be stated as follows:

To what extent have responsive policies and regulatory framework co-evolved with the increasing environmental impacts of the construction materials sector in Uganda?

1.7.1 Sub-questions

In order to guide the inquiry on the research question, sub-findings on the following sub-questions were derived and then synthesised into the overall findings.

- What have been the key drivers of the consumption and production trends of burnt clay bricks and cement?
- What have been the environmental impacts of the burnt clay brick and cement sub-sectors?
- What have been the trends in policies towards the regulation of the burnt clay bricks and cement sub-sectors?
- What is the overall responsiveness of policy to the escalating environmental impacts of the construction materials sector and how could this be improved?

1.8 Conceptual approach

This diagram seeks to establish the relationship between policy frameworks and the impacts of the construction materials sector to the environment (see Figure 1.3). As discussed in Chapter 4 and 5, environmental impacts occur along two major processes which are at the input of raw materials into the system and the disposal of the outputs to the environment. The quantity of inputs and outputs from the processes are driven by the demand and supply patterns of the construction materials. In most cases, in order to effectively control inputs and outputs, the nature of demand of construction materials has to be regulated or influenced. In addition, environmental impacts are also a factor of quantities produced and the efficiency of production and use. A clean process with high volumes could equate in impact to a low volume of output with less clean processes. Therefore for policies to successfully influence the evolution of a low environmental impact and low-carbon construction materials process, both proactive and responsive policies have to target the input and output processes, the demand and supply patterns as well as improvement in the efficiency of production and use of construction materials.

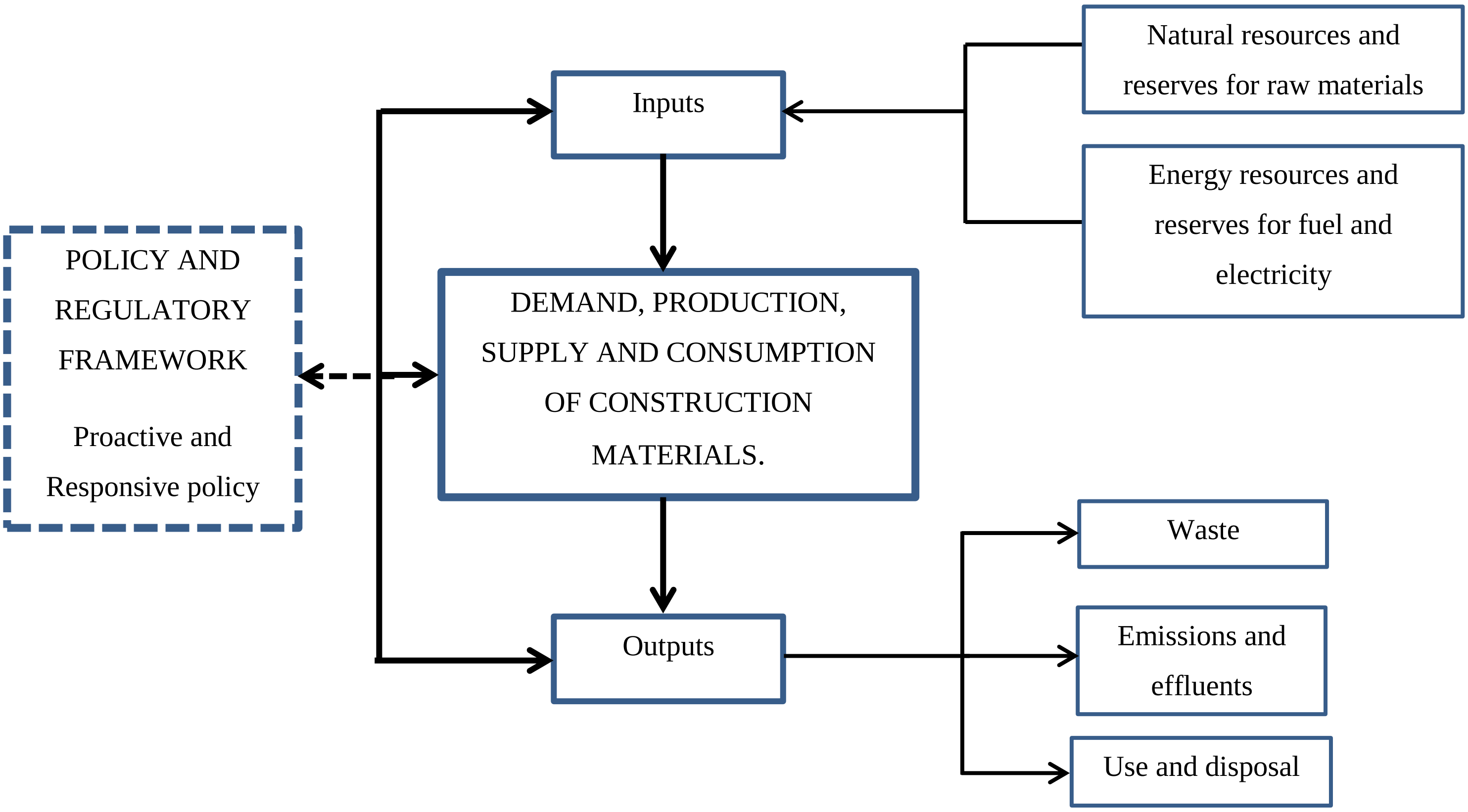


Figure 1.3. Conceptual framework diagram

1.9 Definition of key concepts

Carbon emissions- The release of carbon dioxide gas (CO_2) into the atmosphere and its effects over a specified area and period of time. Carbon dioxide is considered a greenhouse gas.

Embodied Energy- total energy required to produce and install a material or product during all stages of the life cycle.

Energy efficiency- method of reducing energy consumption by using less energy to attain the same amount of useful output.

Greenhouse gases- Gases in the earth's lower atmosphere that may contribute to global warming, including the major component CO_2. Other GHG gases are Sulphur Oxide, Nitrogen Oxide and Methane among others.

Life cycle- Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal (Young et al, 2002).

Life-cycle analysis- This is a method that compiles and evaluates the different inputs and outputs and their potential impacts throughout the life of a material or product from the manufacturing stage to the use and disposal stages. The two materials that are focused on in this study are cement and burnt clay bricks.

Life-cycle inventory (LCI)- This is the classified input and output data with respect to the life cycle process being studied. For example the data for LCI of cement are classified under the raw material inputs, energy requirements, emissions and solid waste produced per tonne/Kg of cement.

Low-carbon development- This is a forward-looking national economic development plan or set of plans and strategies that encompass low-emission and/or climate-resilient economic growth.

Policy- “a course or principle of action adopted or proposed by a government, party, business or individual”. It can take different forms such as non-intervention or regulation, for example through licencing, encouragement of voluntary change and public service provision.

Policy co-evolution- interaction between changing intensity of impacts versus policy changes in responses.

Policy framework- The set of guidelines, as well as long term goals which are taken in to account when policies are being made. They give the direction in which the country, organisation or firm is moving or aspiring to move.

Resource efficiency- A way of utilising the earth’s limited resources in a manner where more value can be realised with less natural resource input. It also means that increase in aggregate economic value is achieved through more productive use of resources, taking their whole life cycle into account.

Sustainable materials- These are materials that minimize resource use, have low ecological impacts, pose no or low human and environmental health risks, and assist with sustainable site strategies.

Product system- “These are the diverse, but individual, operations necessary to extract energy materials, produce intermediates, formulate or produce, use the product and manage wastes in various operations.” (Owens, 1997:48).

1.10 Delimitation of the scope.

The construction materials sector is an extremely diverse and fragmented sector more so in the developing countries. In the absence of long-term inventory and systematic statistical database at economic and materials level, it is a difficult sector to study especially for Uganda. It is mainly for this reason alongside the time constraints that the study focused on the impact assessment component of the LCA technique while only highlighting the quantitative inventory operations and systems relevant to this component.

Within the context of Uganda's economy, the study prioritised two medium-scale producers of cement and burnt clay bricks as the case studies (Hima cement Limited and Butende Brick Works) whose product systems along the life cycle processes were fairly well documented and easier to track compared to the activities of larger scale local producers such as Tororo Cement and the artisan brick makers. The research studies the activities of the artisan brick makers mainly for comparison purposes of their life cycle processes with those of Butende Brick Works so as to identify better practices. Furthermore, the recommendations mainly focused on how policies and regulatory framework can guide the sustainable development of the construction materials sector and did not delve into recommendations for specific alternative materials or industry practices that would be resource efficient with low embodied energy among other impacts which call for mitigation interventions. The findings of the study are therefore still far from demonstrating the comprehensive picture of Uganda's construction materials sector in terms of inventory, impacts and policy response but are a start to highlighting its diverse impacts.

1.11 Structure and organisation of the report

This report is structured into seven chapters and ends with the reference list and the appendices. The introduction chapter presents the current perspective, understanding and background information about the research topic, and also motivates for the study focus and selected case studies. The chapter also includes the problem statement and a clear articulation of the rationale of the study, as well as its aims and objectives, coupled with highlights on the importance of the study and the parameters guiding the investigation mainly in terms of the main research question and sub-questions. Finally, it includes the delimitation of the study that highlights the related areas that could not be comprehensively investigated.

Chapter two focuses on literature review which appraises the key theoretical fields of the study and especially life cycle analysis and policy co-evolution processes. The choice of scholarly articles, journals and other resources for the literature review were guided by the research sub-questions and the theoretical context of sustainable construction materials with regards to the life cycle analysis of the key construction materials in Uganda. Some of the key literature that was appraised include Ngoasheng (1995) that discusses the structural linkages within the cement and burnt clay brick industries, Calkins (2009), that examines life cycle analysis processes, Chen et al (2017) that discusses the matter of sustainable materials management and the Office of the president (2009) that analyses the practices for policy formation and evolution.

Chapter three presents and motivates on the methods of the study by focusing on processes taken within a qualitative study approach. It expounds on the nature of data acquired from both the secondary and primary data sources which included interviews, site visits, policy documents and print media. The chapter also explains the different tools used to acquire the data as well as the approach used for data analysis and derivation of findings.

Chapter four to six constitute the substantive chapters of the report and they answer the research sub-questions guided by the processes adopted in the burnt clay brick and cement case studies (Butende Brick Works and Hima Cement Limited). Chapter four substantiates on the first sub-question. It analysis and sub-findings on the manufacturing processes as well as the demand and supply trends within the materials sub-sector. Chapter five, especially with a focus on the case study materials substantiates on the life cycle processes of the cement and burnt clay bricks sub-sectors and their related environment impacts. Chapter six substantiates on the adequacy of the different sectoral policies in guiding the sustainable development of the construction materials sector. It also substantiates on the extent to which the policies are adequately evolving towards effective guidance for sustainable practices within the construction materials sector.

Chapter seven presents the overall consolidation of findings, conclusion and recommendations of the study. It answers the main research question by integrating the sub-findings to the four sub-questions of the study as derived through the substantive chapters. In addition, the chapter makes recommendations with regard to how and which sectoral policies can be strengthened to guide the sustainable development of the construction materials sector and the construction industry in general. The report then ends with a comprehensive reference list and appendices which present additional content which could not be integrated into the main body of the report.

Chapter 2 Literature review

2.1 Introduction

Considering the steady growth of the construction industry in Uganda, with construction materials as a key input, and its subsequent adverse environmental effects, it has become essential to understand and analyse the full impact of the construction materials sector and how different policies can evolve in order to guide sustainability across the industry. The study falls within the theoretical framework of sustainable construction (which also includes the sustainable materials sector), focusing on life cycle impact analysis (LCIA) as a methodology for determining environmental impacts.

The appraisal initially reviews reports on the system dynamics along the life cycle of burnt clay bricks and cement such as their supply and demand trends, life cycle inventory (LCI) as well as the sectoral backward and forward linkages. The appraisal then focuses on how governance structures and policies (both local and international) can guide the sustainable growth and evolution of the construction materials sector guided by key systems along the life cycle of construction materials. Both national (Ugandan) and international policies that address issues of the environment, energy and building code in relation to construction materials are reviewed as well as sustainable material management practices.

2.2 Structure and linkages of Uganda's burnt clay bricks industry

Uganda's clay brick industry is a major supplier of building materials to the construction industry with clay bricks as the most commonly used walling component. They accounted for approximately 60% of all walling materials in both urban and rural areas in 2009 and 2010 (Hashemi et al, 2015). However, the percentages of burnt and un-burnt clay bricks used in construction are not systematically documented or reported thus making it impossible to quantify production in the country. Furthermore, such production takes place mainly at three different scales with the main players being individual or family artisan producers, followed by small scale semi-mechanised producers and lastly the medium-scale producers. The combined production, in addition to being poorly documented, is also insufficient to meet the country's future demand for burnt clay bricks (World Bank, 1989). In general, most of the producers are artisan-scale operators located in close proximity to the clay deposits which occur naturally in different parts of Uganda especially in the Lake Nyanza basin (in places such as Kajjansi, Kamonkoli, Kitiko, Masooli, among others) (refer to Figure 1.1) (Uganda Investment Authority, 2017).

Uganda Clays Limited, with factories in Kajjansi and Kamonkoli, is the largest medium-sized sole producer of burnt clay bricks in Uganda, manufacturing 2,764,481 units of brick products in 2015, which accounted for 24% of the market share (Uganda Clays Limited, 2015). It also produces other clay products like roofing tiles, 'maxpans', ventilators, floor and quarry tiles among others. Because of the significantly better technology and capital, these materials are of superior quality (they are also ISO 9001:2008 certified) compared to the artisan and small-scale operators, making it the supplier of choice for high-budget and formally controlled construction projects.

However the significant market share (76%) of the artisan and medium sized producers cannot be ignored. They largely fall under the informal sector which dominates Uganda's construction industry because of "under-development with low levels of industrialisation" which leads to the adoption of "labour-intensive" methods of production (UN-HABITAT, 2010:92). Their bricks are cheaper and readily accessible to low-cost developers and the middle-income population engaged in construction. However, the quality of their products vary considerably and this affects the structural integrity and overall embodied energy of the bricks. Furthermore the artisan and small scale producers have low fixed and total costs and their brick output is flexible because it responds to the market demand at a given time (ibid).

In relation to sectoral linkages, the brick making industry (like the cement production industry) is strongly linked to the construction industry because of the use of bricks (and cement) in walling, foundations, finishes and landscaping especially for low cost housing, middle-income residential projects, commercial and institutional projects. This means that the growth or decline of the construction industry directly impacts on the growth or decline of the burnt clay brick industry based on what relationship Ngoasheng (1995:89) identifies as a "forward linkage".

Within the manufacturing sector, the contribution of the brick making industry to the total output of the sector, especially in Uganda, is poorly documented because of the predominantly informal nature of operation. All the same, it significantly contributes to employment and wages especially of the unskilled labour force compared to the cement industry because it is less capital intensive (UN HABITAT, 2010). Furthermore, Ngoasheng (1995) identifies inputs into the brick sector from other sectors of the South African economy like mining especially of kaolin, forestry sector, electricity, wholesale trade, retail, transport and storage, business and service sector, especially industrial machines and equipment. Ngoasheng (ibid), also argues that second to the construction sector, the energy sector is very important to the brick and tile making industry because of the nature of energy intensive processes involved during production. This emphasizes the fact that the successful regulation of the brick making industry towards sustainability should be systematically rooted in successful regulation across its diverse sectoral and industrial linkages.

2.3 Structure and linkages of Uganda's cement industry

In comparison to the brick making industry, Uganda's cement manufacturing industry is formally controlled and relatively better documented. There are three major producers of cement, which are Tororo Cement, Hima Cement Ltd. and Kampala Cement Company Ltd. (see Figure 1.1). Limestone from Hima and Tororo hills supplies a majority of the raw material for Uganda's Portland cement industry which is supplemented by supplies from smaller deposits in Sukulu hills, Karamoja region and imports of clinker from Kenya and South Africa (Uganda Investment Authority). Both Hima Cement and Tororo Cement produced 2.1 million metric tons of cement in 2014, which shows a steady increase in production of about 37% since 2010 (see Table 4.1 and 4.2). Cement is primarily used as a flooring material (about 30%), as well as for plaster and wall finishing in residential developments (Hashemi et al: 2015) and as structural concrete in commercial, industrial and civil works.

In terms of sectoral linkages within the construction industry, Ngoasheng (1995) highlights the fact that cement consumption is closely linked to the civil engineering sub-sector where it accounts for about 7% to 10% of the total cost of engineering structures like bridges and roads. Therefore, the growth or decline of this sub-sector directly affects the rate of consumption of cement. Ngoasheng (ibid:28) further identifies other sectors that account for intermediate inputs into the cement industry (in South Africa) such as "electricity, gas and steam", "other mining", "coal mining", "paper containers", "transport and storage" and particularly for Uganda, the forestry sector. Similar to the brick industry, energy is a vital input in cement production and accounts for about a third (in costs) of the total inputs in the industry (ibid). In light of rising energy prices in Uganda and increasing environmental concerns, there is an urgent need to explore alternative sources of energy and energy efficient ways of cement production.

Therefore, just like the brick- making industry, successful regulation of the cement industry towards sustainability should be systematically rooted in successful regulation across its diverse sectoral and industrial linkages. This may involve the promotion of innovative and efficient practices across the life cycle of construction materials such as more efficient mining, production, construction and recycling practices as well as adoption of appropriate alternative materials to meet the steadily increasing demand for cement (and burnt clay bricks).

2.4 The demand for construction materials in Uganda

A study by the UNDP (1989) argues that the demand patterns of construction materials (like bricks and cement) is influenced by multiple factors over and above population growth as a key deriver. For Uganda in particular, political stability and steady economic growth in the last two decades has spurred the growth of the construction industry and subsequent increase in demand of construction materials. Similarly, influences on the choice of construction materials are equally as complex as influences on demand. Such choices are mainly influenced by peer pressure and other secondary factors such as scarcity, durability, choice of developer and embodied energy among others (UN HABITAT, 2010) (see Table 2.1). In general, cheaper but poor quality materials like low quality burnt clay bricks are more prevalent in poorer areas while higher quality materials like cement and high-end burnt clay bricks are commonly used in affluent neighbourhoods and mostly in urban areas (ibid).

Table 2.1. Builder rationale for choice of construction materials. Source: UN HABITAT, 2010.

Town	Durable	Inadequate resources	I don’t know	Cheaper	That is what I wanted	N.A
Kampala (%) (urban area)	24.7	13.0	15.7	5.0	0.3	41.1
Gulu (%) (rural area)	3.4	4.7	8.7	7.4	0.0	75.8

The table above illustrates the fact that the majority of people in both urban and rural areas have very diverse reasons for the choice of construction materials for their dwellings. It also shows that in urban areas, durability is the second common determinant for the choice of construction materials whereas in rural areas about 8.7% of the people did not know why they chose the materials they did followed by the fact that the materials they chose were cheaper (7.4%). This could explain why cement, bricks and iron sheets are more commonly used in urban areas because they are considered more durable whereas earth, bricks, thatch, mud and poles are considerably used in the rural areas alongside bricks and iron sheets because they are relatively cheaper materials (see Figure 2.1).

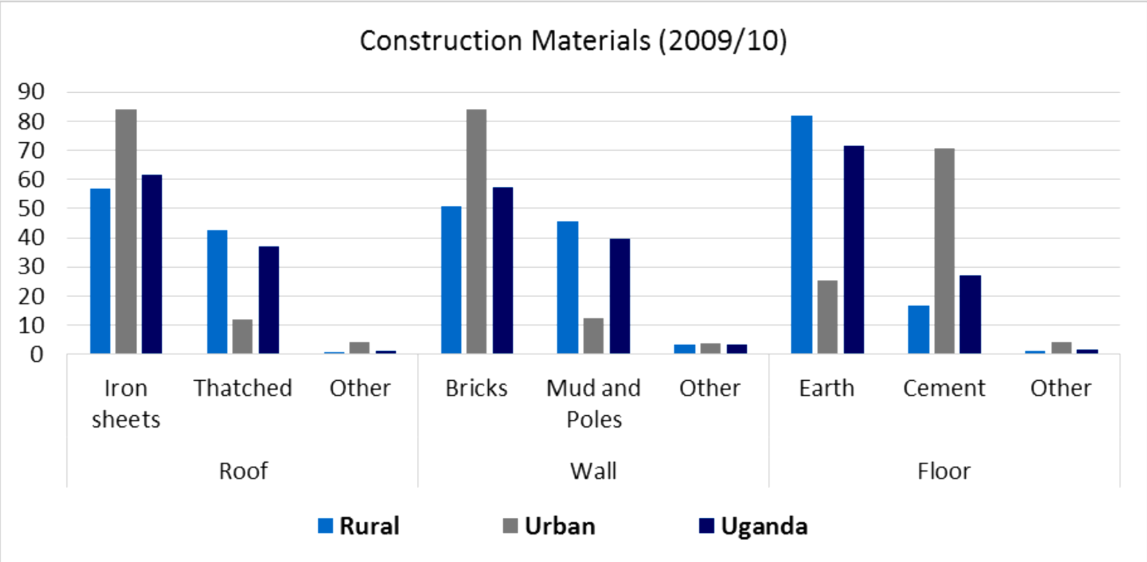


Figure 2.1. Key construction materials for the main building elements Uganda in the year 2009/2010 (%) (UBOS, 2010).

2.5 Evaluating environmental and health impacts of construction materials.

During the life cycle of any construction material, the interaction with the environment occurs in two main ways which are the earth (and its biosphere) as the source of the finite raw materials and as a sink for the solid waste, emissions and effluent emitted from the various processes. Evaluation of the environmental performance of the building materials sector entails an intricate process as it has to take into account the diverse impacts of inputs and outputs along a material's life cycle within the framework of the life-cycle inventory (LCI) (Calkins, 2009). Some of the identified techniques for determining these impacts are the Life Cycle Analysis (LCA), Sustainability Assessment (SA) and Embodied Energy (EE). The LCA quantifies all inputs such as energy, water and raw materials, among others as well as outputs such as emissions, effluent and wastes for a given scope. The SA is normally guided by a set of sustainability standards towards the analysis of materials sourcing, manufacturing, installation, operation and end of life. Lastly EE, is the “total energy consumed in raw material acquisition, manufacture, transport and disposal of a building material/ product” (ibid: 59) as well as the entire building. This study focuses on the LCA and EE techniques in order to determine the environmental impacts of the cement and burnt clay brick sectors in Uganda.

2.5.1 Life Cycle Assessment technique.

Young et al (2002) describe LCA as the evaluation of the cradle, gate and grave processes of materials from resource extraction, to material production, distribution and finally their disposal (or recycling if it is being practiced) (See Figure 2.2). This is done to provide information on a product’s energy, materials, wastes and emissions form a life cycle perspective along with an examination of associated environmental issues” (Owens, 1997:38).

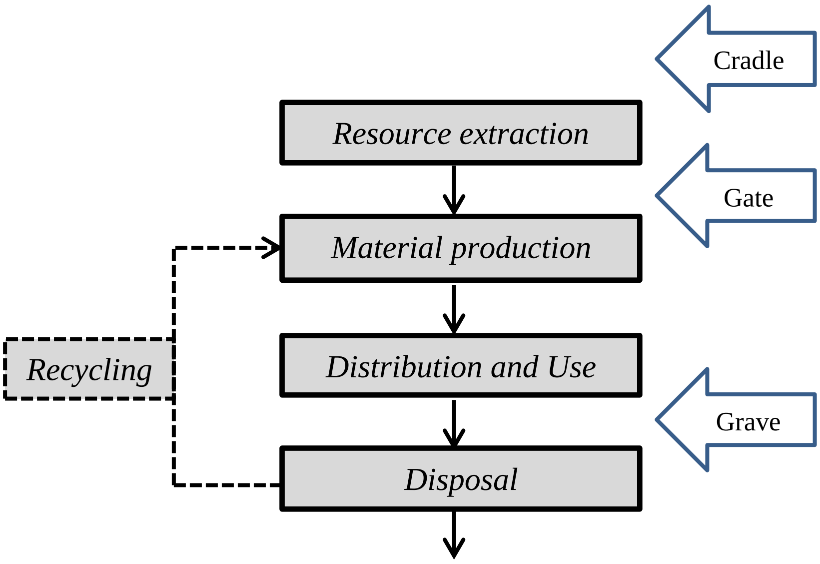


Figure 2.2. The LCA of construction materials. Source: Young et al, 2002.

According to ISO 14044:2006(E), LCA is considered to have four phases which are;

- Scope definition
- Inventory analysis
- Impact assessment
- Interpretation

The scope of the LCA defines the intended application, its specific audience as well as goals and objectives for carrying out the study. It is here that the depth and breadth is clearly defined and vary across different studies depending on the goals and objectives (ISO 14044:2006(E)). This study is meant to draw the attention of both policy makers and civil society on the increasing negative environmental impacts along the life cycle of the construction materials sector and thus guide policy direction for greening the entire sector.

The inventory phase analyses the “system inputs of energy and materials along with the outputs of emissions and wastes throughout life cycle, usually as quantitative mass loadings” whereas the impact assessment phase “examines this inventory with respect to probable environmental issues using both qualitative and quantitative methods (Owen, 1997:37). Therefore, this study focused on the impact assessment component while highlighting the inventory operations and systems relevant to this component. The life cycle interpretation phase is one where the “results of an LCI or an LCIA, or both, are summarized and discussed as a basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition” (ISO 14044:2006(E):v).

Determining the environmental performance and impacts of construction materials using the LCA technique can lead to the required insights to guide responsive policy intervention but the process is essentially dependent on the existence of political will and institutional capacity to quantify and track the impacts. This would also ensure the availability of skilled personnel and evaluation resources such as systematic data alongside the required software and hardware which are not comprehensively available or accessible in Uganda at the moment.

2.5.2 Determining the LCA of cement

The study of the life cycle assessments of construction materials such as cement requires a life cycle inventory (LCI) of the relevant inputs and outputs of a product as well as their diverse environmental impacts. This inventory includes all the resources and energy required to extract limestone and required raw materials as well as the processes extending to the use and disposal or recycling of cement and cement products (Young et al, 2002). The values are often normalised and reported per unit of cement (Kg, tonnes or m^3) (see Figure 2.4).

Table 2.2. Example of LCI results for 1Kg of cement from a plant in Sweden. Source: Bjorkland:1998:220.

INPUTS		OUTPUTS	
Raw Materials		**Air Emissions**	
Explosives	0.27 g	Carbon dioxide	800 g
Grinding media	0.09 g	Particulate	0.16 g
Iron sulfate	9.2 g	Nitrogen oxides	1.9 g
Quartzite	46 g	Hydrocarbons	0.016 g
Waste oil	12 g	Ashes	0.0020 g
Limestone	1400 g	Cadmium	0.000010 g
Gypsum	46 g	Methane	0.31 g
		Carbon monoxide	0.78 g
		Chromium	0.000017 g
Energy		Copper	0.0000026 g
Coal	0.86 MJ	Mercury	0.0000035 g
Coke	1.5 MJ	Nitrous oxide	0.00000015 g
Diesel	0.058 MJ	PAH	0.00000034 g
Fossil fuel	0.93 MJ	Lead	0.0000087 g
Oil	0.016 MJ	Phenol	0.00000042 g
Waste fossil fuel	0.53 MJ	Sulfur dioxide	0.45 g
Electricity	0.47 MJ	Thallium	0.00010 g
		Volatile organic carbons	0.13 g
		Zinc	0.000013 g
		Water Emissions	
		COD	0.000087 g
		Total nitrogen	0.000014 g
		Oil	0.000030 g

Note: Not all flows have been tracked back to the Earth. LCI results are for illustrative purposes only, and are not intended to be representative of LCI study results.

Whereas LCI as a tool helps to keep track of "mass and energy flows" across the different processes of the life cycle, it requires "more accurate and more comprehensive inventories of energy consumption and raw materials usage – and doing so while providing a "zoom lens" from unit process, to complete facilities, to corporate divisions, to the level of the company or across the industry" (Young et al, 2002:5). This means that in order for the tool to be successful in tracking environmental impacts, there needs to be an integrated data-set within a data-sharing system from the manufacturers, miners, the construction industry and regulatory institutions. However due to the lack of such a data-set in Uganda coupled with time and resource constraints, this study did not delve into the unit quantities of outputs, inputs and energy but rather relied on case studies and secondary data on similar examples to compile the inventory that would guide the impact assessment.

The cement production industry is extremely capital intensive and employs complex technology at a large scale in order to extract limestone and process it into Portland cement. It entails energy intensive process in mining, transportation, production and packaging among others and primarily uses grid electricity and combustible fuel like petroleum, coke and coal.

Ngoaheng (1995:58) highlights the fact that energy use and cost per tonne of cement depends on “energy prices”, “type of technology and raw material characteristics (wetness, grindability, hardness)”. In the Ugandan context, high energy prices significantly increase the cost per tonne of cement produced compared to South Africa that has comparatively lower electricity and petroleum-product prices for industries. Similarly, the landlocked nature of the country significantly increases transportation emissions and costs of raw materials and machinery required for cement production and construction compared to neighbouring coastal countries such as Kenya and Tanzania.

The key raw material needed to produce cement are calcium carbonate, silica, alumina and iron ore, all of which are extracted from limestone rock, chalk, clayey schist or clay. According to LafargeHolcim (2107), the four major processes involved to convert the raw material to cement are; crushing, stacking and reclaiming, raw meal drying, grinding and homogenisation, clinkerisation, and finally cement grinding, storage and packing (see Figure 2.3). Even though the figure presents the common processes across most cement producers, variations should be expected especially in terms of technology adopted and the type of energy used to heat up the kiln.

Clinkerisation is the most energy intensive process as it requires heating and sustaining the kiln feed at temperatures of up to 1500^0C in order to transform it into clinker which is later ground to produce Portland cement. It is also during this process that the combustible fuel is required which can be met with petroleum products, coal or waste biomass substitutes such as coffee and rice husks. This fuel substitution as currently being carried out by some cement factories in Uganda such as Hima Cement Ltd. is considered to be a low impact practice because of the reduction in carbon emissions associated with the reduction in the quantities of petroleum and coal products used in firing the kiln.

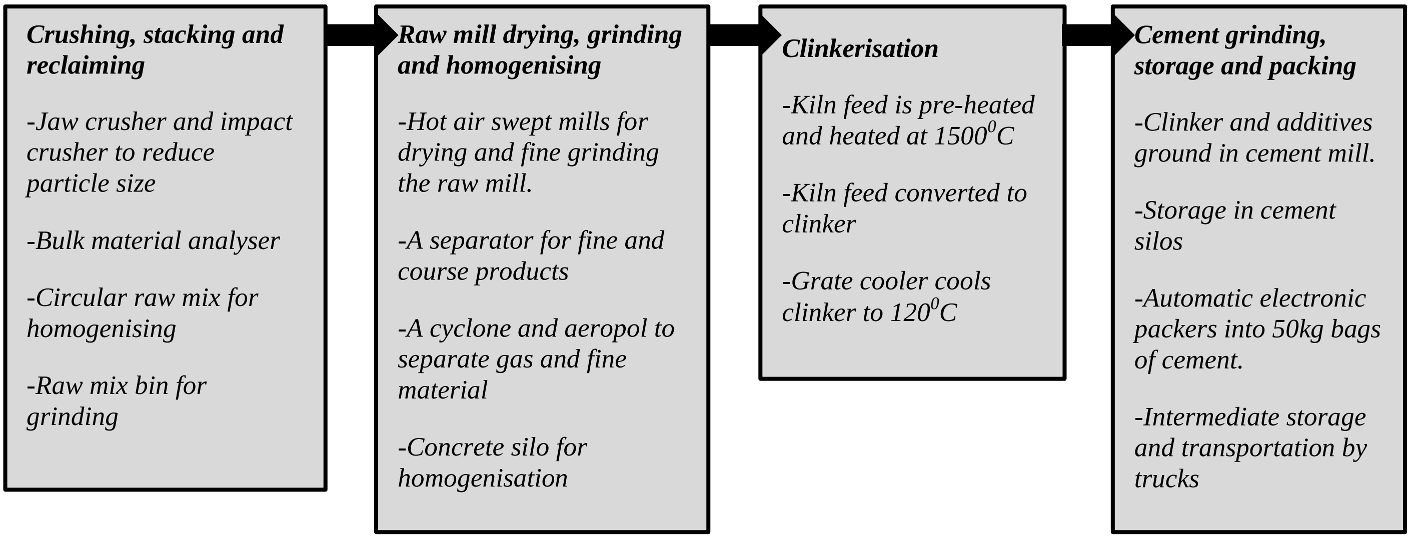


Figure 2.3. Cement production processes. Source: LafargHolcim:2017.

Further on, it is in the production of downstream cement products like concrete, cement blocks and cement stabilised soil blocks where medium scale companies participate but their activities with regards to energy and related impacts are not systematically documented. According to Hashemi (2015, citing Hammond 2015), the embodied energy of a 200mm hollow cement block wall and a 140mm cement- stabilised soil block wall is estimated at 127MJ/m^2 and 176MJ/m^2 respectively (see Table 2.3).

Table 2.3. Embodied energy of brick and concrete walls components per m2 of wall element. Source: Hashemi et al, (2015:7878).

Product	Brick/Block Size: L × W × H (mm)	External Wall Thickness (mm)	EE of Material (MJ/Kg)	Mass per item/littre (Kg)	EE of Wall (MJ/m^2)	EE of Wall (MJ/m^3)
Artisan Burned Brick/Block	300 × 150 × 130	150	4.76	7.6	810	5398
	20 mm mortar		1.11	1.65		
	220 × 110 × 65	220	4.76	2	1067	4849
	20 mm mortar		1.11	1.65		
Small-Scale Brick	220 × 110 × 65	220	17.136	2	3542	16,100
	20 mm mortar		1.11	1.65		
General Clay Brick	215 × 102.5 × 65	215	3	2	791	3677
	10 mm mortar		1.11	1.65		
Cement Stabilised Soil Blocks	290 × 140 × 115	140	0.68	8	176	1257
	10 mm mortar		1.11	1.65		
Hollow Concrete Block *	400 × 200 × 200	200	0.59	14	127	636
	20 mm mortar		1.11	1.65		

* Assumptions: 50% Hollow; 8 Mpa compressive strength.

From the above table, the embodied energy of artisan fired clay bricks is higher than cement-stabilised soil block and cement block but one of the major setback in using the cement blocks is their higher cost in comparison to the burnt clay bricks. According to UBOS (2016), one concrete block of size 150x200x400 costs an average of Ug. Shs. 3000 (approximately R 10) while a burnt clay brick of size 100x100x200 costs an average of Ug. Shs. 300 (approximately R 1).

2.3.2 Determining the LCA of burnt clay bricks

The overall process of brick manufacturing includes five major processes which are raw material extraction, weathering and homogenisation, forming and cutting, drying and firing and lastly storage and transportation of the finished products (see Figure 2.4). The impacts of the burnt clay bricks on the environment stem from the energy resources required along the life cycle processes and pollutants such as emissions, liquid effluents and solid wastes to the environment. Venta (1998) argues that clay brick should be a relatively low impact material (compared to cement and cement products) especially due to lower processing temperatures as well as the abundance of clay as a raw material for the industry. However, according to Hashemi and Cruickshank (2015), "low quality, high material waste and excessive energy waste during production and handling" characterise Uganda's traditional brick manufacturing processes which in turn increase the negative environmental impacts of the burnt clay bricks.

Approximately 91% of the energy needs of this industry are met by firewood as opposed to alternative sources such as agricultural wastes like coffee and rice husks (World Bank, 1989). This implies that the burnt clay brick industry is contributing to massive deforestation through its growing need for firewood and this in turn impacts on weather patterns and perpetual destruction of natural eco-systems. Clay mining in Uganda also takes place in highly ecologically sensitive sites such as the water catchment basins of Lake Nalubaale and Lake Kyoga. This in turn contributes to water pollution, soil erosion, flooding and extinction or migration of plant and animal species.

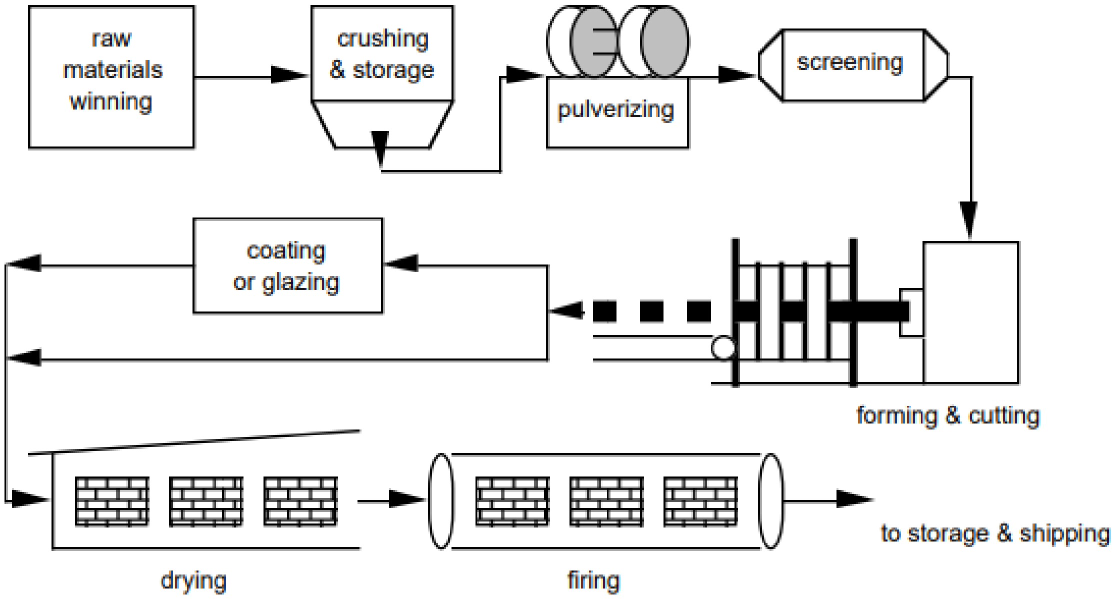


Figure 2.4. Flow diagram of a clay brick plant. Source: Venta, 1998:17.

According to Venta (1998:28-29), the LCI of the relevant inputs and outputs of the entire burnt clay brick system can be normalised per unit of brick (tonne or by Kg) and they include:

- Energy use and efficiency which encompasses the use of a single fuel or mix of fuels as well as energy saving technologies. The fuel could be wood fuel, biomass wastes, coal, fuel oil and/or natural gas, among others.
- Atmospheric emissions that accrue from transportation, use of petroleum products in the production machinery and high temperatures in the brick kiln. The commonly associated emissions are CO_2, CO, SO_2, NOX, CH_4, and particulate matter (PM).
- Liquid and solid wastes mainly caused by runoff from storage and machining areas as well as brick rejects from the kiln, handling, transportation and construction phases.
- Recycling that occurs when the bricks are re-purposed or recycled especially the rejects of the entire process as well as rubble from demolished brick walls.

From prior studies of carbon emission and embodied energy of artisan burnt clay brick, the embodied energy was estimated at 4,760MJ/tonne compared to 3,000MJ/tonne of that produced from a medium sized manufacturer (See Table 2.3). This is mainly because of inefficiencies in the firing of the bricks under the artisan process (Hashemi et al 2015 citing Hammond 2011).

2.4 Policy evolution and co-evolution for sustainable development

2.4.1 Green growth

Fast tracking economic growth and progress (especially of the GDP) is desirable particularly for the least developed nations such as Uganda. To a large extent, this progress is deeply rooted in how the earth's finite natural capital is being effectively converted to other forms of capital. The World Bank (2012:v) describes green growth as

> Growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of the environmental management and natural capital in preventing physical disasters

This definition puts the emphasis of economic growth away from simply snowballing the gross domestic product figures to a more integrated approach where the meaningful GDP rises alongside better environmental performance. Furthermore, Bowen and Hepburn (2014:407) argue that "undermining the ecological basis for human civilisation will damage human welfare and further undermine economic growth". This line of thought in the sustainability debates falls under the green agenda discourse. However, other definitions of green growth put emphasis on the social dimensions referred to as 'brown capital'. The brown environmental agenda focuses on the understanding that social issues such as inequity in access to resources, opportunities and services alongside wider challenges such as poverty, environmental injustice and disease cannot be separated from the environment. It recognises that "human beings are an integral and indivisible part on the earth system" (Plesis, 2015:1849). This debate further argues that improvement in basic human conditions now such as health, nutrition, housing and employment, among others is instrumental for improvement in standards of living and better environmental performance in both the short and long run.

Plesis (ibid) argues that both the green and brown agenda debates converge in the recognition that human activities in the last century have been a key driver for environmental degradation and eventually faster climate change and thus transformation of such harmful mind-sets and activities will also be key in the response to climate change. Furthermore, Bowen and Hepburn (2014) posit that green growth is critical (at both micro and macro level) especially with the increasing evident effects of climate change because it can champion economic revival, lead to progressive development of underserved communities and countries as well as promotion of environmental health. Therefore it entails a movement away from “laissez-faire principles and imply large-scale, persistent, and pervasive collective action at various levels (whether state-led or driven by groups within civil society)” (ibid, 2014:412).

2.4.2 The concept of emergence in complexity theories

Public policies play a vital role in directing innovation and development even though previous studies have not yet fully established the extent to which policy and economic development (or sustainable development for that matter) co-evolve and how. The dearth in knowledge is mainly attributed to the complex relationships among the diverse stakeholders involved in policy processes, various magnitudes and contexts of the policy problem as well as the different opportunities and constraints within the policy structure or framework (Sotarauta and Srinivas, 2005). Due to such varying dynamics, Pederson et al (2014:3) refers public policy as instruments which “facilitate and dictate certain actions and constrain or preclude others and influence the allocation of economic and political resources, modifying the costs and benefits associated with alternative political strategies, and consequently altering ensuing political development”. This means that policy and its overall framework greatly influences the priorities of action of the state with regard to where it is willing to direct its limited resources based on an on-going assessment of the opportunity cost.

Sotarauta and Srinivas (2005) investigate the subject matter within the context of emergence and complexity theories where complexity is described as the “intricate relationship that arises from the interaction of agents that are capable in adapting to and evolving with a changing environment” (ibid:315). This theory emphasizes the fact that change at the micro-agent level does meaningfully influence overall system evolution at the macro level. This means that for a desired change to be visible at a national level, a number of individuals, institutions and local governments have to go through that change and as a collective, they contribute to the desired outcome at national level. Emergence is the observable “overall system behaviour that comes out of the interaction of many participants and it cannot be predicted or envisioned from knowledge of what each component of a system does in isolation.” (ibid). The behaviour of the ‘whole’ system also feeds back and influences the behaviour of the different micro-parts and interactions (see Figure 2.4).

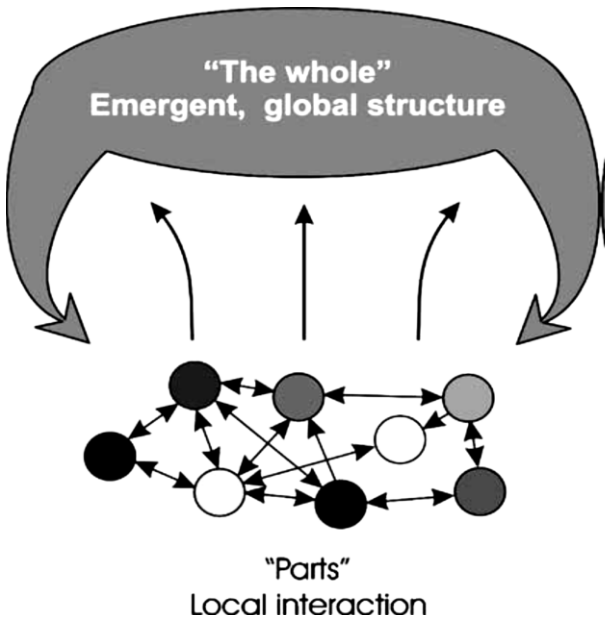


Figure 2.5. Langton's view on emergence on complex systems. Source: Sotarauta and Srinivas , 2005:316.

Even though the changes and interactions of the different parts may be viewed as inconsequential in some systems and may also occur organically, their influence is critical when change in the entire system is required (ibid). Underdal (2012:16) further argues that significant political change occurs through "interactive accretion of actor behaviour rather than through centralised leadership guided by some synoptic master plan". Therefore, the writers agree that the different parts, which may consist the people at the grassroots, local governments and grass root institutions such as NGOs and cooperatives play a crucial role in influencing systems change at national level and therefore should be facilitated and enabled to participate for effective policy changes or evolution.

2.4.3 The evolution and co-evolution approach in policy processes

Sotarauta and Srinivas (2005) describe the evolutionary approach as that which understands the processes and dynamics of the different policy agents in a given time and context. It requires that the actions and interactions of the agents "adopt, transform, upgrade or lock in areas of development" as well as encompass "ignorance, confusion and chance" as important aspects of the entire process as forces that may also influence development (ibid:315). Ekelland (1990:138) further argues that evolution is a continuous process guided by an "endless chain of events" and therefore should not be thought of as a system with an end point as previously assumed. This means that the different agents in the process have to continuously learn from different strategies that have been adopted before or by similar case studies so as to be able to plan and adapt for their specific context as the process continues.

Sotarauta and Srinivas (2005) identify four key processes of social and economic evolution (which serve as a crucial insight for the study in relation to sustainability evolution) and these are variation, selection, retention and the struggle over scarce resources (see Figure 2.5). These are elaborated as follows:

- Variation may be intentionally formulated or independently occurring solution or options to a problem
- Selection of policies and ideas that are easily adaptable and relevant to the context
- Retention of the successful of a new variety influenced by factors such as cultural beliefs and institutional capacity. It may also involve preservation, duplication or reproduction of selected varieties
- Struggle over scarce resources may lead to struggle within institutions and different agents or actors and also influence the development of new variations.

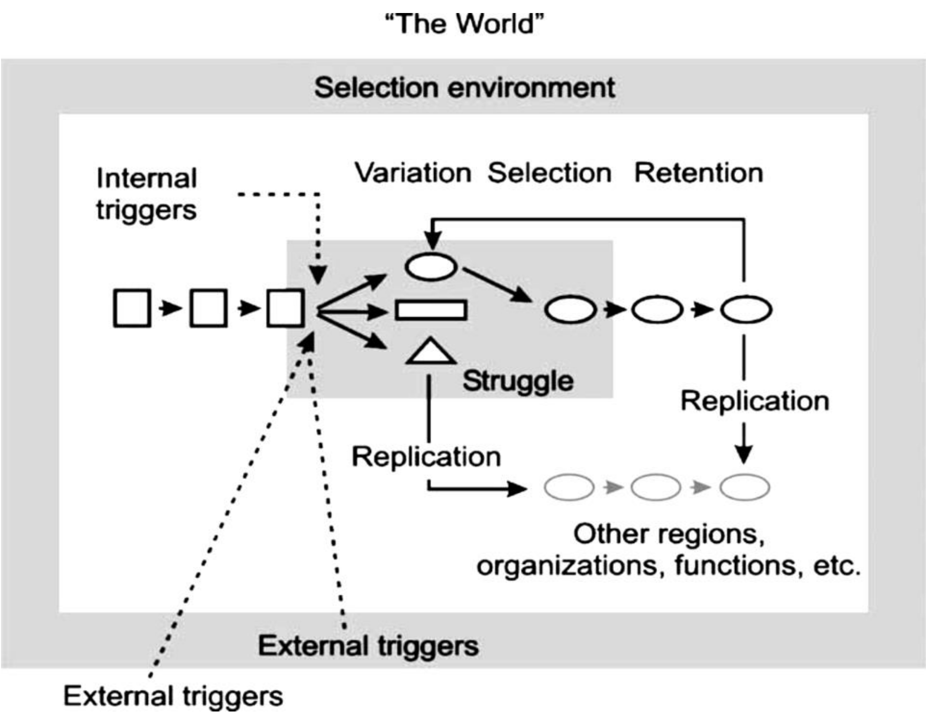


Figure 2.6. The basic conceptual frame of an evolutionary approach. Source: Sotarauta and Srinivas (2005:318).

With regard to co-evolution, a crucial aspect of this study is the role of struggles, tensions, failures and co-operation in the “emergence of new social and economic [or sustainability] directions that is in the process of selection, variation and retention” (Sotarauta and Srinivas, 2005:318). The change or co-evolution process is triggered by the adjustments or re-adaptations that happen between the interactions of the different actors and institutions within the entire system and therefore needs to be understood as a continuous process. The continuously changing selection environment is also important in the entire framework as it is influenced by the nature of interactions of the different actors and their dynamic context which in turn can influence the nature of the four processes (variation, selection, retention and struggle over scarce resources). In the case of the policy environment, the selection environment consists of three important elements which are:

- Policy makers and institutional structures
- Markets (producers and consumers)
- Natural systems (eco-systems and related resources)

2.5 Uganda’s decentralised policy framework and government structures

Uganda has pursued a decentralised economic development framework since the late 1980s. It was adopted with the primary objective of empowering people and institutions at different levels of society for meaningful participation in decision-making and implementation. Mugabi (2004:1) argues that the decentralised approach is essential towards “improving access to basic services; increasing people’s participation in decision-making; assisting in developing people’s capacities; and enhancing government’s responsiveness, transparency and accountability”.

Uganda’s constitution of 1995 provides the tenets of the decentralisation process where it outlines the government’s mandate in providing financial technical and skilled manpower support to ensure that power at different levels is distributed to the appropriate institutions and people. In order to give effect to the provisions of the constitution, the Local Government Act was enacted in 1997 and later amended in 2001. Among other provisions, the act provided for the structuring/distribution of power down to local governments from the district level to the town council or village council. The local government councils provided for within a district are:

- The District or City Council

- The Municipal Council
- The City Division Council
- The Municipal Division Council
- The Sub-County
- The Town Council Administrative

Councils in a district are:

- The County Council
- The Parish or Ward Council
- The Village Council

Local government and administrative units are known as local councils. Local councils are further classified as either rural or urban:

Table 2.4. Local government and administrative units in Uganda. Source: Mugabi (2004:7).

Rural local council	Urban local council
District Council County Council Sub-County Council Parish Council Village Council	City Council City Division Council Municipal Council Municipal Division Council Town Council Parish or Ward Council Village Council

However, even if the constitution provides for this bottom up approach that prioritises the needs and contributions of the people in the decision-making process, much of what is currently in practice is primarily a top-down approach where laws are passed and the local government structures are expected to implement them. This could be partly attributed to lack of awareness of the people of their roles in the decision-making process as well as a lack of sufficient resources at some of the lowest local government levels to enable effective mobilisation of their communities to participate in the diverse processes. The lack of stronger lower/local government structures undermines the interactive process in decision-making and policy formulation that is meant to enable policies to evolve with the changing dynamics at the various levels. More so in the framework of policy evolution or co-evolution where the needs or processes of the various actors at micro/ local government level are crucial in creating meaningful change or evolution of policies.

2.6 Sustainable materials management (SMM)

Chen et al (2016:1) argue that comprehensive “sustainable materials management” (SMM) is a crucial framework towards “developing environmental policy” and optimizing resource efficiency. This framework entails a detailed understanding of the life cycle stages of the construction materials right from the natural resource inputs stage to the consumption and production as well as the outputs and disposal stages. Due to the complexity of this system, Chen et al (ibid) highlight the need for collaboration of different government bodies, civil society and professional organisations in order to collect and share the necessary data on the construction materials sector, public awareness and appropriate policy formulation to guide sustainable development of the construction materials sub-sector. Though the SMM framework may pose an initial challenge for a country like Uganda with minimal data on the construction materials sector and a weak track record in collaboration between the different government ministries, it would serve as a crucial guide for the development of efficient and resilient policies for the sector and the economy as a whole.

2.7 Policies and regulatory framework in relation to construction materials in Uganda

Public policies regarding sustainable growth and development of Uganda’s construction industry, and especially the construction materials sector, are not adequately comprehensive to efficiently guide the industry. As an example, bits and pieces on LCI of construction materials are included in the National Environment Management Policy 1994, National Energy Policy 2015 (NEP), National Construction Industry Policy, Building Control Act and most recently the Uganda National Climate Change Policy. In its objectives, the NEP (2015:39) generally notes that it aims to promote low impact alternative sources of energy, “reduce energy related emissions” and “efficient utilisation of energy” resources among others. Similarly, The National Construction Industry (2010:43), stipulates that in its measure to promote sustainable economic and social development, it shall:

Conduct environmental and social impact assessments during planning, development and maintenance of physical infrastructure and ensure that adequate mitigation measures are provided for.

Although one would expect the above policies to have taken a strong stance on the choice, standards and environmental impact of construction materials like burnt clay bricks and cement, they have kept a remote distance to these crucial industries and sub-sectors. In so doing, they have created room for the sub-sectors and their key actors in the market to escalate the impacts of their operations to destructive levels. This study therefore investigates the implications of the policy gaps in relation to the operations of the cement and burnt clay brick sub-sectors. This is followed with recommendations towards addressing the gaps in order to ensure a healthy and synergetic co-evolution of practices with the responsive regulatory policy framework as well as adequate institutional capacity for implementation. Some of the key elements for this to happen would be accurate/systematic policy data-sets, monitoring and data sharing.

Chapter 3 Research Method of the Study

3.1 Introduction

The chapter presents and motivates for the methods of the study and focuses on the processes taken within the qualitative study approach. The main data required were those on the environmental impacts of the burnt clay bricks and cement sub-sectors as well as the co-evolution trends of the different policies meant to mitigate these impacts and guide the sustainable development of the construction materials sector. It is divided into five main parts which are the research design, data collection, summary of the data requirements for each sub-question presented in a table format, the ethical considerations and lastly the limitations encountered during the entire process of the study. The methodology helps to ensure that the required data are collected and analysed within an ethically acceptable framework of the university.

3.2 Research design and overall approach

The study adopts a qualitative research approach as it facilitates for the "exploring and understanding the meaning individuals or groups ascribe to a social or human problem." (Crewel, 2014:32). In this case, the social problem is the environmental impact of two commonly processed and used construction materials in Uganda, that is burnt clay brick and cement, and the stakeholder groups are the concerned policy makers and those directly engaged in the production, environmental, natural resource management, construction and trade issues of the materials. The study also adopts a case study approach based on the study of two manufacturers, one for cement and the other one for burnt clay bricks. The case study for cement was chosen from one of the largest and oldest manufactures, Hima Cement Limited, which allowed for the study of cement production trends over a period of about 30 years. The case study of burnt clay bricks is a small-scale manufacturer, Butende Brick Works, in a semi-rural location where bricks are largely utilised by middle-income earners and institutions. The choice of this manufacture was mainly motivated by the fact that it has been in operation for over 20 years and has been formally organised which made it easier to study the different life cycle processes and possible changes/improvements in the sub-sector.

3.3 Data Collection

Qualitative data collection tools were employed to gather both primary and secondary data. The tools include review of documents, interview guides, direct observation and visual recording (mainly through photography) (Crewel, 2014). Secondary data were collected from documents such as Uganda and international policy documents in order to establish the stance of the concerned ministries and organisations on the life cycle processes of construction materials. Additional secondary data were obtained from print media and statistical documents with regards to supply, demand and environmental impacts of these materials so as to understand the current level of research and action around burnt clay bricks and cement and other construction materials on the market. The primary data were collected through the direct observation of actual processes and impacts of the case study operations and also through open ended interviews of two professionals in the construction industry, four government officials, and one respondent employee at the burnt clay brick factory.

3.4 Primary Data

Primary data were mainly collected from three main sources (direct observation, interview and visual material such as maps). With the method of observation, the researcher was a complete observer during a site visit to the brick manufacturing factory so that she can witness the different mining and manufacturing processes and also observe some circumstances that may be obvious to the participants (Crewel, 2014). The main tool used was an observation guide which aided the researcher on what key areas to observe and document. Due to the limitations discussed under section 3.5, the researcher could not make direct observations on the Hima Cement case study. Instead, secondary data were relied upon for this case.

The interview method was used to acquire in depth information that had not been written about previously, historical information or that which has not been observed (ibid). The respondents interviewed were of three main categories and they included three policy makers, a participant manufacturer of burnt clay bricks, two construction industry professionals (an architect and engineer). The policy makers were purposely chosen from different ministries that have an influence on the life cycle processes of the construction materials sector (National Environment Management Authority, Ministry of Energy and Mineral Development and Ministry of Works and Transport). The construction industry professionals (the architect and the engineer) were purposely selected because of their role in specifying these materials and would therefore give an insight into what influences their choice of construction materials and their understanding of their environmental impact of burnt clay bricks and cement along their life cycles. The materials manufacturers were selected because of their in-depth understanding of the inputs and outputs of the mining and manufacturing processes along the materials life-cycle. An open ended interview approach (using interview guides as tools) was adopted in order to interface and capture data from the different respondents.

Lastly, visual materials such as satellite images from Google maps of particular sites taken over a certain period of time were used to gather some physical data as it is a creative way of capturing information and also not very intrusive (ibid). Such maps showing the extent of the limestone deposits and deforestation trends were studied and adapted so as to complement the data on the impacts of extraction and manufacturing of cement and burnt clay bricks.

3.5 Secondary Data

These data were collected from sources such as policy documents, government statistical abstracts, academic journals as well as technical reports in order to derive findings on policy co-evolution processes versus the production and consumption trends, the value chain and life cycle processes and inventory of the cement and burnt clay brick sub-sectors. Some of the key policy documents reviewed were the National Environment Policy, The Energy Policy of Uganda, The Public Health (Buildings) Act, The Mining and Minerals Policy and The National Industry Policy of Uganda so as to establish the stance of these policies with regard to regulating or minimising the environmental impacts of the construction materials sector. In addition, statistical release documents by the Uganda Bureau of statistics were studied (in order to extract data on production and consumption trends) and print media articles so as to understand the current level of concerns around burnt clay bricks and cement sub-sectors. Crewell, (2014) argues that collecting data using documents is advantageous as it can easily be obtained at the required time.

3.6 Summary of data requirements per sub-question

This sub-section illustrates the various data required for each sub-question and the tools that were required to obtain this data as well as the data analysis processes. In doing so, it outlines the different data processes that were undertaken to achieve the sub-findings which in turn answer the main sub-question.

Table 3.1. Summary of data required per research sub-question.

Research sub-questions and overall research question	Data needed Data collection tools Data collection processes	Data analysis and processes
Sub-question 1 What have been the key drivers of the consumption and production trends of burnt clay bricks and cement?	The main source is secondary data which comprises; -Statistics for the net domestic supply and consumption of burnt clay bricks and cement. -The use categories of these materials (for housing, institutional and civic works). -List of the variations of market products from cement and burnt clay. -Identification of the key actors in the production and consumption of these materials. Primary data comprises. -The production methods adopted by the two	Data were categorised by the total quantities produced over a certain number of years. Also, total consumption over a certain period of time by different entities. The data are mainly represented on tables and graphs.

	case study manufacturers of cement and burnt clay bricks. Sources of data Electronic and printed data in the form of journals, print media documents and books as well as interview guides, observation guides and photography.	Derivation of sub-findings is based upon the quantities produced and consumed as well as the key drivers of the trends and the production methods adopted. Analysis and sub-finding are substantiated in Chapter 4.
Sub-question 2 What have been the critical environmental impacts of burnt clay bricks and cement?	Primary data comprises; Life-cycle Impact Analysis (LCIA) of burnt clay bricks and cement through site visit and observation of the factories. Tools Semi- structured interviews and photography, observation guide.	Data were categorised among the inputs, the market and the output of the burnt clay bricks and cement industries. Derivation of sub-findings was based on the social and environmental impacts of the materials along their life-cycle. Analysis and sub-finding are presented in Chapter 5.

	Secondary data comprises; Embodied energy (EE) of burnt clay brick and cement. The documented social and environmental impacts of burnt clay bricks and cement. Sources of data Electronic and printed data, newspaper articles, journal articles, documents books and maps.	
Sub-question 3 What have been the policy evolutions with regards to the regulation of the burnt clay bricks and cement sub-sectors?	Mostly secondary data were collected and comprised of: -A comparative analysis of national policies over time and their stance on the burnt clay bricks, cement and generally the construction material sub-sector. Sources such as the National Environment Policy, National Energy Policy, National Construction Industry	Data is categorised into different policies that are relevant to processes along the life cycle of the construction materials and how they respondent to critical issues identified. Derivation of sub-findings is based upon the changes in policy over time as regards the life cycle of the construction materials.

	Policy Building Control Act and Ministry of Tourism, trade and industry policy. -The core priorities of Uganda's vision 2040, Climate change strategy as regards to sustainable construction material sub-sector. Sources of data Electronic and printed data like newspapers, journals, documents and books	Analysis and sub-finding are substantiated in Chapter 6.
Sub-question 4 What is the overall responsiveness of policy to the escalating environmental impacts of the construction materials sector and how could this be improved?	Secondary data: Understanding of policies and how they are changing with changing trends in the construction materials sector and the environment. -Proposed recommendations for effective policy evolution and better industry practices Sources of data Electronic and printed data like newspapers,	Data are categorised into different policies that are relevant to processes along the life cycle and embodied energy of the construction materials sector. Derivation of sub-findings is based upon the level of awareness/consciousness of the current policy frameworks towards development of a sustainable construction

	journals, documents and books.	materials sector. Analysis and sub-finding to be substantiated in Chapter 6 and 7.
Overall research question: The sub-findings from the 4 sub-questions were consolidated in order to derive the main findings of the study as presented in Chapter 7.		

3.7 Ethical considerations

Birch et al (2002) argue that ethics essentially requires good and respectful conduct and thus constitutes a basis for good judgment under different contexts. Due to some of the qualitative data collection methods such as interviews and site visits, some of the key ethical issues such as respecting privacy, confidentiality as well as seeking informed consent before data collection were addressed. For example, with the participant information sheet and consent form signed by the participants, the intentions of the researcher were declared, participants were informed about the nature of the research, their role was explained and anonymity was guaranteed.

Prior to the site visit of the brick works factory, consent to carry out the study and take photographs was obtained from the factory. Photography on the site, as a direct observation tool, was carried out with the consent of the participants and data collected were used for the research report only. In addition the data collected were stored on a private password protected computer and the anonymity of the respondents maintained throughout the research report. To confirm adherence to these provisions, an ethics clearance certificate was obtained from the University of the Witwatersrand and it is attached in the appendices (see Appendix B).

3.8 Limitations to the study

Some of the limitations experienced by the researcher were due to restrictions in accessing the production sites of the proposed case studies, especially Hima Cement Limited and some of the government officials. This was mitigated by relying on data from secondary sources such as print media, journal articles and technical documents on Hima Cement Limited and related case studies and also comparing official reports from credible sources to ensure that the data were matched. Given that the burnt clay brick sub-sector does not comprehensively document some of its processes, the primary data were supplemented with secondary data.

In addition, the researcher experienced some financial and time constraints as data collection involved travelling to Uganda to visit the case study sites and interview the respondents. This required stringent financial planning and continuous working on the research report while the researcher was in the field. In addition, due to the time, technical and financial resource constraints, the researcher did not focus on compiling the detailed quantified life cycle inventory phase but rather focused on the impact assessment component while highlighting the inventory operations and systems relevant to this component. Furthermore, detailed data on the life-cycle processes and inventory of the cement and burnt clay brick sub-sectors in Uganda were scarce and not systematically documented. The researcher therefore relied on comparison with similar case studies from multiple sources or countries and incorporated the data that became available to complement what were collected during the site visits as well as researcher's work experience as a practising graduate architect. The sectoral input-output data were also not systematically captured in Uganda's statistics documents and therefore some of it were captured from very diverse sources and had to be compared and contrasted in order to get a more coherent picture.

Chapter 4 Consumption and production trends of cement and burnt clay bricks

4.1 Introduction

This chapter presents both secondary and primary data and the analysis towards sub-findings for sub-question 1 which is; ‘What have been the key drivers of the consumption and production trends of burnt clay bricks and cement?’ The analysis and substantiation is presented for each construction material (cement and burnt clay bricks) based on the trends and processes of the two case study manufacturers (Hima Cement Limited for cement and Butende Brick Works (BBW) for burnt clay bricks).

The chapter first appraises data on the overall trends in the production, consumption and supply of each material at national level while focusing on the changing trends in capacities and the key factors influencing these trends. Then it examines the value chain of each of the case studies so as to unpack and analyse specific data on the consumption and production trends under each material producer. The value chain was studied under the following three key themes that vary with each material:

- Raw material extraction
- Production trends (capacities produced, organisational structures and technology adopted)
- Distribution
- Sales and consumption

Primary data were obtained through direct observation during the site visit to BBW factory and an interview with its production manager as well as other respondents such as a professional and practising engineer. This was supplemented by secondary data from print media, academic journal articles and technical reports so as to extract data on production trends of Hima Cement Limited and BBW in order to close the gap on the critical data that could not be obtained through site visit or interviews. By understanding the production and consumption trends, the major actors and processes are identified in order to guide the approach to better/coherent planning within the sub-sector.

4.2 Trends in Uganda’s cement production capacity

Uganda’s cement market started with a sole company, Uganda Cement Industries, which was a government parastatal set up in 1953 and later privatised in 1994 by way of splitting into

Hima Cement Uganda and Tororo Cement which were sold to two different investors. The production capacity of Uganda Cement Industries then was a paltry 70,000 tonnes of cement per annum. Eleven years later after privatisation, the production capacity of both Hima Cement and Tororo Cement had grown to 692,710 tonnes, a 890% increase in production (Uganda Bureau of Statistics, 2010) and to 2,330,000 metric tonnes of cement in 2015 (see Table 4.2). This sharp increase in production capacity was stimulated by political stability in the early 1990s, increase in capital investment by privately owned manufacturing companies, adoption of better production and management techniques as well as better economic development policies that supported private sector investments over that period.

Currently, Uganda's cement industry has an installed capacity of 3.7 million tonnes of cement (Khisa, 2017) with the three main players in the market being Tororo Cement in Tororo District, Hima Cement in Kasese District and a relatively new player, Kampala Cement located in Mukono District (see Figure 4.1). Tororo Cement Ltd. has the largest` market share at 51% and Hima Cement accounts for 9% and imports the remainder from Bamburi Cement of Kenya, both of which (Hima Cement Ltd and Bamburi Cement) are subsidiaries of the global company, LafareHolcim Ltd. The relatively newer company, Kampala Cement also displayed a substantial market share in terms of its installed capacity of 1.0 Mta, thus placing it higher than Hima Cement Ltd. (see Table 4.2).

However, it is important to note that if all the companies were to produce at installed capacity, there would be a surplus production of 1.4 Mta relative to local market demand. Furthermore, the expansion in cement production capacity comes at a time when cement prices are already falling, from Uganda Shs.33,000 (approximately $10) in 2016 to Shs.28,000 (approximately $8) per 50kg bag in 2017 and this was attributed to increased competition in the market (Khisa, 2017). With more cement production companies entering the market, the current fall in prices may be the start of price wars and possible reduction in profit margin within the industry. Khisa (ibid:1) argues that this capacity surplus is likely to lead to "sub-optimal utilisation rates, hence rising operational costs and compressed margins among the cement producers."

Additionally, in order to supplement local production, Uganda imported 335,000 metric tonnes of cement in 2015 (see Figure 4.3) from Kenya, South Africa, India and United Arab Emirates, among others (*Cement production set to increase*, 2016). However, the trend of importation of cement has shown a gradual reduction over the years. For example, the quantity dropped by 168 tonnes from 2010 to 2015 (from 503,000 metric tonnes to 335,000 metric tonnes as shown in Table 4.1). This was attributed to the increase in capital investment and improved production techniques such as value addition to locally produced clinker in order to achieve higher grade cement which was previously being imported. This is currently done by Hima Cement Ltd. In an interview with the Daily Monitor Newspaper in Uganda in February (2017), the CEO of the Uganda Unit, confirmed that unlike other companies in the market importing clinker from Kenya, Hima Cement adds value to the limestone to get clinker. However, due to lower duty on cement imports in Uganda from non-East African community countries, cheap imported cement still floods the market and they offer lower prices that could also weaken Ugandan producers.

Table 4.1. Installed and projected cement production capacity of Uganda in 2016. Source, Khisa, (2017).

Cement company	Installed capacity (million tonnes per annum(Mta))	Expected expansion (Mta)	Projected total production (Mta)
Tororo Cement Ltd.	1.9	1.1	3.0
Hima Cement Ltd.	0.8	1.0	1.8
Kampala Cement Co. Ltd.	1.0	-	1.0
Simba cement	-	1.0	1.0
Totals (Mta)	3.7	3.3	6.8

According to UBOS (2016), the net domestic supply of cement in Uganda was 2,234,000 tonnes per annum in 2015 and the volume has been gradually increasing over the years (see Table 4.2). For example in the last 6 years, the percentage increase in the net domestic supply of cement was approximately 50% (ibid). This value implies that cement consumption has been steadily increasing too over the past six years which in turn has influenced net domestic supply of cement. However, the specific quantities consumed by the sectors of the economy are not documented in Table 4.2.

Table 4.2. Annual change in NDS (‘000 Tonnes): Source: UBOS (2015:61).

Category (000 metric tonnes)	2010	2011	2012	2013	2014	2015
Production	1,347	1,666	1,780	2,023	2,141	2,330
Imports	503	501	449	322	397	335
Exports	362	502	556	593	485	431
Net Domestic Supply (NDS)	1,489	1,665	1,673	1,752	2,053	2,234
Annual change in NDS		11.8	0.5	4.7	17.2	8.8

Nonetheless, data from UBOS (2016) revealed that residential developments followed by commercial developments were the most dominant in number of plans approved and occupational permits issued in 22 municipalities in Uganda (see figure 5 and 6).

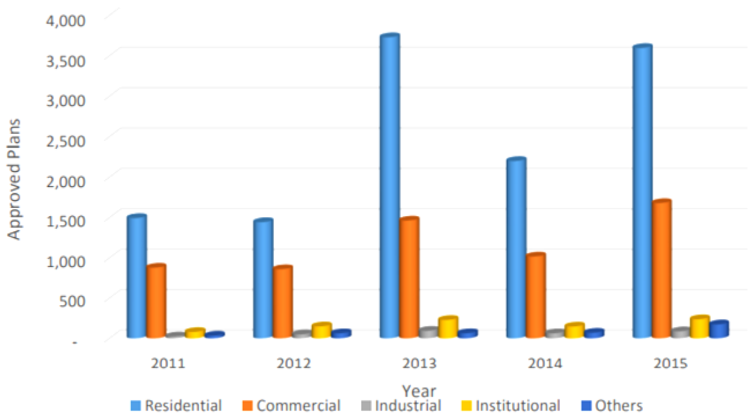


Figure 4.1. Approved plans by category between 2011 and 2015. Source: Uganda Bureau of Statistics (2016:69).

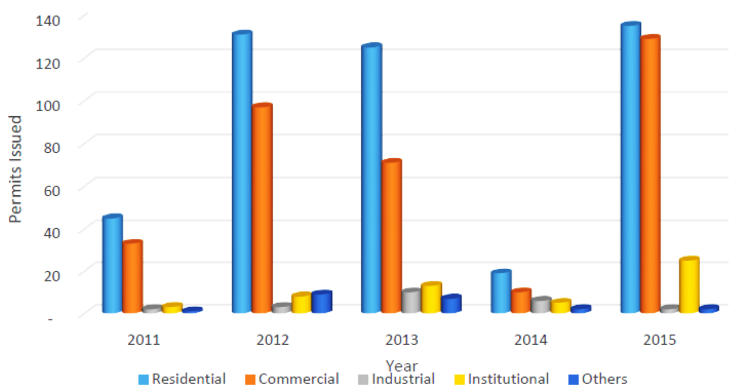


Figure 4.2. Occupational permits issued by category between 2011 and 2015. Source: UBOS, 2017:69.

With cement and clay bricks being the most common construction materials in Uganda, the data above indicates that residential and commercial construction projects could be the largest consumers of cement and burnt clay bricks in Uganda. Tables 4.1 and 4.2 show that 2014 had the least number of approved plans and occupational permits issued especially for residential developments. Even with these low figures, there was an increase in in the NDS of cement between 2014 and 2015 of about 8.8%. This percentage increase could have been consumed by the civil engineering sector. Civil works of road and infrastructure development by the government have significantly contributed to the consumption of cement and expansion of the cement industries. For example, there have been major infrastructure projects in the past five years which include the construction of 250 MW Bujagali and 500 MW Karuma hydropower dams, 620 Km of paved road surfaces, road bridges and culvert bridges (UBOS, 2016). It is also noted that the increase in production capacity of some cement production companies such as Hima Cement Ltd. has been mainly driven by "speculative growth to meet the anticipated demand as government rolls out infrastructural development projects including hydropower dams and oil and gas installations" (Khisa, 2017).

In an interview with the Daily Monitor newspaper (Muhumuza, 2017), the CEO of Hima Cement Ltd. said that one of the reasons they increased their production capacity was in order to be able to supply cement to the Standard Gauge Railway (SGR) Project whose construction was anticipated to commence in 2018. The other projects and quantities in which Hima cement signed a memorandum of understanding to supply cement are 30,000 tons for the Entebbe Airport expansion, 30,000 tons for Mubende-Kakumiro-Kagadi road and Soroti-Moroto road projects (LafargeHolcim, 2017). Such civil works projects heavily utilise structural concrete which has cement as one of its major inputs and thus have significantly contributed to the levels of local consumption and importation of cement and the expansion of local cement plants.

Additionally, cement from Uganda is exported and consumed in other markets such as Rwanda, Democratic Republic of Congo and South Sudan (see Figure 4.3). In 2015 for example, 431,000 metric tonnes were exported which reflects a reduction of 27% in comparison to the 485,000 metric tonnes exported in 2014 and the 593,000 metric tonnes exported in 2013 (see Table 4.2). This was attributed to the on- going political instability in two of the major export markets of South Sudan and the Democratic Republic of Congo since 2013 (Khisa, 2017).

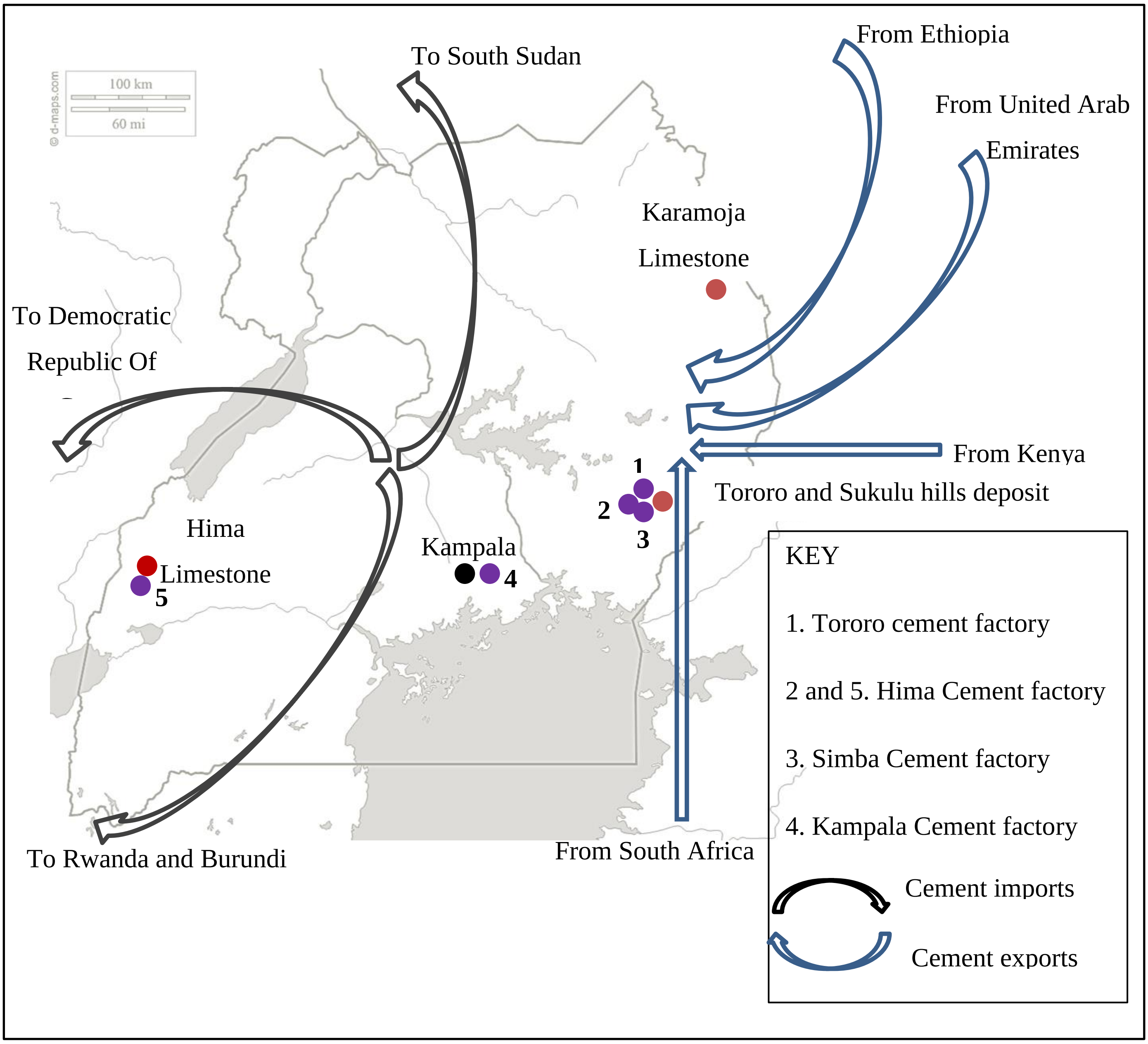


Figure 4.3. Cement industries, limestone deposit sites and direction of imports and exports of cement in Uganda. Source: d-maps.com.

4.3 The value chain of cement produced by Hima Cement Ltd.

This section explores the nature of the different structures of Uganda's Portland cement industry (with a focus on the case study Hima Cement Ltd) from the raw material extraction phase, to the production phase, to distribution and consumption and finally the use and disposal phase (see Figure 4.4 and 2.2).

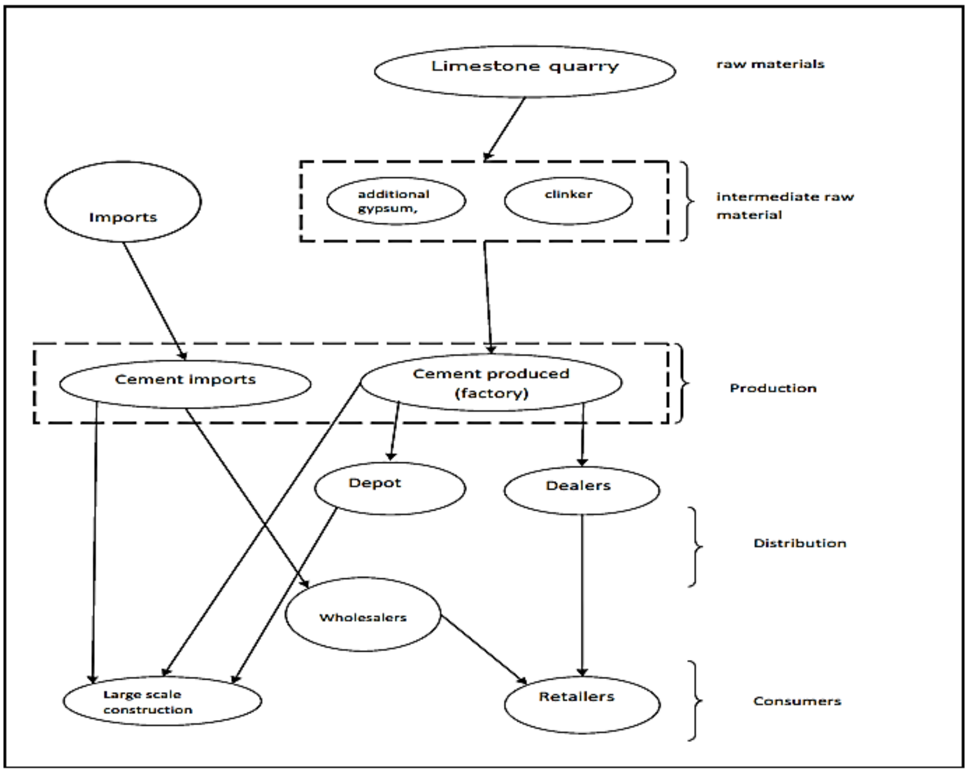


Figure 4.4. The value chain of cement in Uganda. Source: Mbongwe et al, 2014:5

4.3.1 Limestone extraction by Hima Cement Ltd

Hima cement extracts limestone of varying quality from three quarries, which are; Musekura and Hima quarry in Kasese District and Dura quarry in Kamwenge district (see Figure 4.5). The limestone at Musekura and Dura is secondary limestone derived from calcrete tufa (lake derived limestone) and the one at Hima is true limestone (Uganda Investment Authority, 2017). Secondary limestone is deposited from "solution in cracks and cavities of other rocks" and primary/true limestone is that which may be "crystalline, clastic, granular or massive depending on the method of formation" (Kogel, 2006:582). The deposit at Dura is approximately 2 million tonnes but has been partially eroded and the one at Musekura is estimated at 543,400 tonnes, whereas the one at Hima is quite extensive at 20 million tonnes with a maximum thickness of 7.5m and covering an area of about 500 hectares. However, only 6 million tonnes of the Hima quarry deposits are suitable for the manufacture of Portland cement (ibid).

The existence of these deposits at Hima largely influenced the location of the main cement production factory there. In an interview with the Daily Monitor newspaper (Muhumuza, 2017), the CEO of Hima Cement Ltd stated that in addition to the three quarries in western

Uganda, the company is in the final stages of an exploration process for limestone in Karamoja, north-eastern Uganda. Based on the prospects from the exploitation of the reserves, they have set up a grinding station in Tororo, closer to the mines and also aims to set up a clinker line after they determine if the quantities of limestone reserves are commercially viable to support such a venture.

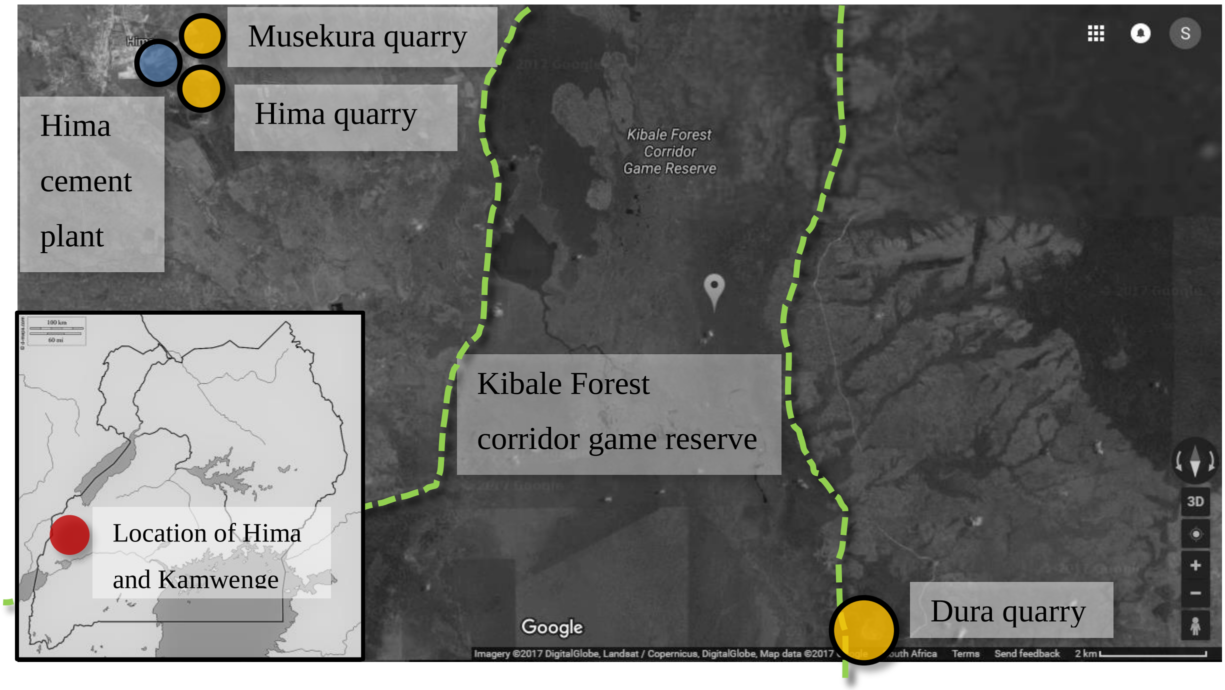


Figure 4.5. Hima Cement limestone quarries. Source: Adapted from Google Earth, 2017.

The method of mining used at the different quarrying sites in Kasese and Kamwenge is open cast mining (NAPE, 2009). Excavation of the top soil reveals the limestone which is then drilled to obtain samples for chemical analysis which then guide further drilling and blasting using explosives so as to disintegrate the limestone rocks into smaller chunks that are easier to transport (ibid). It is then loaded on tipper trucks and transported to the open yard storage at the factory where the limestone and the other required raw materials are stored and homogenised. From the Dura quarry, the limestone is transported approximately 18 km, through the Kibale forest corridor within the game reserve, to the open yard in Hima. For both Musekura and Hima quarry, the transportation distances to the yard are much shorter as they are located in close proximity to the factory (see Figure 4.5). From the storage yard, the limestone is then transported by trucks and unloaded into the hopper of the limestone crusher which marks the beginning of the production process (SEG-MUK, 2014).

Figure 4.6. Image showing trucks and excavators at Dura quarry. Source: National Association of Professional Environmentalists (NAPE), 2015.

Figure 4.7. Images of a drilling machine on the left and the hopper of a limestone crusher on the right at Hima Cement factory. Source: SEG-MUK, 2014:2, 3.

4.3.2 Manufacturing of cement by Hima Cement Limited.

The overall processes at the factory are fully mechanised with the main source of energy for the machines being hydro- power from the grid and backup power from diesel generators. According to LafargeHolcim (2107), the four major processes involved in the conversion of the raw material to cement are crushing, stacking and reclaiming, raw meal drying, grinding and homogenisation, clinkerisation, and finally cement grinding, storage and packing. These are common across cement producers in Uganda but it differs for Hima Cement in the nature of technology adopted, the mix of kiln fuel used and the value addition to the clinker.

In the crushing, stacking and reclaiming process, the limestone and some clay mix are crushed in a jaw crusher and an impact crusher that reduce the particle sizes to below 50mm. The material is then transported by a conveyer belt over a bulk-material analyser to ensure that the required quality is maintained. The raw material is then stored in a circular raw mixer for homogenising and thereafter conveyed to a raw mix bin for grinding. Other additives such as high purity limestone, sand and iron ore are also crushed and ground independently to the required size and consistency. Further on, for the second phase of drying, grinding and homogenisation, the raw mill mix (high grade limestone, sand and iron ore) are fed into air swept mills for drying and fine grinding. The mill is continuously fed with hot gases from a preheater. The material feeds to a separator that sifts the fine from the coarse material. The reject coarse material is sent back for further grinding and the fine material, now called raw meal is sent to a 'Cyclone' and an air slide called an 'Aeropol' is used to separate the fine materials from the gases. The very fine material called pre-heater dust is collected and conveyed to another air slide where it is mixed with the fine materials and transported to an air lift vessel. From here, it is lifted to a concrete silo by compressed air where it is stored and homogenised. The fine raw material mix is called kiln feed.

The next phase, clinkerisation, is one of the most heat intensive phases in the cement manufacturing process. Hima Cement Ltd. installed a 5 stage precalciner kiln (considered to be more energy efficient) in 2010. The kiln feed is loaded into a pre-heater kiln system preheated by heat from the combustion chamber and then transferred to a rotary kiln and heated at 1,500^{0}C to form clinker components. The main source of fuel for the kiln is fuel oil and about 53% biomass components such as coffee and rice husks that are injected into the kiln flume by specially developed technology (LafargeHolcim,2017). At such a high temperature, the kiln feed is converted into clinker. The hot clinker then drops onto a grate cooler where it cools down to approximately 120^{0}C. The air needed to cool the clinker is extracted from the atmosphere and pressurised through the cooler plate and clinker bed. The cooled down clinker is then transported to the clinker storage from where it is fed into the cement ball mill hoppers for cement fine-grinding.

Some of the hot air extracted from the clinker cooling process is re-used as secondary or tertiary heat for combustion in the kiln. The clinker, gypsum (3-5%) and different additives are then fed to the cement mill that grinds the feed into a fine powder which is then stored as the final product in concrete silos. From the silos, the cement is conveyed to automated electronic packers at 50 Kg per paper bag. The packed cement is stored for subsequent dispatch to depots by trucks. From previous studies, the overall energy requirements of these manufacturing processes represent between a fifth to a third (20 to 33%) of the production costs in most cement factories and in others it represents nearly 40%" of the total costs. These estimates may be close to the energy consumption levels/costs of Hima Cement (Taylor et al, 2006 and Otterman, 2011),

Figure 4.8. Brands of cement produced and distributed by Hima Cement Ltd. Source, LafargeHolcim, 2017.

4.3.3 Cement distribution and use

From the factory, Hima Cement Ltd contracts independent logistics companies that use trucks and bulk cement tankers to deliver the product to its major distributors in western and central Uganda, Rwanda and South Sudan or directly to major construction sites. The chain of supply from the major distributors then moves to the hardware shops and smaller retailers from where the specific quantities consumed and nature of consumers are harder to trace because of the large prevalence of the small scale informal sector customers. The cement is either used directly in construction projects (especially in civil works, residential and commercial projects) or in the production of downstream concrete products such as concrete pavers, blocks, culverts and edge curbs, among others.

However, Hashemi et al (2017:7872) highlight the fact that the prevailing construction and production methods are very "inefficient, wasteful, energy intensive" which has led to high production costs and environmental degradation. This is well illustrated in Figure 4.9 that shows the excessive use of mortar in construction and the wastefulness and inefficiencies of the informal technologies of production of concrete products.

Figure 4.9. Excessive use of mortar in wall construction in Uganda (Source: Hashemi et al, 2015: 7874.) and making concrete products at O and E concrete and Engineering works (Source: Ugabox, 2017).

4.3.4 Challenges faced by Hima Cement Ltd.

In an interview with the Daily Monitor newspaper (Muhumuza, 2017), the CEO of Hima Cement Ltd. mentioned that the costs of production of cement in Uganda are very high compared to the case of Bamburi Cement in Kenya which is another subsidiary company of LafargeHolcim in East Africa. He attributed this mainly to the unreliable power supply, high power tariffs (at $ 0.11 per kWh for industrial users) and high transport costs. There are frequent power cuts throughout the country and Hima Cement installed back- up diesel generators to ensure that production continues even with the interruptions. In addition to this, 40 % of the fuel needs of the plant are met by petroleum which is transported from Mombasa, Kenya to Kasese (approximately 1,500 Km), over sections with poor road infrastructure. This is not only an expensive undertaking but also further contributes to emissions from the fuel trucks. Furthermore, the need for value addition to locally produced clinker (especially because of the low quality of some of the limestone deposits) has also significantly pushed up the cost of production in relation to other cement companies in Uganda that import the clinker from Kenya, South Africa or China, among other sources. The CEO stated that Hima Cement also faces stiff competition from cheaper imports from countries such as India, China, United Arab Emirates and South Africa. The imports attract relatively low import duties and therefore are able to sell at slightly cheaper prices which weakens the position of locally produced cement.

4.4 Background of Uganda's burnt clay brick industry

ADA (2017:4) argues that no systematic mineralogical investigation has been carried out to determine the quality and quantity of Uganda's clay deposits suitable for brick making apart from limited studies on a few areas such as "Kajjansi in Wakiso district, Bugungu in Mukono district, Buteraniro in Mbarara district, Butende in Masaka, Malawa in Tororo and Butema in Hoima district" (see Figure 4.10).

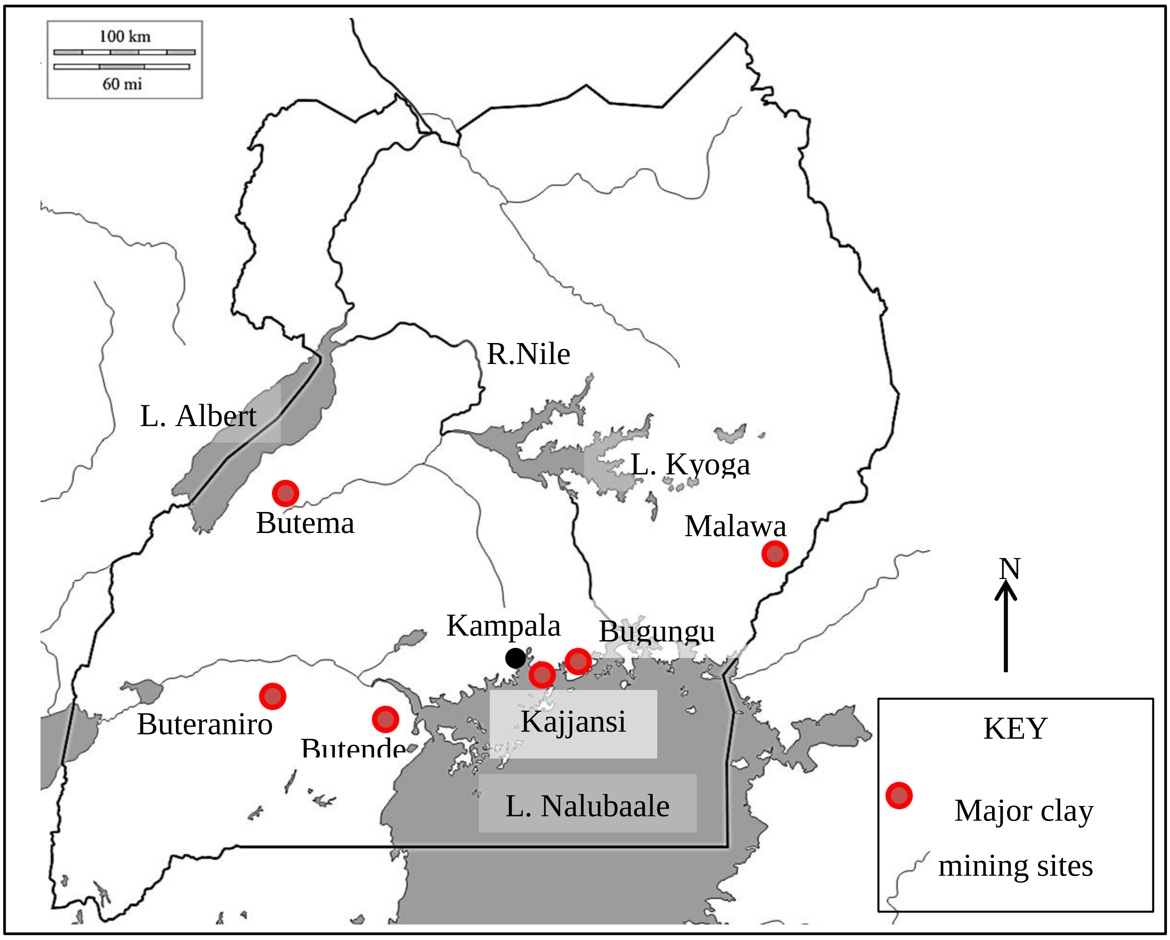


Figure 4.10. Location of major clay deposits as of 2017. Source: Adapted from maps.com.

Due to the scale and technique of production, the burnt clay brick industry in Uganda is classified into three major categories which are; artisan, small scale and medium scale production units (UNDP, 1989). The growth and development of the artisan and small scale production units is not well documented because of the dominance of informal operations and dealings. However, the medium-scale production units and some small-scale operations exist as registered businesses with slightly more formal and documented processes.

The first medium- scale brick manufacturing company in Uganda was Uganda Clays which was set up in 1950 close to the clay deposits at Kajjansi and water resource from Lake Victoria. Other medium sized industrial players that have grown over the years include Lweza Clays Ltd, Pan Uganda Ltd and HERM. Such formal production operations use mechanised production processes while the small-scale producers such as Butende Brick Works (BBW) and some brick production clusters in Kajjansi, Mbarara and Njeru adopt semi-mechanised processes. The nature of the artisan brick producers ranges from individual producers, to groups of 3- 5 people and families who use handmade tools and clamp fired kiln bricks (World Bank, 1989).

4.5 Production trends of burnt clay bricks in Uganda.

Data on the total quantities produced or the installed capacity for production of burnt clay bricks in Uganda is not readily available due to the dominance of the informal brick makers and other informal operations that practice limited book keeping or minimal reporting to the concerned bodies. World Bank statistics (1989) showed that the artisan producers were the largest and most widespread manufacturers of burnt clay bricks in the country. Even though the artisan brick maker was noted to be manufacturing the lowest number of bricks at about 1,000 bricks per cycle (a capacity which has grown to approximately 9,000 bricks as of 2015 (see Table 4.4)), their collective quantities are higher than the medium and small- scale brick makers. The medium- scale operations produced approximately 8,750 tonnes a year, which value has also significantly increased to 70,000 tonnes per year in 2015 (see table 4.4). The overall trend across all the producers shows a substantial increase in production capacity due to expansion of production plants and better organisation by artisan and small scale producers in order to meet the increasing demand. However, the World Bank (1989) disclosed that at the apparently high rate of production, there was an extreme shortage of bricks and tiles especially due to the housing and infrastructural backlog.

Table 4.3. Production trend of Uganda's brick and tile industry. Source World Bank: 1989:6, Emerton et al., 1998, Businge, 2014 and Uganda Clays Ltd, 2016)

Scale of production	Number of bricks per cycle (average) in 1989	Number of bricks per cycle (average) in 2015
Artisan producers	1,000	9,000
Small- scale producers (BBW)	10,000	50,000
Medium- scale producers (Uganda Clays Ltd)	8,750 tonnes per year	70,000 tonnes per year

4.5 Consumption trends of burnt clay bricks

The products of medium- scale producers such as Uganda Clays Ltd are mainly consumed by a niche market of individual consumers for commercial and residential projects and corporate consumers such as construction firms, agencies and institutions. They comprise a minor percentage of the total brick consumed and used throughout the country mainly because of the higher prices at about Ug.Shs. 1,000 per brick (about R 3.30). The most consumed bricks in the urban, peri- urban and rural markets are those produced by artisan brick makers (World Bank, 1989) and it is mainly because of ease of access by buyers and low cost of the bricks (between Ug.Shs. 100- 300, approximately R 0.30- 1.00 per unit) compared to the small and medium- scale producers.

Even though the nature of their burnt clay bricks is highly irregular, unevenly sized, have poor structural qualities and very high embodied energy due to inconsistencies in quality control in the production process (Hashemi et al, 2015), they are relatively affordable to the low and medium income earners. Brick products from small-scale producers such as Butende brick are consumed by some medium income individuals and some corporate organisations who are interested in fairly good quality burnt bricks at an affordable rate of Ug.Shs. 500 per unit (approximately R 1.67). The respondent at BBW pointed out that the quantities consumed by the different parties are never constant or frequent (only a limited number of repeat individuals, institutional and agent customers).

4.6 The value chain of Uganda’s burnt clay brick industry.

According to the African development Agency’s (ADA) report on brick cluster development in Uganda (2017), the value chain of Uganda’s burnt clay brick industry comprises of five major steps which are raw material extraction, production of bricks, packaging and presales, marketing and finally sales, post- sales and reinvestment (see Figure 4.11). Across the different production units (the artisan, small-scale and medium-scale producers), the production chains are basically similar but the processes under each step vary significantly from one production unit to the next. For example, whereas the artisan brick makers use hand held hoes to dig out the clay, the medium- scale producers use diesel-powered machines to excavate. Additionally, the artisan brick makers mainly use clamp kilns to burn the bricks whereas the medium and small-scale producers mostly use the Hoffman kiln (ADA, 2017). This section explores the nature of the steps of the value chain with a focus on Butende Brick works which is a small-scale producer.

Figure 4.11. The value chain of Uganda's burnt clay brick industry. Source: ADA, 2017.

4.6.1 The value chain of bricks manufactured by BBW

This is a small-scale semi-mechanised production plant of burnt clay products which include burnt clay bricks, facing bricks, perforated bricks and max spans, among other products. It is a private business started in the early 1960s by the then Bishop of Masaka diocese to supply construction materials to the church's infrastructure projects such as schools, hospitals and churches located in central and south western Uganda but now it serves a wide range of customers. The factory is located in Butende which is close to the clay raw material in Butende, Lukaya, Kasozi and Buyinzi and markets in Masaka and Rakai districts (approximately 20 Km and 80 Km away respectively) as well Kampala which is 100 Km away (see Figure 4.12). In an interview with one of the senior officials, he said that there are two Hoffman kilns used to burn the clay products with an installed capacity of between 20,000 and 60,000 bricks. Most of the products are made on order from the customers.

The trade licenses hanging on the wall in the office showed that it is a legal brick manufacturing business and the official said that the license has to be renewed annually. He added that the company employs 24 people when in full capacity operations and that none of these employees have undergone formal training in brick making. Instead, training happens on-the-job. In addition, there are management and administrative staff (director, manager, supervisor, cashier, secretary, assistant secretary and a security guard) who ensure proper management and operation of the business.

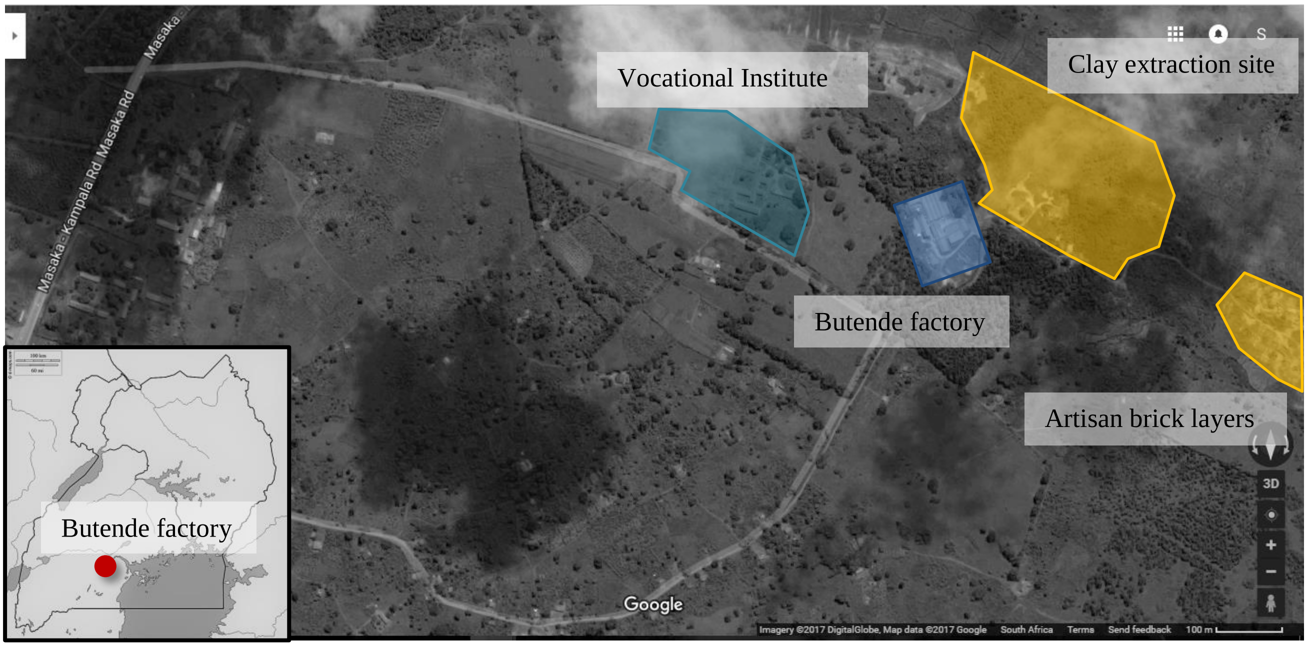


Figure 4.12. Location of Butende brick factory. Source: Adapted from Google maps, 2017.

4.6.2 Clay extraction by BBW.

The factory is suitably located close to the source of the raw material and currently the clay is extracted from a site adjacent to the factory (see figure 4.12). The production manager said that the clay is dug either manually or with an excavator depending on the quantities required and loaded onto a truck to an open yard within the factory grounds for weathering. The other sites where the clay is excavated include Lukaya, Buyinzi, Naluzale and Kasozi, among others which are located within a 10 to 15 Km radius from the factory.

The production manager noted that the excavation sites are rotated in order to give the clay deposits time to 'renew' themselves although he did not specify the amount of time given for each site. Nonetheless, according to ADA (2017), such renewal can take up to 10 years on undisturbed sites. In the open yard, the clay is screened of any visible vegetation matter and stones and left out in the open to weather and homogenise for about 3 months so that the vegetation matter rots and the clay attains a uniform texture. It is then manually dug out, loaded on a truck or carried by workers and offloaded into the machine production bay.

4.6.3 Brick production process at BBW factory

The shed of the production bay constitutes a rudimentary construction of burnt clay bricks, wooden poles and corrugated iron sheets as the main materials. It comprises of an open space where the clay is piled on the ground and the production machine area which contains a crusher or pressing machine, three mixing machines and a moulding machine with different moulds. These are driven by hydro-electricity supplied from the national grid and supplemented by diesel generators whenever there is a power cut, which is a frequent occurrence as confirmed by the respondent official. He added that electricity and diesel expenses constitute the major expenses of the factory amounting to approximately Shs. 6,000,000 (approximately R 20,000) per month and the bill has been steadily increasing over the years. This has in turn pushed up the prices of their clay bricks so as to meet the increasing costs.

In the machine production bay, the clay is first mixed with additives in order to attain the required composition and texture for the targeted products. From here it is manually fed to the crusher where it is thoroughly tempered by mechanically breaking it up, watering and kneading. It is then conveyed through three processing machines where it is additionally tempered to a fine mixture suitable for the targeted product (see Figure 4.13). The clay is then forced through the rectangular opening of the moulding machine which also cuts it to the required length, width and thickness. The cut product is manually moved to the drying shed.

Between 1,200- 1,500 bricks can be cut in a day depending on the workers present to transport the formed products to the drying shed (an open, well aerated shelter made of rudimentary materials which are eucalyptus poles, burnt clay bricks and iron sheets). It is designed in a way that it lets in draughts of air to dry the clay products to a certain moisture content and also protect the products from extreme weather elements such as rain and direct sunshine (see Figure 4.13). The respondent official said that there are fourteen such drying sheds at Butende Brick factory where the products are left to dry for 7 to 14 days depending on the prevailing weather conditions. After this, the clay products are manually carried to and stacked into one of the Hoffman kilns, the bigger of which has a maximum capacity of 60,000 bricks and is approximately 20 years old.

Figure 4.13. The processing machine on the left and the drying racks in the drying shed on the right at Butende Brick factory.

The Hoffman kilns are rectangular shaped and according to the professional engineer respondent, they are more energy efficient compared to the clamp kilns commonly used by the informal brick makers. The reduction in energy consumption is mainly due to minimising heat loss through the high levels of heat recycling by the Hoffman kiln. The bricks are stacked into different chambers of the kiln, the entrances are sealed with green bricks and clay and the bricks are burned for eight days at about 900-1,200 ^{0}C (Greentech Knowledge Solutions Pvt Ltd, 2014). The kiln comprises of three major zones which are the firing zone, pre-heating zone and loading zone. In the firing zone, the eucalyptus wood-fuel is continuously fed for four days. The respondent official said that three 2-tonne truck loads of eucalyptus are needed to fire the kiln over the four days and these are sourced from the company’s own forests planted about 5-10 Km from the factory. The wood fuel is supplemented by six 2-tonne trucks of coffee husks sourced from a subcontractor and these are fed into the kiln from the feed holes at the top of the kiln from the second day to the eighth day (see Figure 4.13).

Figure 4.14. The exterior and interior of the Hoffman kiln at Butende brick factory. Source: author, 2017.

Figure 4.15. The source of fuel for the kilns in the factory yard; eucalyptus wood on the left and coffee husks on the right.

The heat from the firing zone is moved through the brick pre-heating zone (second zone), by a draught caused by a fan at the end of the kiln run by a diesel generator. The hot draught is continuously passed over the bricks till they are dry during the eight days. After the fire dies down, a cold air draught is passed through the kiln to slowly cool down the bricks. They are then manually offloaded onto distribution trucks (third zone) to either the construction sites directly or the major distributor at Butende trading centre as well as being temporarily stacked on the factory site.

4.6.4 Packaging, sales and use of Butende brick

Butende Brick Works sells its burnt clay brick at Ug. Shs. 500 (approximately R 1.6) because it is a fairly good quality brick that is fair faced, more evenly sized (230mmx115mmx75mm) and with good structural properties. The price is much higher compared to the price of an artisan clay brick at Ug. Shs. 200 (approximately R 0.6) which means that it is a relatively pricey brick that is not affordable to low income earners for construction of affordable housing. However, in comparison to the superior Lweza brick (manufactured close to Kajjansi, see Figure 4.2.1) which is Ug. Shs. 1000 (approximately R 3.3), it is much cheaper and has found its niche market in institutions like the church, non-profit organisations and middle to high income residential home developers.

Due to the relatively good quality of the bricks, they are mostly used in structural walls and as a finishing (see Figure 4.16) where better workmanship is employed which in turn means less wastage of mortar through the joints and finishing plaster. The customers collect their bricks from the factory site or the main distributors at Butende trading centre (using different capacity trucks) to their respective construction sites. However, since there is no special packaging of the bricks (like on wooden crates and wrapped up), they are manually loaded onto the back of trucks and transported over some bumpy or murram roads. Therefore, there is a high percentage of damage to the bricks and clients have to buy extra bricks with a high allowance for damages which leads to increase in waste and construction costs.

Figure 4.16. Use of exposed Butende brick as a structural wall and finishing by Studio FH Architects on a project in Rakai.

4.6.5 Challenges faced by Butende Brick Works.

According to the respondent official, one of the major challenges faced is the high cost of electricity at Ug. Shs. 6,000,000 (approximately R 20,000) per month and has been increasing over the years. This has greatly increased the cost of production of the bricks which is reflected in the increasing cost of their products. The business operation also experiences frequent power cuts which interrupt production processes. This has led to faster breakdown and degradation of the machinery and also necessitated the use of a diesel generator with the added cost of diesel fuel. Altogether, these factors have contributed to the increase in costs of production and subsequent increase in the prices of the bricks.

Another challenge experienced is the inadequate layout of the production sheds which interrupts the flow in the production process especially in extreme weather conditions such as torrential rains. For example, during a rainy day, I observed that the workers carrying the bricks to the drying sheds as well as to and from the kilns (with some open spaces between them), paused their work while waiting for the rain to subside thus wasting productive time. The rain was also seeping through the machine production bay as well as the drying sheds which may have affected the moisture content of the clay and the drying process of the bricks in the drying shed. In addition, there is limited enclosed storage space, especially for the wood fuel and finished products which are thus left out in the open and exposed to the elements such as the rain and direct sun. In particular, the eucalyptus wood becomes damp and therefore gives off more smoke thus increasing emissions from the burning process of the clay bricks.

However, when asked about the availability of raw materials such as clay and water, the respondent official said that they have not experienced any shortages yet from their five major extraction sites except from minor changes in the colour and composition of the clay that some of their customers were not satisfied with.

4.7 The value chain of bricks manufactured by artisan brick producers.

According to the World Bank (1989), artisan brick manufacturers are the major suppliers of bricks in Uganda and they operate throughout the country (in the urban, rural and peri-urban areas) wherever there is market and some raw materials. They are notably located along roads in order to reduce transportation costs as well as for marketing purposes. Generally their production capacity is “elastic with no set capacity or capacity factor” but rather depending on the current demand and orders from customers directly or through agents (ibid:7). Their production sites are mobile and are quickly set up based on availability of market and raw materials. The production process is “highly labour intensive and the investment requirements are low, consisting of simple, locally available implements” (ibid) such as hand held hoes, wooden moulds and plastic jerry cans, among others. Production is carried out seasonally and mostly in the dry season.

A study by Kayamba and Kwesiga (2017) revealed that some of the artisan brick makers are organised in small groups of between 3 to 5 individuals while for others it is an informal family business (not formally registered). Some artisan makers said that they have formally registered their businesses. However, most of the workers are not formally trained in brick-making but instead learn the skills on-the-job (ibid). The artisan bricks are characterised by highly irregular sizes, uneven faces, very low weight and general inconsistencies in structural qualities which thus makes them unsuitable for buildings higher than a single storey. Nonetheless, even with these poor qualities, an artisan brick is the most commonly used brick type because of its affordability especially for the low and middle income earners and ease of accessibility to the brick makers which translates to lower transportation costs.

4.7.1 The artisan brick production process

The production workshops of artisan brick producers are set up right next to the clay deposits or a short distance away and the clay is prospected on the basis of past experience of the brick makers of what the physical characteristics of good clay would be and not necessarily through scientific testing. This means that even the clay that may be unsuitable for brick making is likely to be used thus leading to poor quality of the bricks as well as high levels of wastage. “The overall process of production from clay moulding to finished product takes around three weeks for 4,000 to 10,000 bricks” and an “average of 5 weeks for 5 people to excavate, mould and fire up to 9,000 bricks” (Hashemi and Cruickshawk, 2015:4 citing Emerton et al., 1998).

In Kayamba and Kwesiga’s study (2017) focusing on artisan brick makers in western Uganda, it is noted that clay is excavated using hand held hoes as shown in Figure 4.5.6, loaded onto wheel barrows or trucks and offloaded onto the brick making site. Due to the excavation, the pits are left open and were noted to be filled with pools of water which provide breeding grounds for mosquitoes and possible drowning hazards especially for children. The clay is then mixed with water to the desired consistency, left to mature overnight, and then worked and trampled upon till it attains a uniform texture. This process is known as ‘wet-forming’. The wet-formed clay is filled into wooden moulds to form the bricks, compressed and smoothened out with hands before being slid onto a flat wooden table locally known as ‘emeeza’ in order to smoothen the bricks on both sides.

The formed bricks are further smoothened using a flat piece of wood with a handle locally known as ‘kaboy’. They are then laid out on a flat earth surface to dry for two days and turned in order to ensure even drying. The dry bricks are then piled up with spaces in the middle and covered with dried grass for about a month to ensure proper aeration for gradual drying without cracking (see Figure 4.17) and thereafter they are ready for firing.

Figure 4.17. Clay excavation using hoes and forming with rudimentary wooden tools. Source: Kayamba and Kwesiga (2017:13,14).

In an interview with a professional practising engineer, he noted that the clamp kilns used by artisan brick makers are highly inefficient in their energy use and also produce high levels of emissions per tonne of bricks compared to the Hoffman kiln. This is mainly due to the fact that there is no mechanism for heat recycling thus leading to excessive heat loss. In addition, Hashemi and Cruickshawk (2015:5) observed that “the firing period and temperature are kept low to save as much wood as possible”. This could be one of the key contributing factors to the low quality bricks which normally translate to between 25% and 45% of the entire production with unsatisfactory structural properties (ibid).

The main source of fuel is eucalyptus wood and indigenous tree species sourced from both planted and natural forests. According to the World Bank (1989), 0.5m^3 of wood fuel is required to fire a tonne of clamp kiln bricks which is much higher than the general clay bricks at an estimated $0.3m^3$ of wood fuel. During Kayamba and Kwesiga's study (2017), the bricks were stacked in a pyramidal shape with two firing openings at the bottom and the exterior of the brick stack completely smeared with a layer of clay. The wood was fed through the openings and firing took place over four days. The artisan brick-makers determined that the stack was fully heated by the burning of the dry grass exhausted at the top of the kiln. Thereafter, the openings were sealed with bricks and clay for additional firing of the bricks before the fire openings were unsealed to allow the stack to cool down. The last two processes took about seven days.

After firing, the bricks are loaded onto trucks and transported to construction sites that are usually located close to the brick making yards. However, because of the poor structural qualities of the bricks, "around 10- 17% is wasted during transportation, handling and construction processes on site" (Hashemi and Cruickshank 2015: 5 citing Anderson & Thornback, 2012; World Bank, 1989). In addition, the unevenness of the finished bricks leads to usage of excessive mortar joints during the construction process, which is therefore very wasteful of mortar and especially the high impact cement (see figure 4.10). When all the products have been dispatched, the brick makers continue to work from that particular site if the clay deposits and the markets are within a commercially viable range, otherwise they move to the next location and rent another piece of land closer to both the market and raw material. An official at the Ministry of Energy and Mineral Development noted that it is mostly because of the mobile nature of artisan brick makers that certain pilot interventions such as building energy efficient kiln for them in Mukono, central Uganda, were unsuccessful as the kilns were abandoned when the brick-makers moved on to new sites.

Figure 4.18. A labourer firing the clamp kiln on the left. Source: ADA, 2017:16. Breakage and wastage of product on the right. Source: Hashemi and Cruickshank 2015: 5.

4.8 Analysis and interpretation of key findings

Escalating growth trends and expansion in production capacity of Portland cement and burnt clay brick industries in Uganda started to escalate since the early 1990s due to political stability that allowed for increased private investment, improvement in production technologies and growth of the construction sector. For the cement industry where intensive capital investments are required, companies such as Hima Cement Ltd. benefited from acquisition by firms such as Bamburi Cement in Kenya and later LafargeHolcim. This facilitated for the required recapitalisation to support the adoption of the latest production technologies in order to meet international standards as well as allowing for the expansion of overall production capacity. In addition, the high capital investment barrier has constrained the entry of players in the industry to three so far, all of whom are foreign investors thus making the market a tight and highly contested oligopoly. Whereas this would have ensured that their activities are easier to regulate, this has not necessarily been the case.

In contrast, the burnt clay brick industry has remained largely dominated by local, informally organised, artisan and small-scale producers coupled with a few foreign investors among the medium-scale producers. Production in the sector is therefore characterised by low levels of research, documentation, technological advancement and product improvement in comparison to acceptable international standards. Even though some medium and small scale producers have tried to improve their production processes and overall product quality, the rate of adoption of newer, more efficient technologies or improvement on the older ones is extremely slow or even lacking. For example BBW (the case study operation) has been using the same kiln for 20 years with no major change or improvement.

Apart from the technological factor as one of the key determinants in the production trends of cement and burnt clay bricks, the demand for the two materials has also rapidly increased and is predicted to continue rising over the years due to rapid urbanisation contributing to housing and infrastructure backlog (World Bank, 1989). However, it is important to note that about 34.6% of Ugandans still live on $ 1.90 dollars a day (World Bank, 2016) which means that they cannot afford the current costs of cement or small and medium-scale burnt clay bricks for the construction of their houses. This possibly explains why the major consumers of cement and cement products are mostly the government's infrastructure and civil works projects with some middle and high income earners for their residential and commercial projects. The majority of the people, who are low and lower-middle-income earners use the artisan clay bricks as well as mud bricks, even if their structural and environmental properties are considerably very low (Hasheni et al, 2015).

In addition, the use of cement and burnt clay bricks in construction projects throughout the country is typically characterised by high levels of wastage as well as substandard works that require frequent reworks and renovations (ibid) due to poor workmanship (mainly linked to relaxed quality control measures and high levels of unskilled labour in the construction industry and the construction materials sector). The reduction of these high levels of wastage of construction materials requires better skills and tighter quality controls across the various stages of the materials and construction sector.

Furthermore, the costs of production for both burnt clay brick and Portland cement are generally high in Uganda and this was primarily attributed to the high prices of electricity and diesel/ petrol, unreliable power supply and poor road and rail infrastructure which in turn drives up the prices of the products. In terms of the energy requirements, the cement industry heavily leans on hydro-electricity from the grid as well as petroleum products and the burnt clay bricks industry mostly depends on wood fuel from natural and planted forests/ woodlands. Even though there are some isolated cases (such as Butende Brick Works and Hima Cement Ltd.) that use significant quantities of waste biomass for fuel, the overall trend reflects inadequate adoption of such fuels.

In terms of availability of raw materials, the unregulated increase and expansion of producers of cement and burnt clay bricks has led to the rapid decline in reserves of both minerals especially for the clays as well as the exploration for new clay and limestone sites (such as in Karamoja region for limestone). However the extent of Uganda's clay deposits suitable for brick making has not been systematically explored or documented. There is therefore no satisfactory way of benchmarking the diminishing rate and this makes it hard to coherently regulate the sector.

4.9 Conclusion

It can be argued that foreign investment coupled with enabling government industrial policies due to the related tax base for expenditure on public-sector infrastructure, have mostly driven the growth and development of the cement industry and the medium scale brick producers in Uganda. However, on the whole, the burnt clay brick industry has not experienced major production efficiency improvements, especially by the informal artisan producers, even with the large demand for their products among the low and middle income earners. Beyond the issuing of mining licenses and business operation licences, there has been limited government involvement in the adoption of appropriate and efficient technologies and on-going research or production process evaluation and improvement within the cement and burnt clay bricks industries in the country. Most of the companies adopt their own production technology and methods or the most common ones among peers even where it is unlikely to be the most efficient thus leading to on-going high levels of wastage and pollution. This is particularly so in the clamp kilns among the artisan brick makers which are characterised by numerous production-process shortfalls.

Additionally, factors such as government and foreign investment as well as levels of disposable income among the local population have largely influenced the current demand for the different construction materials. Whereas government investment in civil works has influenced the growth of the cement industries, the low levels of disposable income among the low and middle income earners has significantly contributed to the thriving of the burnt clay brick production sub-sector especially by artisan producers. A better understanding of who the major consumers are could guide on whom to direct the various policy instruments in order to improve the demand of higher quality sustainable products or the adoption of sustainable alternative materials. Furthermore, a significant dependence of both the cement and burnt clay brick industries on petroleum products and wood fuel for their fuel needs has been substantiated with the associated negative impacts on the environment. Even if the potential to adopt alternative biomass fuels such as coffee husks and rice husks is high, it is not systematically pursued because of inadequate awareness and limited coordination between the producers, suppliers and the potential consumers of this biofuel. Systematic and responsive policy instruments could be geared towards incentivising or enforcing responsive practices especially as regards to low-carbon production operations/processes.

Chapter 5 Environmental impacts of the burnt clay bricks and the Portland cement sectors

5.1 Introduction

This chapter substantiates on the second sub-question and it presents the impacts of Uganda's burnt clay brick and cement sectors on the environment and especially the impacts on the land, water and air and the resultant effect on the vegetation, animals and human beings. Data are presented across the products' life cycle from the extraction of raw materials, to production and distribution, use and final disposal stages. The study adopts the life cycle impact assessment (LCIA) process to evaluate the environmental impacts on the systems surrounding the cradle, gate and grave stages along the lifespan of burnt clay bricks and cement (see Figure 2.3) and based on insights from Butende Brick works and Hima Cement Ltd. as the case studies. Under each stage, the researcher investigates the nature of the following key sub- themes;

- Material inputs
- Wastes produced
- Nature of environmental modification
- Energy requirements

The findings are based on the analysis of data from direct observation, interviews, maps as well as secondary data on the LCIA for cement and burnt clay bricks.

5.2. The LCIA of Uganda's Portland cement industry, the case of Hima Cement.

According to Hashemi et al (2015:7867), "almost all available studies in the area of Life Cycle Assessment (LCA) and embodied energy have been carried out in developed countries" and there are few case studies in African countries." This is not a good trend as the cement industry is extremely energy intensive, greatly pollutes the air and distorts the natural landscape (Young et al, 2012) and therefore requires stricter documentation that is not being done in order to ensure a sustainable value chain. Even though Hima Cement Ltd. occasionally publishes some statistics on how much reduction in carbon emissions it has achieved and the percentage of alternative fuels used, these incidents are isolated as well as uncontested, and therefore do not give a complete picture of the true life cycle impacts of their products. However, based on secondary data from environmental reports, print media and case studies with similar production trends, this section investigates the environmental impacts of cement produced by Hima Cement Ltd across the life cycle of its products.

5.3 Key environmental concerns of limestone excavation by Hima Cement Uganda.

5.3.1 Effects on vegetation, air, water bodies and wildlife

The company actively mines in three quarries, which are Musekura, Hima and Dura and also prospecting for mining in the pastoralist Karamoja region of North-eastern Uganda. From their location, Musekura and Dura are in ecologically sensitive sites that are close to water bodies and their catchment areas. For example, Dura quarry has its quarry sites A, B and C falling within the boundaries as well as on the fringes of Ramsar site of Kibaale National Park (see Figure 5.1). The drainage features in that area constitutes of the Dura River, which drains into Nsonga River and eventually the Nsonga swamp and the River Rwekereba that divides the limestone deposits as it flows into the Dura River. All these features constitute the ecologically diverse catchment area of Lake George which is a fresh water lake in western Uganda.

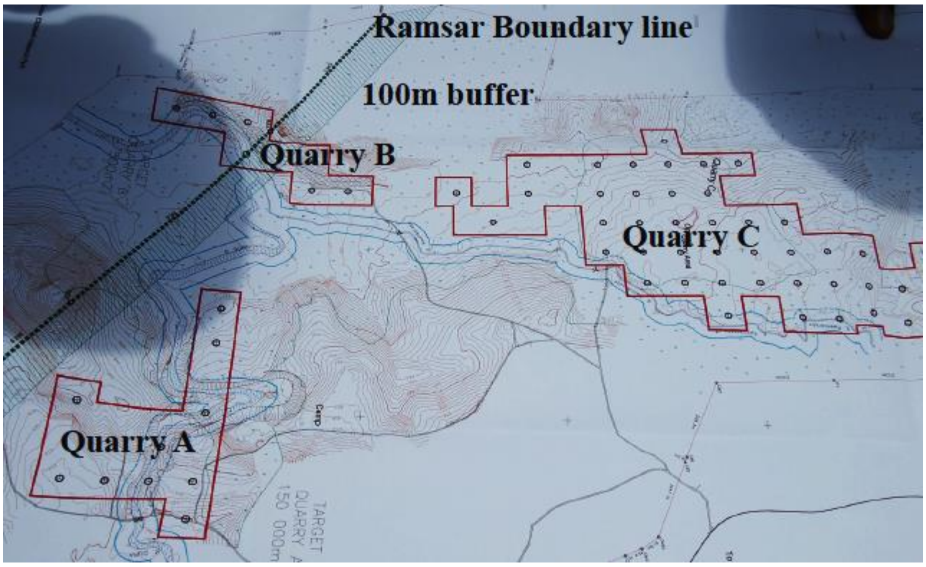


Figure 5.1. Layout of Hima Cement quarries at Dura in proximity to Ramsar site of Kibale National Park. Source: NAPE, 2009.

NAPE (2015) reported that activities on this site have led to pollution of this drainage system through continuous discharge of untreated waste water with dissolved limestone and other associated waste into River Rwekereba. If this was to continue for 25 to 30 years, it would lead to high salinity levels and accumulation of contaminants which would eventually affect people, vegetation, fish and other aquatic life in that eco- system (ibid, 2015). A significant increase in the erosion and sedimentation of River Rwenkereba due to the disturbance of the landscape from mining activity was also noted by NAPE officials who cautioned that this could affect water flow and life in the drainage system of the river.

The location of Dura quarry on the fringes of Kibale National Park has also led to significant habitat modification of the forests, grasslands and rivers on which many animal species depend for survival. NAPE officials observed that limestone mining broke up the continuity of the forest with the grassland due to the quarry pits and depressions. The use of open pit mining also "resulted in significant deforestation through forest clearing and the construction of the road to the quarry" and additionally led to quarry pits of up to a depth of 5– 10m and expected to increase up to 15m deep (NAPE, 2015:1). One of the visible effects of these activities was the abandonment by chimpanzees and other animals of their habitats, stagnant water filling the quarry pit leading to increase in mosquitoes and tsetse flies and large expanses of bare land that was once forested or with savannah grasslands (see Figure 5.3) which leads to change in microclimate and distortion of the natural landscape.

The CEO of Hima Cement Uganda (LafargeHolcim, 2013), reported that they carry out quarry rehabilitation by application of top soil and planting trees such as eucalyptus and acacia although these species are not indigenous to the area and do not cover the large expanses of land impacted by the mining activities. In addition to environmental degradation, NAPE (2015) reported that noise pollution and vibrations from the machinery, explosives and trucks are further causing wildlife stress and migration especially at the Dura quarry.

Figure 5.2. The quarry pit at Dura quarry on the left and the road to the quarry where trees were cleared on the right. Source: NAPE: 2015.

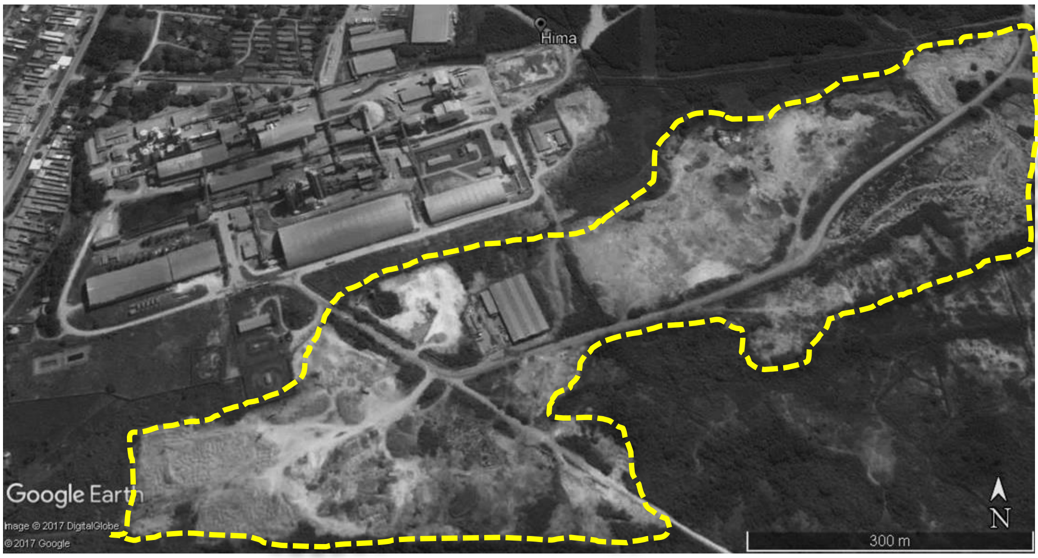


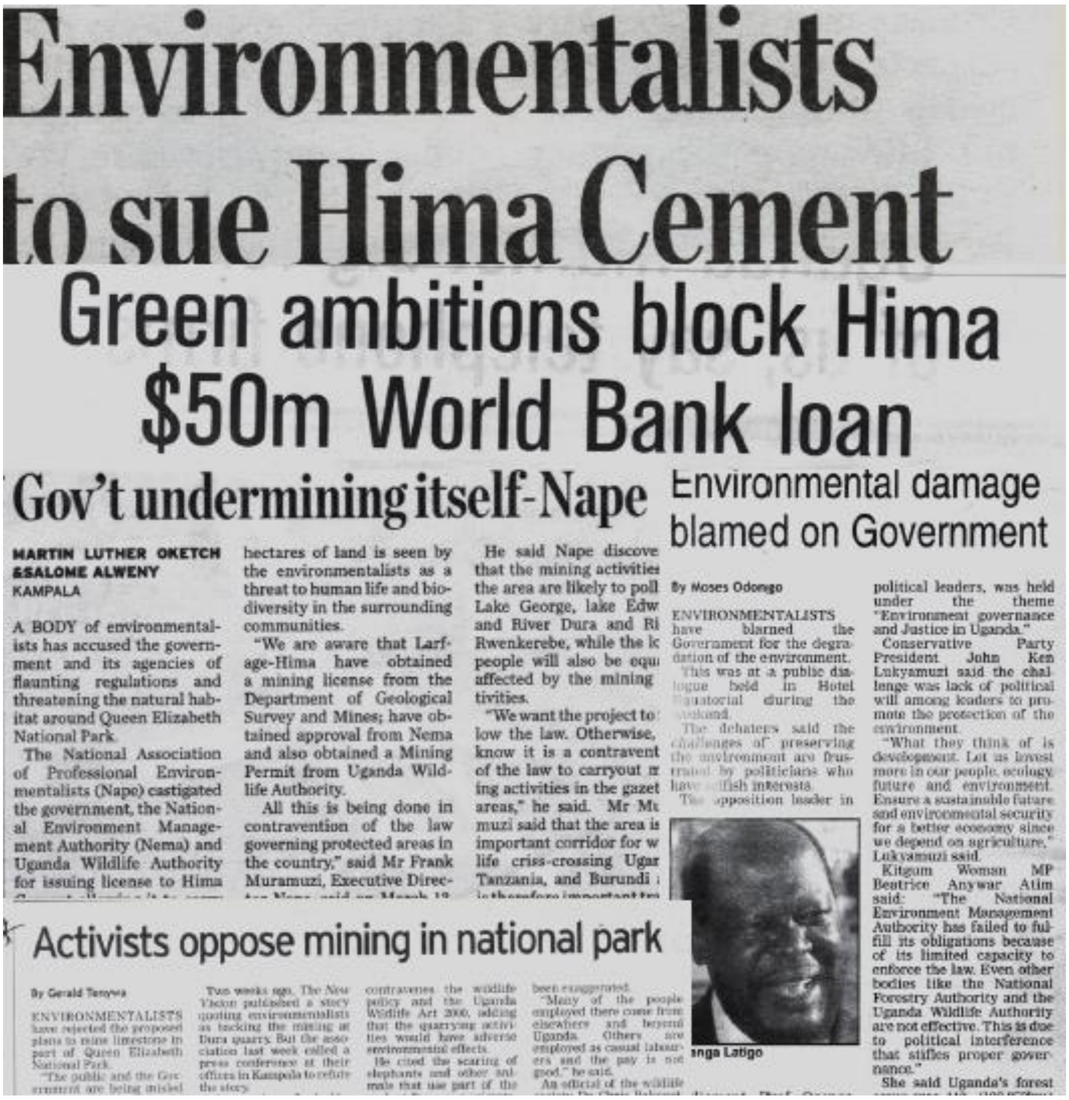
Figure 5.3. Hima cement Ltd factory and the Hima quarry showing the extensive deforested landscape. Source: Adopted from Google Earth (2017).

Within the different quarry sites, there is poorly managed waste as well as leakages of oils, lubricants and diesel as there is no adequate storage and the materials are left discarded around the sites. This leads to contamination of the soil and water bodies as well as subsequent effects on wildlife and people's health. Air pollution from dust and carbon emissions from trucks and machinery were the additional impacts noted by NAPE officials as major problems from cement mining at Dura and Hima quarry sites. The dust particles originate from "ore crushing, transportation of crushed ore, loading bins, mine and motor vehicle traffic, use of the road and waste rock piles". The dust contains waste heavy metals such as arsenic and lead which are detrimental to animal and human health of the surrounding communities of Hima and Kamwenge (ibid). The emissions from the trucks and machinery contain carbon emissions (CO_2) which significantly contributes to global warming.

5.3.2 The socio-economic effects.

Mwesigwa (2014) reported in the Guardian News that mineral deposits in the Karamoja region (such as limestone) were leading to human rights abuse of the indigenous pastoralists communities. This was through land grabbing as most of the land is communally owned for livestock grazing. Additional factors contributing to the displacement include lack of information and community involvement in decision making. Also, low wages to the workers and use of child labour were also reported as additional impacts of the mineral-induced land grabbing in the region. Even though Hima Cement Ltd was not specifically cited in this article, it is one of the companies prospecting for limestone so as to start mining activities in the region as soon as possible.

The case is similar for the Dura quarry in Kamwenge District where it was more notorious for the disregard of the local communities in the consultation and planning stages for the quarry activities and raising awareness of the impacts of mining at Dura. In particular, setting up the quarry would push the animals towards the people's homes and farms which posed safety concerns to the people and destruction of their livelihoods (NAPE, 2009). It was after the intervention of NAPE and other concerned non-profit organisations that Hima Cement Ltd started consultations with the local communities but this was way after the necessary permits had been granted by the government and National Wildlife Authority. Such an approach destroys the livelihood of indigenous communities especially if viable alternative options are not provided, and further leads to additional environmental degradation as the communities look for other ways of survival or for new settlements.



Environmentalists to sue Hima Cement

Green ambitions block Hima $50m World Bank loan

Gov't undermining itself-Nape

MARTIN LUTHER OKETCH &SALOME ALWENY
KAMPALA

A BODY of environmentalists has accused the government and its agencies of flaunting regulations and threatening the natural habitat around Queen Elizabeth National Park.

The National Association of Professional Environmentalists (Nape) castigated the government, the National Environment Management Authority (Nema) and Uganda Wildlife Authority for issuing license to Hima

hectares of land is seen by the environmentalists as a threat to human life and biodiversity in the surrounding communities.

"We are aware that Larfage-Hima have obtained a mining license from the Department of Geological Survey and Mines; have obtained approval from Nema and also obtained a Mining Permit from Uganda Wildlife Authority.

All this is being done in contravention of the law governing protected areas in the country," said Mr Frank Muramuzi, Executive Direc-

He said Nape discove that the mining activitie the area are likely to poll Lake George, lake Edw and River Dura and Ri Rwenkerebe, while the lc people will also be equ affected by the mining tivities.

"We want the project to low the law. Otherwise, know it is a contravent of the law to carryout m ing activities in the gazet areas," he said. Mr Mu muzi said that the area is important corridor for w life criss-crossing Ugar Tanzania, and Burundi

Environmental damage blamed on Government

By Moses Odongo

ENVIRONMENTALISTS have blamed the Government for the degradation of the environment.

This was at a public dialogue held in Hotel Equatorial during the weekend.

The debaters said the challenges of preserving the environment are frustrated by politicians who have selfish interests.

The opposition leader in

anga Latigo

political leaders, was held under the theme "Environment governance and Justice in Uganda."

Conservative Party President John Ken Lukyamuzi said the challenge was lack of political will among leaders to promote the protection of the environment.

"What they think of is development. Let us invest more in our people, ecology, future and environment. Ensure a sustainable future and environmental security for a better economy since we depend on agriculture," Lukyamuzi said.

Kitgum Woman MP Beatrice Anywar Atim said: "The National Environment Management Authority has failed to fulfill its obligations because of its limited capacity to enforce the law. Even other bodies like the National Forestry Authority and the Uganda Wildlife Authority are not effective. This is due to political interference that stifles proper governance."

She said Uganda's forest

Activists oppose mining in national park

By Gerald Tenywa

Figure 5.4. Newspaper clippings on the environmental and ethical concerns that surrounded limestone mining in Dura quarry by Hima Cement Uganda. Source: NAPE, 2009:13.

5.3.3 Energy demand in cement manufacturing by Hima Cement.

"Cement manufacturing is one of the leading energy consuming" (Rahman et al, 2015) industrial processes and thus a cause for environmental concerns due to the high emission levels associated with burning fossil fuels among other forms of energy. According to MEMD (2014), about 66% of the electricity generated and 22% of the energy requirements were consumed by manufacturing industries. Even though there is no specific data on the percentages consumed by the cement industries and Hima Cement Ltd in particular, there would be no reason to doubt that they do require a significant amount of the total electricity generated, most of which goes into clinker production and cement production processes (see Figure 5.6). The main sources of fuel used in the production processes at Hima Cement factory are fuel oil (transported by road from the port city of Mombasa in Kenya) and electricity from the grid (mainly hydro- electricity). However, the company reports that 53% of the total kiln fuel is met by biomass (coffee husks, rice husks and groundnut husks, among others) as well as recycled heat from cooling the clinker.

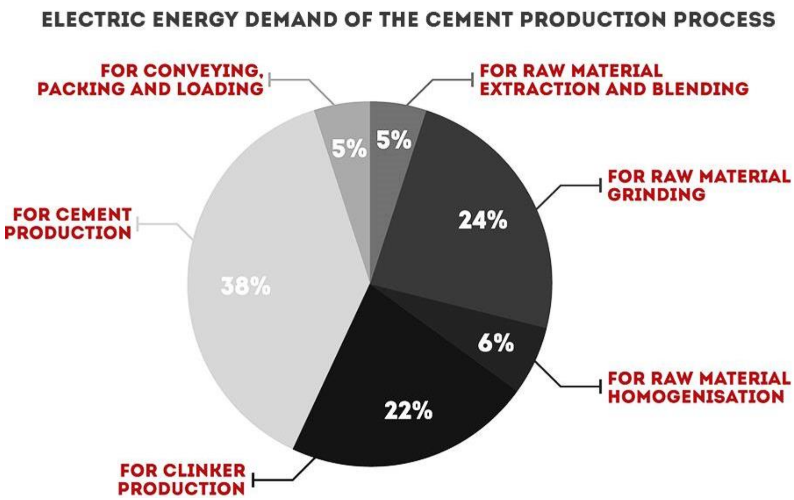


Figure 5.5. . Electricity energy demand of the cement production process. Source: Cembureau (2013).

Due to the lack of data on the energy consumption patterns of Hima Cement Ltd. or other cement producers in Uganda in general, it is a major challenge to estimate the amount of energy or electricity consumed per tonne of cement or clinker produced by Hima Cement Ltd. In comparison, data collected by the World Business Council for Sustainable Development (WBCSD, 2009) on the typical energy utilisation per tonne of clinker produced in Africa and the Middle East showed that 3,887 MJ/tonne of cement were used and the values had been steadily decreasing since 2000 where it was at 4,067 MJ/tonne. This was attributed to improvement in kiln technologies and overall cement production processes. With the new energy efficient 5-stage Precalciner kiln installed at Hima Cement Ltd, its energy consumption is estimated at 3,000 MJ to manufacture a tonne of clinker (WBCSD, 2002). Therefore, for Hima Cement Ltd, its energy consumption per tonne of clinker produced can approximately be placed at slightly below 3,000 to about 3,500 MJ/ tonne of clinker. Even though a cement kiln consuming below 3,500 MJ/tonne of clinker is regarded to be energy efficient by WBCSD-CSI and IEA (2009), there is still room for reduction in the overall energy demand by the industry. Additionally, a significant proportion of the energy used to operate the kilns at Hima Cement is met by petroleum products that are transported about

1,500Km from Mombasa, Kenya and therefore the contribution to GHG emissions for such fuels is significantly high.

5.3.4 Emissions

Commonly cited estimates show that cement production processes are the source of over 8% of global CO_2 emissions (Building Green, 2004). The industry is a direct emitter of CO_2 due to its heat intensive processes that require the burning of fuels to provide the necessary heat which also results to other pollutants such as Nitrogen Oxide ($NO_{X)}$ and Sulphur dioxide (SO_2) and “heavy metal discharge from the pre- calciner kiln system” (ibid:7). In an interview with the Daily Monitor newspaper (2013), a project manager then at Hima Cement Ltd, pointed out that the company upgraded their old production line in 2010 with the latest technology such as bag filter technology to trap cement dust and a Gas Conditioning Tower (GCT) in order to mitigate stack emissions. With this in place, the project manager was confident that Hima Cement would reduce its emission to 0.01 mg/m^3 as is the case with the Bamburi plant in Kenya which uses the same technology. Before the installation of the improved technology, cement dust and emissions were released directly into the air which caused constant hazy conditions over Rugendara Trading Centre (see Figure 5.6).

In addition, members of the surrounding communities complained of chronic cough and other lung related complications (Basime and Ninsiima, 2013). Besides these hazards, cement production emissions entails additional risks such as cancer and respiratory complications associated with long tern exposure to cement dust and factory emissions. Uncontrolled dust exposure also alters the soil composition which may eventually affect vegetation and crop cultivation. Nonetheless, even with these physical signs of air pollution, there was no publicly available data from Hima Cement Ltd showing the composition and quantities of their emissions in a manner that would reflect systematic planning and monitoring of its production activities.

Figure 5.6. Dust from the old plant of Hima Factory causing permanent hazy skies over Rugendara trading centre and surrounding communities. Source: Basime and Ninsiima, 2013.

In a bid to reduce carbon emissions, Hima Cement factory uses locally sourced alternative biomass fuel such as coffee husks, groundnut husks and rice husks among others, alongside fuel oil as kiln fuel. “[A]lternative fossil fuels can be 20-25% less carbon intensive (gross) than traditional coal and petcoke” (Building Green, 2004:7) and this was illustrated by the CO_2 reductions with the increased percentages of waste biomass substitutes at Hima Cement Ltd (see Table 5.1).

Table 5.1. Reported alternative fuel substitution by Hima Cement and reported CO_2 emission reduction. Source MEMD, 2014 and Petterson, 2014.

Year	Biomass quantities substituted by Hima Cement(Tonnes)	Reported percentage of waste biomass fuel used	Reported CO_2 Reductions (Tonnes)/ annum
2004	5,229	23%	7,000
2005	12,230	29%	17,000
2014	80,000	53%	67,000

According to WBCSD, 2009, the average CO_2 emissions for a dry kiln with a preheater and precalciner in 2006 was estimated at 842Kg/ tonne of clinker produced which value could be significantly lower for Hima Cement due to the substitution with biomass fuel and improvement in kiln technology since 2006. For production of cementitious products, the average net CO_2 emissions for Africa and the Middle East was estimated at 667Kg/ tonne of cement which value could still be significantly lower for Hima Cement to date because of on-going improvements of technology and increased use of biomass. However, the specific quantities of carbon emissions cannot be established because of lack of readily available data and regular systematic reporting by the company.

The Hima plant reported that it uses pozzolan substitutes in its cement production. "Pozzolans, natural rocks of volcanic origin, make it possible to reduce the quantity of clinker in the cement composition, thereby reducing CO_2 emissions generated by the clinkerisation process. For a given quantity of cement, the proportion of pozzolans in cement is about 35% and that of clinker 60%" (Lafarge, 2011) which in principle should be contributing to less CO_2 emissions. Other sources of CO_2 emissions are the indirect emissions from generation and transmission of electricity from the power plant in eastern Uganda and emissions from the fuel tankers transporting petroleum products over a distance of about 1500Km from Mombasa, Kenya.

5.4 The LCIA of Uganda's burnt clay brick industry, the case of BBW

5.4.1 Environmental impacts from clay excavation.

One of the major impacts of clay excavation is the destruction of vegetation, wetlands and bio-diversity. BBW excavates its clay from the wetland sites of Butende, Kasozi and Lukaya, among others. Even though these contain the best clays for brick making, they also support a large diversity of plants such as papyrus and some indigenous tree species and animal life which face extinction once the clay is uncontrollably mined. These swamps also form the catchment area for Lake Victoria.

The excavation for clay requires clearing the vegetation and digging out the clay manually or with an excavator thus leaving behind ditches that get filled with water. This result into destruction of natural habitats and also affects the natural filtration systems of Lake Victoria thus increasing the levels of contamination (see Figure 5.8). All this happens with minimal checks and balances from NEMA and MEMD. The production manager confirmed that other than the business license, BBW is not required to obtain a clay mining license and that its activities have not been monitored or regulated by NEMA in the last 20 years he has been with the company. This presents an environmental challenge as there is no specific data on the rate at which swamps are dwindling at various locations so that conservation and rehabilitation measures can be put in place.

Figure 5.7. Water logged pits and destruction of natural vegetation at a clay excavation site at Butende.

Even though BBW made efforts to restore vegetation in a former excavation site adjacent to the factory by planting eucalyptus trees, these were not the indigenous species to the site and therefore would not lead to full restoration of the bio-diversity of the eco-system that was destroyed. The eucalyptus trees are also eventually used to provide fuel for the kiln which thus further diminishes the restoration outcome.

Another impact of clay excavation for brick making has been the increase in levels of soil degradation and landscape degradation/deformation. Clay excavation has led to high levels of soil degradation due to the removal of vegetation cover that holds the soil particles together. This has made the soils vulnerable to erosion and contributed to the siltation around the Lake Victoria basin which is a host to numerous clay excavation sites including those of BBW. This generally affects small scale crop growing and fishing by the surrounding communities to the excavation sites (Kayamba and Kwesiga, 2017). In addition, excavation of clay has led to unsightly pits filled with stagnant water and mounds of unwanted clay such as the ones at Butende (see Figure 5.8). The ditches and mounds affect the continuity of the swamplands and destroyed animal habitats for various species such as the crested crane. The stagnant water has also led to an increase in mosquito and tsetse fly infestations which transmit malaria and sleeping sickness.

5.4.2 Environmental impacts from burnt clay brick manufacturing.

One of the major environmental impacts of burnt clay manufacturing is its high energy demand and especially for biomass fuels as the main energy source for the sub-sector in Uganda where wood fuels alone account for 89% of Uganda's energy consumption (MEMD, 2016). Current demand by the burnt clay brick industry is estimated at 6 million tonnes of wood fuel for the clamp kilns used by artisan brick makers and 22,000 tonnes of wood fuel for the pit and improved kilns used by small-scale and medium scale producers such as BBW (ibid). These numbers show that the burnt clay brick industry consumes the largest amount of wood fuel and is therefore primarily responsible for the high rates of deforestation occurring in Uganda at present. Per cycle of burnt clay bricks manufactured, BBW required three 2-tonne capacity lorries of eucalyptus wood (translates to approximately $0.3m^3$ or less per tonne of product) which was supplemented with six 2- tonne capacity lorries of coffee husks. The respondent official at BBW said that the wood was sourced from both the company's eucalyptus forests and from private suppliers.

In comparison, the clamp kilns used by artisan brick makers consume about $0.5m^3$ of wood fuel per tonne of product which is $0.19m^3$ higher than that of the kilns used by medium and small- scale producers (see Table 5.2). The quantities are higher for clamp kilns because of inefficiently built kilns with a lot of heat loss and little to no substitution with biomass wastes as is the case for BBW. The wood is indiscriminately sourced from both natural and planted forests and thus contributes to the highest rates of deforestation as well as the disappearance of indigenous tree species in places such as Rakai, Masaka, Kamwenge and Mbarara. The rainfall in these areas and surrounding districts has significantly reduced and the average temperatures considerably increased over the years (see Appendix C6 for increase in average temperatures of recorded nearby districts).

Table 5.2. Wood fuel consumption by different brick kilns in Uganda. Source: Hashemi and Cruickshank: 2015:6.

Product	Required equivalent fuelwood per tonne of product (m^3)	Energy consumption per tonne of product (MJ)	Energy consumption compared to "General Clay Bricks"
General Clay Bricks	Est. 0.315	3000	100%
Artisan/ Clamp Fired Bricks	0.5	4760	159%

Previous studies have revealed that the EE of artisan clamp fired bricks at 4.76MJ/Kg is much higher than that of general clay bricks by 1.76MJ/Kg which is attributed to the inefficiencies in production (see Table 2.3). Some of this embodied energy is lost due to the high levels of wastages on brick making sites which is estimated at between 10- 17% for the clamp kilns and about 5% for Hoffman kilns such as the one at BBW (Hashemi and Cruickshank: 2015 and Greentech Knowledge Solutions Pvt Ltd, 2014).

Small and medium-scale mechanised producers also depend on electricity from the grid and petrol products to run their machinery and equipment and this entails further energy impacts/consumption as well as associated carbon emissions from the use of petroleum products. However, their contribution to the overall EE of the clay products has not yet been monitored, reported or analysed.

Another major environmental impact of brick manufacturing is the contribution to GHG gas emissions. The firing of burnt clay bricks has a "high probability of air pollution as the combustion products are simply released into the atmosphere without any mitigation" (Kornelius, 2015:131). Greenhouse gases such as CO_2, SO_2 and NO_2 and particulate matter (PM_{10}) are released during the combustion process. The clamp kilns used by artisan brick makers have higher levels of emissions due to their related high levels of heat loss compared to the Hoffman kiln. However most of the Hoffman kilns used by medium and large scale companies such as BBW, do not have any filter technology installed to curb the release of these harmful gasses to the atmosphere or surrounding communities which have led to increase in micro-temperatures around the brick burning sites. In addition, most of the brick producers, especially the artisan and medium-scale producers are located in close proximity to their markets in commercial and residential zones where residents are at risk of inhaling the PM_{10} and dust from brick manufacturing processes. During the field visit for direct observations, it was noted that the workers at BBW as well as different sites of artisan brick makers, workers did not have appropriate protective gear such as face masks and gloves and were therefore vulnerable to occupational respiratory health risks.

5.4.3 Environmental impacts of the distribution, use and disposal patterns of burnt clay bricks, cement and cement products.

The transportation of cement from the factory to the depots and to end-users is done by transport and logistics companies that use trucks which utilise petroleum products. In addition, the CEO of Hima Cement pointed out that due to the immature and poorly managed transportation/ logistics sector in Uganda, some of the owners of the trucks do not monitor the conditions of their trucks which are often in poor mechanical state (LafargeHolcim, 2015). This means that they consume more fuel and thus emit relatively higher levels of CO_2 emissions to the environment per tonne of cement for every km travelled. The trucks used to transport burnt clay bricks by the clients to their sites are usually in worse condition which means that the associated distribution carbon emissions for bricks could also be significantly high relatively to that of cement.

The use patterns, EE and environmental impacts of construction with burnt clay bricks, concrete, concrete products and cement are not easy to monitor comprehensively due to the lack of data especially because of the prevalence of the informal sector in the construction industry (UN Habitat, 2010). World Bank (1989) further notes that the industry is marred by inneficiencies and material wastefulness, use of old ineffeicent machinery, high dependence on petroleum products for fuel, low levels of skilled manpower and poor management among other critical shortcomings.

Hashemi et al (2015) present data on the embodied energy of two concrete products commonly used in Uganda (hollow concete blocks and cement stabilised soil blocks) and burnt clay bricks. Their study showed that on the overall, the concrete products have lower embodied energy compared to the burnt clay bricks (see Table 5.3). The embodied energy of a cement stabilised soil block wall at 176 MJ/m^2 is much higher than that of a hollow concrete block at 127 MJ/m^2 and the two values could go higher for the case of Uganda because of the thick mortar joints used at about 30mm compared to the recommended 15mm as well as the other inefficiencies listed above. The EE of a wall of clamp fired bricks was estimated at between 1,619MJ/m^2 and 1,067MJ/m^2. This is much higher than the general clay bricks at 791MJ/m^2 especially due to the wood fuel requirements in the manufacturing process of the brick products which was not required for the concrete products that required compaction and sun drying instead.

Table 5.3. Embodied energy of selected cement products and burnt clay bricks produced in Uganda. Source: Hashemi et al, 2015:7878 and Hashemi and Cruickshank: 2015.

Product	Size (mm)	Mass per item (Kg)	EE of material (MJ/Kg)	EE of wall (MJ/m^2)	EE of wall (MJ/m^3)
Cement stabilised soil blocks	290x140x115 10mm mortar joint	8 1.65	0.68 1.11	176	1,257
Hollow concrete block*	400x200x200 20mm mortar joint	14 1.65	0.59 1.11	127	636
Artisan clamp fired brick	300x150x130 20mm Mortar 220x110x65 20mm Mortar	7.6 1.65 2 1.65	4.76 1.11 4.76 1.11	1,619 1,067	5,398 4,849
General clay brick	215x102.5x65 20mm Mortar	2 1.65	3 1.11	791	3,677

*Assumption: 50% hollow, 8MPA compressive strength.

5.4.4 Disposal and recycling of burnt clay bricks and concrete products.

Muhwezi et al (2012:289) showed that "[c]oncrete indicated the highest wastage levels on the sites surveyed with an average of 19.79% in Uganda, followed by mortar at 16.55% which are ten and three times respectively above the acceptable norms." These two materials were closely followed by bricks/blocks at 12.98 % which is above the acceptable norm of 4% (ibid). The high levels of wastage was attributed to poor skills, inefficient equipment, poor storage facilities, poor site management and inadequate coordination between the architects, engineers, contractors and sub-contractors, among other factors. This waste is normally transported to dumping sites where it increases overall volumes of waste, occupies finite landfill space and in particular signifies a waste of the related embodied energy used in manufacturing the materials. Currently, there is no coherent framework for utilisation of these wastes or any company with a dedicated business on the recycling of the waste which thus leads to an environmental problem as construction wastes are set to continue increasing in the future, hand-in-hand with growth in the sector as urbanisation and economic growth intensifies.

5.5 Conclusion.

The cement and burnt clay bricks sectors in Uganda entail high levels of negative and widespread impacts on Uganda's environment along their life cycle. The high energy demand as well as high levels of emissions and degradation of eco-systems are experienced during raw material extraction, materials manufacturing and in use as well as disposal stages of their life cycle. Even with the proven and visible environmental impacts of the cement and burnt clay brick sub-sectors, systematic reporting and monitoring on their life cycle inventory (LCI) was not evident. Likewise, the analysis shows that due to the high levels of fragmentation in the structure of the cement and burnt clay brick manufacturing sub-sectors as well as the concerned regulatory bodies, there has been limited coordination and information sharing which thus leads to inefficiencies and intensification of their environmental destruction. All this has been happening within a framework of limited, disjointed and incomprehensive government monitoring and regulation, which in turn encourages laxity in compliance with related environmental laws and regulations among the producers as well as wasteful utilisation among project developers and builders.

The activities associated with limestone and clay extraction have greatly contributed to the destruction of natural habitats. For example, the study finds that part of Dura quarry is located within Kibaale National Park and its forested landscapes and as a result of Hima cement operations, have led to the disfiguring of the landscape, cutting down the vegetation, water and air pollution, among other impacts thus affecting ecological diversity, animal habitats, drainage patterns and neighbouring local communities. The situation has been aggravated by lack of consultation between the mining parties, different government agencies and the local communities who are most affected by the impacts of the related activities. This raises major concerns related to human rights abuse.

The energy needs of both the cement and burnt clay brick industries have been met by petroleum products, wood fuels, grid electricity, and biomass wastes from coffee husks, rice husks, and groundnut husks, among others. On a positive note, there is a substantial use of biomass waste as a substitute for petroleum products and wood fuels in cement production at Hima Cement Limited and Butende Brick Works. Other more organised medium and small-scale brick manufacturers are following this trend. However the artisan, some small-scale brick makers and some cement producers are still heavily relying on wood fuels and petroleum products to fire their kilns. This contributes significantly to high levels of deforestation as well as carbon emissions with the associated global warming and climate change. In addition to the GHG emissions, other pollution impacts associated with both the burnt clay brick and cement industries include particulate matter ($PM_{10)}$ and cement dust which have led to high levels of respiratory health complications especially among the communities in proximity to the manufacturing sites.

In view of the high levels of embodied energy of concrete products and burnt clay bricks, the artisan clamp bricks had the highest levels due to inefficiencies and wastefulness associated with the informal sector producers. An important aspect of the life cycle that is currently absent within Uganda’s construction industry is the recycling and re-purposing of construction demolition and production waste from the brick and burnt clay industries in spite of the potential and environmental benefits that would accrue from such a cradle-to-grave intervention in the two sub-sectors as well as the construction industry as a whole.

Chapter 6 Policy development and the environmental impacts of the construction materials sector.

6.1 Introduction and overview.

Environmental policy and planning is a vital tool in ensuring that development and exploitation of natural resources for economic development are in harmony with the need to conserve the environment. Arising from this imperative, this chapter presents the policies and strategies across the different sectors that can provide insights on Uganda's policy approach to mitigating and adapting to the adverse environmental effects of the construction materials sector and especially environmental degradation, pollution and energy consumption. The chapter therefore presents the sub-findings for sub-question 3 and sub-question 4. Furthermore, the chapter investigates the major environmental concern areas within Uganda's national development policy and then narrows down to the evolution of particular environmental protection and conservation policies, mining policies, industrial development policies, infrastructure development policies and human settlements policies when cross-referenced to the life cycle of construction materials. Guided by the insights on the value chain and LCIA of Uganda's construction materials sector from Chapter 4 and 5 respectively, the analysis is based on data from the policy documents as guided by some of the key issues identified and abstracted as concerns C1-C5 here below.

- Natural resource management, environmental protection and restoration- C1
- Energy (embodied energy, renewable energy and energy efficiency)- C2
- The informal sector- C3
- Solid waste and emissions control and regulation- C4
- Production technology, quality and alternatives- C5

As discussed in Chapter 3 (see Section 3.2.1), primary data were obtained through interviews with key respondents from the National Environment Management Agency (NEMA), Ministry of Energy and Mineral development (MEMD), Ministry of Housing and Human Settlements (MHHS) as well as responses from a registered and practising architect and engineer. The data were supplemented by secondary data from policy documents and reports.

6.2 Environmental protection within the national development framework.

6.2.1 Data Overview.

The main sources of data for this sub-section are secondary sources which entail the review of four policy documents. First the data look at the general background of the policies with regards to when they were formulated and amended as well as their key focus issues. The data then reflects on whether the key policies identify and provide action or regulation with regards to the key issues (C1-C6 identified above).

Table 6.1. Uganda's constitution and development visions alongside their key concerns.

Abbr.	**National Policy**	**Formulated**	**Amendments**	**Key Concerns**
CU	Constitution of Uganda	1962	1966 1967 1995 (Current Constitution)	-Administration -Human rights -Democracy -Environment
	Development Visions			
V2	Vision 2040	2007	-	-Sustainable wealth creation -Employment -Inclusive growth
NP1 NP2	National Development Plan I (NDP I)	2010	2015- (NDP II)	-Economic competitiveness

Table 6.2. Environmental protection and advancement within Uganda's national policies and visions.

	CU	V2	NP	
			NP1	NP2
C1	✓ -Establishment of NEMA	✓ -Restoration of fragile eco-systems - Promotion of a green economy	✓ -Water and wetland resource management -Environmental responsibility in	✓ -Restoration of fragile eco- systems - Promotion of a green economy

			mining -Forestry sector advancement -Institutional collaboration	-Forestry sector management Wetland and natural resource management
C2	✓ -Promote sustainable energy policies	✓ -Promote renewable energy	✓ -Promote renewable energy	✓ -Promote renewable energy -Improve energy efficiency -Expansion of grid
C3	x	x	✓ -Promote artisanal mining. -Skills development in informal sector	✓ -Promote artisanal mining. -Skills development in informal sector
C4	x	✓ -Commitment to reduction in air and water pollution.	✓ -Recognises pollution as a problem	✓ -commitment to better waste management
C5	x	✓ -Promotion of environmentally sound technologies	✓ -Promote innovation and better technology	✓ -Coordination between research and industry. -Science and technology development

The data shows that the development visions are abreast with all the key concerns (C1- C5) and they lightly touch on the concerns as part of the sustainable development aspirations for the country. These are generally mentioned within the visions and constitution and not necessarily in relation to the construction materials sector. However, it was noted that the level of attention/detail on most concerns did not evolve with subsequent amendments. They have primarily remained at casual mention level as was the case in original drafts. For example from V2 to NP2, the vision merely maintains the recognition of pollution as a problem, while also mentioning the need to prioritise renewable energy and protect natural eco- systems but without delving into the detailed mechanisms of how they hope to achieve the outcomes especially with the most recent vision like the NP2. The Constitution also mainly focuses on setting a framework within which C1 and C2 could be addressed but does not mention the other concerns due to its focus on the general governance of the country.

6.2.2 Analysis and sub-findings.

The 1995 constitution of Uganda mentions the country's commitment to the protection and preservation of the environment by providing for measures to "protect and preserve the environment from abuse, pollution and degradation;" and "to manage the environment for sustainable development". (Government of Uganda (GOU), 1995: article 245). Since 1994, the constitution paved the way for a number of subsequent national environmental protection and conservation policy instruments. These include the National Environment Management Policy (NEMP) published in 1994 and the National Environment Act (NEA) enacted in 1995. Most of the most contemporary policies were published under climate change policy and include the National Adaptation Programme of Action (2007), the National Development Plan (NDP) 2010 and the National Climate Change Policy (2015). Tumushabe et al (2013:13) observe that NEMP laid the foundation for reforms and specific actions related to the governance of the environment in Uganda. Its overall goal was to enable "sustainable social and economic development which maintains and enhances environmental quality and resource productivity on a long term basis…." (ibid). Subsequently, NEA contained the strategies to achieve the NEMP policy objectives and most importantly it provided for the establishment of the National Environment Management Authority (NEMA) as an agency mandated with the tasks of supervision, coordination and monitoring of all activities in the field of the environment. However, it can be argued that both policies were formulated to respond to the dominant human activities at that time such as small scale agriculture, deforestation and the moderate levels of pollution. Specific frameworks on how to deal with future challenges such as increased GHG gas emissions from economic development contributing to climate change, increased energy demand, higher levels of environmental degradation and resource depletion were therefore not comprehensively addressed.

With more contemporary articulations of national economic development aspirations in frameworks such as the Vision 2040 (2007), the National Development Action Plan I (NDP I, 2010 -2015) and currently the NDP II (2015-2020), the country's main development aspirations are articulated towards the creation of a “Transformed Ugandan society from a peasant to a modern and prosperous country within 30 years”. The government hopes to pursue this based on the principles of sustainable wealth creation, employment and inclusive growth as well as focusing on the identified primary growths sectors such as oil and gas, mining, manufacturing, forestry and housing. Other complementary and enabling sectors mentioned were the transport sector, energy sector and environment sector. With regards to development constraints, the frameworks acknowledge the rapid environmental degradation accruing from deforestation, destruction of wetlands and increasing levels of pollution, among others and how this is directly associated with the increased levels of poverty as well as the development path pursued.

However since 1998, Uganda started experiencing some of the devastating impacts of climate change which included unpredictable weather patterns, El Nino rains that destroyed large expanses of transportation infrastructure and caused flooding, drought that led to the decrease of water levels in Lake Victoria, famine and epidemic outbreaks among others (Tumushabe et al, 2013). Even with such visible signs, the development frameworks such as the NDP II seemed to be and are possibly still hell-bent on prioritising a high pollution and a high carbon emission development path in order to fast track economic development. Even though the NDP I and NDP II made some low-key references to promoting low-carbon economic development, promoting energy efficiency, diversifying the energy portfolio in favour of renewable energy and ensuring sustainable management of environmental resources, they still lacked an integrated approach, ownership, realistic timelines and specific benchmarking data. This made it difficult to implement and monitor the impacts and hence influence policy revisions and improvements. The trend shows that there is increasing awareness of the escalating levels of environmental destruction and climate change due to the pursued path of development, and accompanied by minimal commitment by government to mitigate this trend of impacts. According to Tumushabe et al (ibid), some of these recent development plans were never fully implemented due to lack of funding and political commitment of the various actors to see them through.

6.3. Policies on environmental protection and conservation

6.3.1 Data Overview

Data reviewed in this sub-section are mainly secondary data derived from the different environmental management, forestry and wildlife conservation policies as listed in Table 6.3. The data are supplemented by primary data from a respondent in NEMA.

Table 6.3.Evolution of Uganda's environmental protection policies.

National policy legislation	Year	Amendment
The National Environment Act (NEA) Main objectives -Formulate regulation for sustainable environment management -Establish environment management authority	1995	
The Uganda Wildlife Act (UWA) Main objectives -Conservation and sustainable management of wildlife -Establish Uganda Wildlife Authority	1996	2014, 2017
National Forestry Policy (NFP) Main objectives -Ensure the efficient conservation and utilisation of forestry resources -Manage the interests of different parties in the sector	2001	
National Forestry and Tree Planting Act (NFTPA)	2003	
Sectoral policies		
National Environment Management Policy (NEMP)	1994	
National Environment Action Plan (NEAP)	1995	
The National Environment (wetlands, river banks and lake shores management) Regulations (NEAR)	2000	
The National Adaption Programmes of Action (NAPA)	2007	
The National Disaster Preparedness and Management Policy (NDPMP)	2010	
The National Climate Change Policy (NCCP)	2015	

Table 6.4. Responses to concerns 1-5 within Uganda's environment protection policy framework.

	NEA	UWA	NFP
C1	✓ Key policy areas -Provides for limits on resource exploitation -Environmental restoration and conservation requirements on ecological sites -Stipulates duties of NEMA NEMP ✓ Key policy areas -Recognises challenges of rampant deforestation and environmental degradation -Provided for the formation of NEMA NEAR ✓ Key policy areas -Make an inventory state of wetlands, lakeshores and river banks -Regulate economic activities in these areas NCCP ✓ Key policy areas -Long-term water, wetlands and forestry protection and conservation paln	✓ Key policy areas -Promote wildlife conservation as a viable form of land use. -Protection of wildlife conservation areas from encroachment	✓ Key policy areas -Policy harmonisation -Develop codes of conduct and standards -Soil and forestry bio-diversity conservation -Conservation and creation of forested areas NFTPA ✓ Key policy areas -Declaration of forest reserves. -Enhancement of productive capacity of forests
C2	✓ NEA: Key policy areas	X	✓ NFP -Key policy areas Curb the uncontrolled

	-Promote research into and used of renewable energy in partnership with the lead agency. <u>NEMP</u> ✓ <u>Key policy areas</u> -Identifies the need to reduce dependence on wood fuels. <u>NEAR</u> X <u>NCCP</u> ✓ <u>Key policy areas</u> -Promote use of alternative fuels at household and industrial level -Diversify renewable energy portfolio -Promote energy efficiency		harvesting of timber and wood <u>NFTPA</u> ✓ <u>Key policy areas</u> -Criminalising illegal tree harvesting
C3	<u>NEA</u> X <u>NEMP</u> X <u>NEAR</u> X <u>NCCP</u> ✓ <u>Key policy areas</u> -Adopt community based approaches -Build awareness and capacity across all stakeholders	X	<u>NFP- Key policy areas</u> ✓ -Improvement of livelihoods and poverty. -develop capacity of traditional institutions <u>NFTPA</u> X
C4	<u>NEA: Key policy areas</u> ✓	X	X

	-Provides for establishment of environmental standards. -Prohibits hazardous waste discharge. NEMP Key policy areas -Mentions the need for environment quality standards NEAR ✓ Key policy areas -Prohibits waste disposal in wetlands and river banks NCCP ✓ Key policy areas -Manage GHG sources and sinks. -Sustainable use of solid and liquid waste		
C5	NEA ✓ -Creation of environment database NEMP X NEAR X NCCP ✓ Key policy areas -Technology needs, development and transfer	X	NFP- Key policy areas ✓ -Use of appropriate machinery -Use of certified harvesting contractors NFTPA X

	-Adopt incentive schemes -Appropriate information sharing		

The data show that overall policies formulated under environmental management (NEA, NEMP, NEAR, NCCP) and Forestry (NFP and NFTPA) mention some responses to the concerns under C1-C5 while the wildlife policy (UWA) focuses on C1 with no mention of a response to the other C4-C5 concerns. Additionally, forestry management policy does not mention any strategies for C4 and C5 and the newer policy (NFTPA) does not mention any responses for C3 yet the prior policy mentions some strategy areas for the same concern.

Most policy strategies and responses across environmental management, forestry and wildlife conservation responded to C1 followed by C2 whereas the fewest policy responses were to concerns under C3 and C5.

6.3.2 Analysis of sub-findings

The on-going deterioration in the state of Uganda's environment has been mainly characterised by a 67% deforestation rate since 1990, reduction in bio- diversity from 0.8 in 1988 to 0.7 in 2005 and significant increase in pollution from particulate matter (PM_{10}), NO_2, SO_3 and O_3, among others (NEMA, 2016). Although NEMA cited a variety of causes such as urbanisation, population growth, growth of industries and use of second-hand cars, the nature of growth of the construction materials sector was not mentioned as one of the major contributors to the trend of environmental degradation. However, from 1990 to date, the growth of the cement and burnt clay brick sub-sectors have also contributed considerably to the above mentioned environmental impacts. As discussed earlier, in order to curb this trend of growth, the first statements of environmental management and protection were articulated in the NEMP in 1994 and subsequently the NEA which was enacted in 1995. This paved way for different sectoral and national legislation policies that were enacted in order to ensure inter-governmental environmental protection (see Table 6.3).

The general principles of the National Environment Act (1995) aimed to provide for environmental management and the "right to a decent environment". It contained a package of strategies towards guiding environmental sustainability through committing to set standards for air, water and soil pollution, protection of the ozone layer, setting up an environmental information database and institutions for environmental governance such as NEMA, among others. However, as of 2017, some of the specifications of the various standards that were to be formulated had not yet been articulated or made publically available. These include the air quality and pollution standards.

The act also seemed to lack a proper understanding on how to identify and manage some of the dominant, informal, high- impact activities such as artisan brick making or plan for the growth of future high impact activities such as those arising from the manufacturing sector. Consequently, it has left wider gaps now evident through the ad hoc development of high environmental impact industries, such as the burnt clay bricks and cement industries, with minimal regulations to guide their operations and related impacts. Other policies such as the NFP and the National Environment (wetlands, river banks and lake shores management) Regulations sought to provide more concrete and specific frameworks within which different environmental concerns could be governed.

With the increasing adverse effects of climate change in Uganda especially since 1998, the more contemporary environmental protection policies and strategies were embedded in different action plans in order to mitigate and respond to the anticipated impacts. Some of these were the NAPA, NDPMP, and the more current National Climate Change Policy (NCCP) drafted by Ministry of Water and Environment in 2015. Tumushabe et al (2015) argue that the earlier climate policy regime "lacked a clear articulation of the policy problem, and by implication, the regime did not contain specific policy objectives, strategies, or a definition of institutional roles to confront the problem". However, they paved way for the current NCCP whose main goal is to "ensure a harmonised and coordinated approach towards a climate resilient and low-carbon development path for sustainable development in Uganda" (Ministry of Water and Environment, 2015:13).

One of the most important aspects of this policy is the provision for an inter-sectoral approach towards the reduction of carbon emissions and conserve the environment so as to mitigate the impacts of climate change. The policy further identifies the contribution of the manufacturing sector and especially the cement and lime industries to the overall carbon emissions, and also recognizes the overall reliance on wood fuel by different sectors in Uganda which leads to the high levels of deforestation. However, the policy still fails to stipulate different standards such as pollution control standards and still plans to formulate the standards as was the case with NEA in 1995. Tumushabe et al (ibid) observed that the language of the policy lacked ownership by the ministry and this could undermine the legitimacy in its implementation and thus jeopardise the chances of achieving its specific objectives.

6.4. Policies for a sustainable manufacturing sector

The secondary data presented and analysed in this sub-section are derived from the various mining policies of the country since 1995 and summarised in Table 6.5.

6.4.1 Data Overview: Evolution of mining policies

Table 6.5. Evolution of mining policies in Uganda.

National policy	**Year**	**Amendment**
The Mineral Policy (MP) Main objectives: -Attract investment -Increase mineral production for social and economic development	2000	
The Mining Act (MA) Main objectives: -Ownership and control of minerals -Acquisition of mineral rights	2013	
Draft Mining and Mineral Policy (MMP) Main objectives: -Co-existence of mineral rights and land rights -Efficient mineral resource management -Predictable, transparent and accountable mineral licensing	(Drafted in 2016)	

Table 6.6. Responses to concerns 1-5 within Uganda's mining policy frameworks.

	MP	MA	MMP
C1	✓ Key strategy areas -Minimise and mitigate social and environmental impacts -Rational use and development of natural resources -Promote environmentally friendly technology	✓ Key policy areas -Restriction of wasteful mining -Application for mining lease -Wetland protection from mining activities -Environment restoration requirements -Environmental performance bond requirements	✓ Key strategy areas -Recognise rights of existing land uses -Environment management plan requirement for miners -Ensure commercial regulation of ‘non-rare’ minerals like clay -Address conflicts, disputes and grievances
C2	X	X	X
C3	✓ Key strategy areas -Regularise small scale mining -Information and service provision to small scale miners	X	✓ Key strategy areas -Formalisation and regulation of artisanal and small-scale miners
C4	✓ Key strategy areas -Clean up operations of past negative mining environmental impacts	✓ Key policy areas -Mining waste impact assessment -Restrictions on wetland pollution	✓ Key strategy areas -Regulate use and disposal of toxic and hazardous substances
C5	✓ Key strategy areas -Avail basic and reliable data	✓ Key policy areas -Declaration of mining technology and processes	✓ Key strategy areas -Set up modern mineral analysis lab

	-Create standards -Stimulate scientific and technological development -Training staff		-Promote extensive research across the sector -Training in appropriate technology and environmental management

The mining policies reviewed respond with relatively similar strategies and regulations for the concerns C1, C3, C4 and C5 but no mention of any responses to C3. The MA does not mention any policy responses to C3 even if the prior policy strategy (MP) mentioned that it would plan for the regularisation of artisanal miners. The concern is later responded to in the MMP, although it appears again as a strategy.

6.4.2 Analysis of sub-findings

During the early post-independence era, Uganda's mining sector was considered to be an insignificant contributor to the economy due to its meagre contribution to the overall GDP of the country. It was only later on (in the early 1990s) that mining industry regulations were drafted and the first contemporary one (The Mineral Policy) was formally launched in 2001. This was closely followed by the Mining Act in 2003 which mainly focused on laying the foundations for the development and administration of the mining sector with regard to issues such as ownership of minerals, licenses, lease applications and fees. It also mentioned the country's commitment to the protection of the environment through ensuring adherence to protection standards, restoration standards, environmental performance bond requirements, harmonising with other regulations such as the NEA and the Land Act. However, the policy does not even recognise certain 'non-rare' resources such as clay, sand and stones as minerals that would also require regulating especially when bearing in mind that their environmental, social and economic impacts can be comparable to mainstream minerals such as limestone and pozzolana.

The aim of the current draft regulation in the mining industry, (the draft Mining and Mineral Policy for Uganda 2016) is very similar to that of the Mining Act 2013 which aims to "develop the mineral industry through increased investment, value addition, national participation and revenue generation to contribute significantly to substantiate socio-economic transformation and poverty eradication" (Ministry of Energy and Mineral

Development, 2016:11). The commitments to environmental management and protection are still very similar to those of the previous acts. It still throws the ball of responsibilities to other government acts such as the NEA and the NFA to set "clearly defined, rigorous and monitorable environmental principles and standards" which the mining industry should comply with (ibid: 27). By failing to take direct responsibility for some of the necessary standards and regulations, it creates opportunities and gaps for lax policies that fail to specifically guide the sustainable development of the mining sector even in the face of the escalating adverse environmental impacts as regularly reported in the general media as well as academic publications.

6.4.2. Data overview: Evolution of economic development policies

This sub-section reviews data from the country's industrial and investment policies (see table 6.7) and how they have evolved over time with regards to their priorities towards addressing the key concerns C1-C5 as shown in Table 6.8.

Table 6.7. Evolution of industrial policies in Uganda.

National policy	**Enacted**	**Amendment**
Structural Adjustment Programs (SAPs) Main objective -Liberalisation of the economy	1986	
Uganda Investment Act (UIA) Main objectives: -Creation of Uganda Investment Authority -Regulation of investment activities The Collective Investment Schemes Act	1991 2003	
National Industrial Policy (NIP) Main objectives: -Develop natural domestic-resource based industries	2008	

-Develop knowledge based industries -Develop engineering for capital goods, construction materials, etc		
Sectoral policies		
National Industrial Sector Strategic Plan (NISSP)	2011	
National Standards and Quality Policy (NSQP)	2002	

Table 6.8. Responses to concerns 1-5 within Uganda's industrial policy framework.

	UIA	NIP
C1	X NSQP ✓ <u>Key strategy areas</u> -Mainstream environmentally sustainable processes and systems	✓ <u>Key strategy areas</u> -Efficient resource utilisation -Promote sustainable industrial development
C2	X	X
C3	UIA X NSQP ✓ <u>Key strategy areas</u> -Support medium and small-scale industries to conform to standard	<u>Key strategy areas</u> ✓ -Develop sustainable micro and small-scale industries
C4	UIA X NSQP <u>X</u>	<u>Key strategy areas</u> ✓ -Promote development of recycling -Promote technologies that minimise waste and emissions -Adhere to local and international standards

C5	UIA ✓ <u>Key policy areas</u> -Advancement of old technology or transfer of new ones -Skills development NSQP ✓ <u>Key strategy areas</u> -Develop standards and accreditation systems -Skills development	✓ <u>Key strategy areas</u> -Strategic research and alliances -Skills development -Promote sustainable industrial transformation through technology and innovation

6.3.3 Analysis and sub-findings

In the 1980s, Uganda's industrial development was regulated within a framework of Structural Adjustment Programs (SAPs) so as to revive the economy after the stagnation of the 1970s. Kadoma et al (2016) highlights the fact that "SAPs operated within a liberalised policy framework with no specific industrial policy prescriptions and did not subscribe to strategic thinking about industrialisation". The main focus then was simply to jump-start the industrial sector and therefore regulations such as those requiring adherence to a strict low-carbon development path would have been viewed as inhibitory to private sector investments and growth of the economy. The other policy that supported this drive was the Investment Act which was enacted in 1991 with the aim of promoting more favourable conditions for investment. Later, in the late 1990s, efforts to draft an industrial policy began and the first one to materialise was the National Industrial Policy (NIP) in 2008. Subsequently, an implementation guide was drafted under the National Industrial Sector Strategic Plan (NISSP) in 2011 which still maintained the liberalised approach to industrial development so as to attract both local and international private sector investors. The Vision of the NIP (MTIC, 2008:7) was to "to build the industrial sector into a modern, competitive and dynamic sector fully integrated into the domestic, regional and global economies." Some of its objectives lightly mention the need to promote sustainable industrial development through ensuring efficient utilisation of resources, controlling industrial pollution, strengthening the rate of adoption of cleaner production techniques, promoting recycling and sustainable packaging.

However the policy failed to draw specific implementation guidelines and standards but instead, only outlined its different action plans and regulation points within a generic approach. It also failed to recognise the dominance and significance of the informal and other small to medium enterprises and responding on how they could be regulated to ensure that they also adhere to the overall objectives of the policy. This failure meant that informal sector continued to operate in an ad hoc way even though their impacts on both the economy and the environment continued to dominate.

Following the ratification of the Kyoto Protocol in 2004, (with its primary goal of promoting “cooperation in emissions reduction between industrialized and developing countries”, (Namanya, 2008:255)) and with Uganda becoming a signatory the same year, the Clean Development Mechanisms (CDM) strategy was adopted. In Uganda, the focus of CDM investments was on projects such as hydro- power generation, agriculture and efficient cooking stoves. Such projects/investments largely ignored the manufacturing sector because it was believed that the emissions from industries had not yet reached alarming levels.

Given the status quo and trends today, this was a naïve perspective especially for a country that was already planning to aggressively industrialise as outlined in its NDP. It would therefore have been evident that even if the industrial emissions problem was not a critical problem, it would become critical in the near future. Implementation of CDM still has a long way to being fully adopted within the Ugandan economic development priorities in order to be effective in its mission of promotion of low-carbon industrial growth. A more recent policy that envisioned to guide the development of the industrial sector in the country is the National Standards and Quality Policy (NSQP) which was enacted in 2012. Its vision is to “have an effective and efficient national quality infrastructure that delivers goods and services that are internationally competitive” so as to support “industry, trade, environment and consumer’s health and safety” (MTIC, 2012:18).

Contrary to prior policies, NSQP recognises climate change as a threat to the smooth development and implementation of its aims and objectives. It also seeks to support the development of product specific associations and Micro Small Medium Enterprises (MSME) to conform to national standards and technical regulations even though it does not specify how these enterprises are defined or categorised. With regard to this study, it is therefore not clear if small brick making enterprises would fall within the scope. As a policy, the NSQP seems to have a clearer understanding of the workings of the economy that comprise both big formal industries such as the cement industries and smaller enterprises such as medium scale brick producers. If its objectives are systematically followed through, they could help to curb the numerous inefficiencies, wastes and carbon emissions associated with Uganda's industrial sector.

6.4.3 Data overview on evolution of energy policies

This sub-section reviews data from the key energy policies in Uganda (see Table 6.9) and also maps out their evolution and responses to the key concerns C1-C5 (see Table 6.10).

Table 6.9. Energy policies in Uganda since 1964.

Policy instruments	**Year**	**Amendment**
National policy		
The Electricity Act (EA) Main objectives: -Establish the Electricity Regulatory Authority -Liberalise and introduce competition in the electricity sector	1964	1999
The Energy Policy of Uganda (EP) Main Objectives: -To establish potential of generation and use of various energy sources -Improve access to modern and affordable energy -Improve energy governance and administration -Manage energy related environmental impacts	2002	
Sectoral policies		
Renewable Biomass Energy Demand Strategy (BEDS)	2001- 2010	
Renewable Energy Policy (REP)	2007	
The Atomic Energy Policy	2008	
Renewable Energy Investment Plan Scaling-up renewable energy program. Investment plan	2011	 2015
Power Sector Investment Plan	2011	
Rural Electrification Strategy & Plan for 2013 – 2022	2013	

(RESP)		
Biomass Energy Strategy (BEST) Uganda	2014	

Table 6.10. Responses to concerns C1-5 within Uganda's energy policy framework.

	EA	EP
C1	X	✓ EP- Key strategy areas -Strengthen environmental monitoring unit -Sensitise energy suppliers and users about environmental issues REP ✓ Key strategy areas -Sustainable management of biomass resource base
C2	X	EP- Key strategy areas ✓ -Promote use of alternative energy sources and technologies for homes ad industries -Energy efficiency at home and industrial level -Efficient use of biomass -Optimum and efficient utilisation of petroleum products REP ✓ Key strategy areas -Diversification of renewable energy portfolio -Promote efficiency in heavy wood burning

		industries like brick -Promote use of bio-fuels
C3	✓ Rural electrification and funding	<u>EP- Key strategy areas</u> ✓ -Provide affordable energy to home-based industries <u>REP</u> ✓ <u>Key strategy areas</u> -Training of 'jua kali' artisans and producers
C4	X	<u>EP- Key strategy areas</u> ✓ -Reduction of energy related emissions -Improve the transportation of petroleum Products <u>REP</u> ✓ <u>Key strategy areas</u> -conversion of industrial and municipal waste to energy
C5	✓ <u>Key policy area</u> Acquisition of generation license above 0.5W	<u>EP- Key strategy areas</u> ✓ -Promote markets in energy technologies and services -Quality monitoring <u>REP</u> ✓ <u>Key strategy areas</u>

		-Establish energy bank -Stimulate development and adoption of renewable energy technology -Capacity building -Development new generation and distribution frameworks

The data show that the earlier policy (EA) was mainly concerned with the general administration of the electricity sector and only provided for very mild responses to C3 and C5. The more recent policies (EP and REP) were more aware of the different concerns and therefore provided for some strategies on how they would respond to all concerns under C1-C5.

6.4.4 Analysis of sub-findings

The earliest regulations of the energy sector were promulgated in 1964 under the Electricity Act which was later revised in 1999 with the objective of regulating "the generation, transmission, distribution, sale, export, import and distribution of electrical energy in Uganda" (MEMD, 1999:5). This was a time when the demand for electricity was rapidly increasing due to the rising levels of urbanisation, industrial growth and commercial activities. Yet the generation and supply from the grid was not enough to meet the demand due to declining water levels especially in the Nalubaale Dam reservoir following drought cycles and thus insufficient water to run the hydro power turbines. The 1999 act generally provided more guidelines on the governance of the electricity sector with a focus on establishing a new electricity regulatory authority, financing of the sector, licencing, rural electrification and tariffs. The policy mainly focused on the regulation of formally generated hydro and thermal power and thus failed to envision and anticipate the current energy situation in Uganda where more than three quarters of the energy needs of the country are being met by wood fuels and other forms of biomass which has contributed to massive rates of deforestation.

The subsequent policy document is the Energy Policy of Uganda which was ratified in 2002. It is through this policy that Uganda starts to recognise the need to meet the country's energy demands in an environmentally sustainable manner, the potential of a diversified energy portfolio and the acknowledgment of the intricate linkages between the energy sector with other sectors such as transport, water resources, economy, social wellbeing and the environment. The policy also brings to the fore strategies for preparing an energy resource and consumption database to aid planning and promotion of alternative energy sources for both small and large scale uses, reduction of energy related emissions as well as demand and supply side management. However, in the policy strategies towards diversifying the energy portfolio, petroleum products still hold an important position towards meeting Uganda's energy demands. Equally, no provision was made to progressively phase out the energy products given their associated high levels of GHG emissions or even the more critical factor of long distances (about 1,000 Km from Mombasa by road) that Uganda has to ferry its petroleum products. With the available renewable energy potential for Uganda due to its advantageous position astride the equator, the policy strategy was not ambitious enough and also lacked specific benchmarks and targets for the country's transition to more renewable energy sources at both household and industrial level and thus relieve the pressure on wood fuels to meet the energy demand.

The more current policy statements such as the National Biomass Energy Demand Strategy (BEDS 2001- 2010), Renewable Energy Policy (2007), the Atomic Energy Policy (2007) and the Biomass Energy Strategy (BEST) (2014) (see Table 6.9), express the urgent need to explore alternative energy sources (and especially renewable energy) so as to meet the rising energy demands and support economic advancement. In particular, the REP sets a very realistic even though possibly ambitious target to increase renewable energy supply from 4% to 61% by 2017. The target was never pursued and was not even approached by 2018.

Other priority areas for the policy were to increase energy efficiency at household and industrial level, promote the use of biofuels, modern energy services from home to industrial uses, rural electrification and increase in power generation from renewable resources. The policy was very specific with regard to the targets to be reached by 2017. This was a very different approach compared to all other previous policies appraised above. However, it also failed to identify specifically which institutions, government agencies or companies that needed to collaborate in order to achieve the targets set. The structures, resources and infrastructure that would be required to make the targets happen and the source of finance were additional gaps that were not covered in the policy. As a result, by 2017, Uganda was nowhere near the achievement of the policy targets and was not even close to setting up the required infrastructure to pursuing the targets. However, some of the policy gaps were remedially addressed in the Scaling-up Renewable Energy Program Investment plan (MEMD, 2015) that was more specific on issues of financial and organisational structures required to achieve at least 61% renewable electricity generation/supply. But even under this policy, by 2017, renewable energy projects were still being implemented in a very fragmented manner and their overall impact was not being felt.

The MEMD respondent to the interview for this study cited several challenges hindering performance and policy formulation and implementation. They include lack of sufficient finances, limited human resource, low levels of awareness and innovation and the fact that renewable resources continue to be taken for granted. The respondent also noted that more innovations in energy efficiency and use of renewables is taking place for household uses such as clean and efficient cooking-stove projects than for industrial scale uses, and this reflects a huge gap which still needs to be addressed.

6.5 Policies on sustainable choice and utilisation of construction materials

6.5.1 Data Overview

The data presented and analysed in this sub-section are derived from the country's housing, planning and construction industry policies (see Table 6.11). The section examines the pattern of evolution of these policies with regard to the key concerns C1-C5.

Table 6.11. Policies governing the construction industry in Uganda.

Policy instruments	**Year**	**Amendment**
National policies		
The Public Health Act (PHA). The Public Health (Building) Rules (PHR). <u>Main objectives:</u> -Stipulate environmental, health and safety regulations and standards for buildings	1997	2000
National Construction Industry Policy (NCIP) <u>Main objectives:</u> -Regulate and coordinate the construction industry -Strengthen local participation in the industry	2010	

-Promote use of new and appropriate technologies -Promote sustainable social and economic development		
The Building Control Act (BCA) Main Objectives -Provide building standards -Establish National Building Review Board and building committees -Ensure planned, decent and safe developments in harmony with the environment	2013	
National Housing Policy (NHP)	2016	
Sectoral policies		
Strategic plan for transport	2011-2016	

Table 6.12. Responses to concerns C1-5 within Uganda's planning, housing and construction industry policy framework.

	PHR	NCIP	NHP
C1	X	✓ Key strategies -Protect the environment	✓ Key strategies Promote efficient resource utilisation in housing
C2	X	X	✓ Key strategies -Promote energy efficiency in housing
C3	X	✓ Key strategies Support small and medium scale enterprises -Integrate marginalised groups in design and	✓ Key strategies -Support small scale and large scale material manufacturers

		construction -Improve aces to credit and equipment	
C4	X	X	✓
C5	X	✓ Key strategies -Research in new technologies -Monitor performance of different actors	✓ Key strategies -Construction materials database -Research into local materials and other alternatives -Adopt efficient technologies -Standardisation of materials

The sub-findings show that the initial policy (PHR) did not address any of the key concerns. The trend changes with the subsequent policies NCIP and NHP. The NCIP addresses the concerns C1, C3 and C5 but does not mention any strategies for C2 and C4. However the NHP encompasses strategies for all the concerns C1-C5.

6.5.2 Analysis and sub-findings

The construction industry in Uganda has generally lacked "a definitive government policy and a strong institutional framework, which has encouraged the informal-sector approach to business in the sector without a long-term view on work continuity on the part of local contractors and consultants" (United Nations Conference on Trade and Development (UNCTD), 2011:69). This also means that regulations guiding the efficient use of and development of sustainable construction materials to be used in the sector have been absent or lax and thus have partly contributed to the high levels of wastage and inefficiencies associated with the construction materials sector and the construction industry at large.

One of the guiding regulations for the industry was the Public Health Act passed in 1997 and later revised in 2000. Both acts focused on laying a foundation of the building and construction sector from a health and safety perspective and thus focused on building approval processes, site planning, building design specifications and structural properties of construction materials such as burnt clay bricks and cement. Even by this stage, there was no mention or guidance on the development of or specifications for low EE and low environmental impact materials which would contribute to the growth of a sustainable construction sector. This left the status quo on the use of the most readily available materials (such as artisan clay bricks even if they are not the most sustainable materials) to prevail unabated. A respondent from the Ministry of Works and Transport confirmed that most of the registered materials testing labs focus on the structural capabilities of construction materials and that they do not have facilities to test for properties such as thermal properties or embodied energy of materials. The two acts also completely ignored the operations of the dominant informal sector and how it could possibly be guided towards improved operations. Reaching out to the informal builders, artisan brick-makers and slum-dwellers should have been prioritised through the acts. In addition, the issue of construction/demolition waste was not addressed, even though by that time, construction waste was becoming a critical issue.

Subsequently, the NCIP (MoWT, 2010:1) was one of the first policies that was meant to specifically guide and regulate the growth and development of the construction industry in Uganda and its vision is to achieve an "effective, efficient and sustainable construction industry in which both the public and private sector are informed, conscious and actively involved in decision-making on matters that affect them." It is a very general document that seems far removed from the current state of the industry and it only loosely mentions its commitments to the protection of the environment, development of vocational skills and investing in research and technologies. Later on, The Building Control Act, approved shortly after in 2013, only seemed to echo the provisions of the Public Health (Building) Rules but with less clarity on outcomes.

In contrast, the recently enacted National Housing Policy (MoWT, 2016: iv) seems to recognise that the provision of "adequate housing for all" is also connected to sustainability as reflected in some of its aims:

- Improving the efficiency and quality of housing through appropriate research in building materials and technologies, repair and maintenance;
- Promoting efficient utilization of energy and other resources in housing, so as to address issues of environmental conservation.

The policy goes further to formulate a strategy for the construction materials industry that encompasses both the large scale and small scale material producers and users. Key strategies include promotion of research on construction materials, alternative materials and efficient technologies, developing capacity and skills within the industry, creating a construction materials databank, promoting standardisation of materials, increasing public awareness about the sector and strengthening of regulations and institutional frameworks, among others. This is a very progressive policy framework especially as regards guiding the sustainable development of the construction materials industry and the construction industry at large. However it still calls for systematic implementation and regular updating in order to include more specifications and benchmarks. In addition, the policy also fails to recognise construction waste as an increasing environmental hazard which urgently requires policy attention.

6.6 Conclusion

Since the early 2000s, the government and its different ministries indicated some awareness and commitment to guide sustainable development (especially with regard to the key concerns C1-C5) through its development visions and national as well as sectoral policies. This was mainly in recognition of the adverse impacts of climate change that the country had experienced from 1998 such as drought and floods. The signing of different United Nations Framework Convention on Climate Change (UNFCCC) agreements such as the Kyoto Protocol and more recently the Paris Agreement also required re-orientation of development towards a low-carbon path for all its signatories. Some of the policies that were adopted as a result of the above were the NDP I and II, the National Environment Regulations, the NCCP, NISSP, NSQP, the Energy Policy of Uganda and the National Housing policy, among others. However, the policies, the policy making and implementation processes were noted to be very fragmented, lacked specific targets and benchmarks as well as inadequate understanding of the context within which they emerged and also were to be implemented.

On controlling and guiding the sustainable development of the construction materials industry and especially the cement and burnt clay brick industries, there have been no direct regulations or specifications that have been formulated so far to mitigate or respond to the specific impacts of these sub-sectors. Instead related responses remain spread out across different sectoral policies such as environmental policy, industrial policy, housing policy, public health policy, energy policies and the construction industry policies. They have therefore proven ineffective towards mitigating the general impacts of the sub-sector such as environmental degradation, deforestation, pollution and high levels of energy demand. However, deliberate policies such as those specific to land, air and water quality controls, energy efficiency requirements, minimum technological requirements, carbon emission limits and environmental restoration requirements would have better guided the sustainable development of the construction materials sector.

The sub-finding further indicates that implementation of policies is not systematic or vigilant enough and newer policies were formulated even before the objectives of the older ones were achieved or revised. One of the reasons for the low levels of policy implementation (especially for the environmental policies) is because the government has so far prioritized economic development and other related sector activities at the expense of the associated carbon footprint among other negative impacts. The priority of fast-tracking economic development and industrialisation is mistakenly viewed to be jeopardised by stringent environmental regulations and control. A case in point is the ‘approved’ mining of limestone by Hima Cement Ltd within the Ramsar boundary of Kibale National Park even though the existing wildlife regulations prohibit such activities within the parks as nature conservation zones. On the overall, other cited challenges that undermined the formulation and implementation of policies to guide the industry include lack of qualified manpower within the ministries, limited financing, dominance of the informal sector, poor coordination between the different ministries and the high prevalence of corruption.

Chapter 7 Conclusion and recommendations

7.1 Overview and approach to consolidation.

The study has explored the inter-sectoral environmental impacts along the life cycle and value chains of burnt clay bricks and cement which are the two most commonly used and locally produced construction materials in Uganda. The study also investigated how relevant sector policies have evolved in order to address or guide the sustainable development of the materials sub-sector. The study was structured around four research sub-questions which are:

- What have been the key drivers of the consumption and production trends of burnt clay bricks and cement?
- What have been the environmental impacts of the burnt clay brick and cement sub-sectors?
- What have been the trends in policies towards the regulation of the burnt clay bricks and cement sub-sectors?
- What is the overall responsiveness of policy to the escalating environmental impacts of the construction materials sector and how could this be improved?

Each of the sub- questions substantiated on different aspects of the overall research question which investigated the extent to which responsive policies and regulatory framework have co-evolved with the increasing environmental impacts of the construction materials sector in Uganda.

The primary aim of the study was to identify the policy gaps that are preventing the sustainable development of the construction materials sector and also discover some existing good practices and policies and how these can be strengthened and implemented further for improvement towards a clean development path for the construction industry and the country.

The study finds that in spite of the clear evidence that the current trend of growth and development of the construction materials sector (especially that of burnt clay bricks and the cement sub-sectors) is not sustainable, the related policies are not responsively evolving to mitigate and control the environmental impacts such as pollution, environmental degradation and high levels of energy consumption, among others. Policy documents are still shying away from formulating and implementing the specifications and controls required to successfully guide the growth and development of a low carbon construction industry and an environmentally friendly construction materials sector.

7.2 Research approach

A qualitative research approach was adopted to for the study as it allowed for "exploring and understanding" the different environmental impacts of the construction materials sector and how policies have responded to such over time (Crewel, 2014:32). Two case studies (Butende Brick Works and Hima Cement Works) were studied in order to investigate the value chain and the life cycle of the two construction materials which were prioritised for their prevalence of use as well as resultant environmental impacts. Primary data and secondary data were collected and analysed in order to derive sub-findings on the sub-questions. Primary data were collected through direct observation during site visits as well as interviews with key respondents such as production personnel, construction industry professionals and policy makers. Secondary data were abstracted through the appraisal of policy documents and frameworks as well as academic articles, reports, books and print media excerpts. Although the researcher encountered some methodological, resource and personal limitations, most of the critical data intended for the study were captured and analysed to allow for coherently substantiated findings.

7.3 The key drivers of consumption and production trends of the cement and burnt clay brick industries.

It can be argued that direct foreign investment coupled with enabling industrial growth incentivised by government policies in search of a large tax base, have mainly driven the growth and development of the cement industry as well as the medium scale brick producers in Uganda. However, on the whole, the burnt clay brick industry has not experienced major production advancements and government support, especially for the informal artisan producers, even with the large demand for their products among the low and middle income earners. In addition, beyond the issuing of mining licenses and business operation licences, there has been minimal government guidance on the adoption of appropriate and efficient technologies or on-going research, evaluation and improvement within the cement and burnt clay bricks industries. Most of the companies adopt their own production technology and methods or the most common ones among peers even if it might not be the most efficient.

This has escalated the chances of practices prone to wastage and pollution with the case of the clamp kilns among the artisan brick makers (and their numerous disadvantages) as a key example.

In addition, factors such as public sector and foreign investment as well as levels of disposable income among the local population (see Appendices) have largely influenced the current demand for the different construction materials. Whereas public-sector investment in civil works has driven the growth of the cement industries, the low levels of disposable income (but gradually increasing), the growing population and urbanisation have led to the thriving of the burnt clay brick industry. Understanding who the major consumers of the respective materials are can guide on how to orientate responsive policies in order to incentivise high quality, low EE sustainable products/materials or alternative ones such as compressed earth, stabilised earth blocks, bamboo, lime, among others.

A significant dependence of both the cement and burnt clay brick industries on petroleum products and wood fuel for their energy needs was noted with the associated escalation of negative impacts on the environment. On observation from the case studies, even if Hima Cement Limited and BBW were noted to be integrating some waste biomass into the energy demands of their production processes, this practice has not been widely adopted by other cement producers or artisan brick makers. The potential to adopt alternative biomass fuels such as coffee husks and rice husks is high but it is not being done because of extremely low levels of awareness as well as limited coordination between the producers, suppliers and the potential consumers of the waste biomass fuels.

7.4 Environmental impacts of the cement and burnt clay brick sectors.

Negative environmental impacts with regard to air pollution, water quality, loss of vegetation, soil quality and erosion as well as the displacement of people and wildlife were observed across the different operations along the life cycle of cement and burnt clay bricks. This was particularly associated with the very high energy demands being met either by fossil fuels and/or wood fuels and the associated high levels of emissions of GHG gases such as $CO_{2,}$ SO_2 and NO_3, cement dust and $PM_{10,}$ landscape disfiguration due to mineral extraction and high levels of waste and inefficiencies. In particular, on the activities associated with limestone mining by Hima Cement Ltd., some of the quarry sites were in ecologically sensitive landscapes close to a national park or lake drainage system which led to high levels of deforestation, water contamination, destruction of landscapes, and displacement of wildlife and indigenous communities. The same trend was noted for clay mining for the burnt clay brick industry by BBW and other brick makers that takes place mostly in ecologically sensitive swamplands where clay deposits are extracted.

The study further finds that the kiln energy requirements of both the burnt clay brick and the cement industries comprise the largest portion of production costs and these are met by grid electricity, petroleum products, wood fuels and biomass wastes such as coffee husks, rice husks and groundnut husks. On a positive note, especially for Hima Cement Limited and BBW, there was a substantial integration of biomass wastes to meet kiln fuel requirements which is thus commonly associated with less carbon emissions. However, secondary data analysis as well as interview responses indicated that this responsive intervention has not been systematically adopted among a majority of other cement and brick manufacturers. Instead, the data indicates that the cement industry is still heavily dependent on grid electricity and petroleum fuel products which are associated with high levels of carbon emission. In addition, the burnt clay brick industry remains heavily dependant on wood fuel and thus contributing to the high rates of deforestation taking place in the country.

With regard to the production technology, the literature showed that there were visible efforts by Hima Cement Ltd. (now a subsidiary of the global LafargeHolcim conglomerate) towards adopting relatively newer technologies and also upgrading of older production lines in order to achieve better production efficiency and reduce GHG emissions. On the other hand, the trend of adoption of more efficient and cleaner production techniques for the burnt clay brick industry has been much slower and this was mainly attributed to lower levels of foreign investment in the sub-sector, dominance of the informal sector and less research on better local responsive technologies, among other drivers. On the overall, there is minimal government contribution on the kind of production technologies being adopted and this has led mainly to the adoption of cheaper but inefficient technologies.

The study also finds that the transportation and logistics sector in Uganda (associated with the packaging and movement of production and construction materials) is highly under-developed and mainly characterised by the use of second-hand vehicles in very poor mechanical condition which contributes to a significant share of carbon emissions especially during the distribution stage of the materials. The construction stage of the life cycle is also characterised by high levels of inefficiencies and wastefulness accruing from contributing factors such as limited skilled professionals/crafts-persons and manpower, poor project management and coordination as well as the use of old machinery and tools. All these significantly contribute to the high levels of embodied energy of construction materials and buildings in Uganda as substantiated through the secondary data analysed in the study. Poor construction-waste management practices were also noted with hardly any record of formal or large scale initiatives reported with regard to addressing the issue of construction waste and its associated resource/environmental impacts.

7.5 Policy response to the escalating environmental impacts of the cement and burnt clay brick industries

Even though the construction industry and its related sub-sectors such as the construction materials industries are significantly contributing to Uganda's GDP (and their contribution is estimated to increase because of the housing and infrastructure backlogs being addressed by both government and private sector), specific policies concerning the sustainable growth of the sector have not been evolving in tandem. For example, the study finds that the while the first independent National Construction Industry Policy was enacted in 2010 (approximately 20 years since the revival of the construction industry), it still does not include concrete strategies on how to systematically address the unsustainable growth trend of the industry and the associated construction materials sub-sector. Other policies regarding the mitigation of the environmental impacts of the construction materials sub-sector have been diffused into diverse national policies or development visions, in a fragmented approach. Key among such policies and legislation include the following:

- The National Environment Act (1995)
- The National Environment (wetlands, riverbanks, and lakeshores management) Regulations (2000)
- Energy Policy of Uganda (2002)
- Renewable Energy Investment Plan (2011)
- Strategic Plan for Transport (2011- 2016)
- National Standards and Quality Policy (2012)
- National Climate Change Policy (2015)
- The National Development Plan II (2015- 2020)
- Draft Mining and Minerals Policy (2016)
- National Housing Policy (2016)

The study therefore finds that, to date, no specific policies are addressing the required sustainability practices for the materials sub-sector or related standards on air, water and soil quality as well as pollution controls, have been formulated, updated or implemented. This has partly contributed to the unsustainable impact trends of the sub-sector. Even if such regulations/standards were to be formulated now, they would be faced with critical implementation challenges such as poor inter-sectoral coordination, limited financial, technical and physical infrastructure, dominance of the informal sector that is more challenging to regulate, limited data and research on the materials industry and a noted laxity of the government arising from concerns over ‘stifling’ industrial/economic growth.

In addition, some of the environmental protection and clean development policies that were formulated following the signing of the Kyoto Protocol lacked ownership by the government and were therefore not adequately grounded into the local context and are now facing implementation challenges. In contrast, some contemporary policies such as the National Housing Policy (2016) took a noticeable stance towards creating opportunities for research and adoption of sustainable construction materials and processes so as to minimize the environmental impacts associated with the construction sector. Whereas this constitutes a step in the right direction, it still calls for specific standards which would have to be supported or enforced through different ministries. The implementation as well as the monitoring and evaluation mechanism is therefore not adequately embedded.

7.6 How policy response to the environmental impacts of the construction materials sector could be improved in Uganda.

Environmental policy integration is a very important aspect of sustainable development at a country or sector level and it requires “more holistic and above all proactive search early on in the policy process for opportunities to prevent environmental damage from occurring.” (Ahmed and Triana, 2008:3). This significantly contrasts with the dominant policy making trend in Uganda where environmental goals and values have been placed at the lower end of the scale. This was reflected in the country’s NDP I and II whose common focus is to aggressively industrialise and attract foreign investment so as to fast track modernisation and economic development with muted mentions on how this would be achieved sustainably and especially along a low carbon path. This partly explains why high-environment-impact industries such as the cement and burnt clay brick industries have grown and continuously expanded over the last 28 years with on-going government support while the policies governing their clean operations and mitigation of their environment impacts are not evolving as fast and equally not being stringently implemented or enforced. This has created a policy vacuum which then translates into the continuing environmental degradation and unsustainable growth outcomes of the prevailing practises and operations.

Chen et al (2016:1) argue that “sustainable materials management (SMM)” is critical towards optimising resource efficiency and thus requires a detailed understanding of the life cycle stages of the construction materials sector from the cradle, through the various gates to the grave stages. Furthermore, understanding the demand and supply patterns of construction materials is important in identifying the key drivers that influence the changing trends in the sub-sector and guide policy formation to be specific. In order for this to be successful it requires integration at a national and sectoral level between different government ministries/departments such as the environment, industry development, mining, works and transport as well as skilled and artisanal manpower to craft responsive policies (both reactive and proactive) while also ensuring effective implementation. This close relationship between demand and supply, life cycle stages, impacts and policy responses is illustrated in the conceptual diagram below (see Figure 7.1).

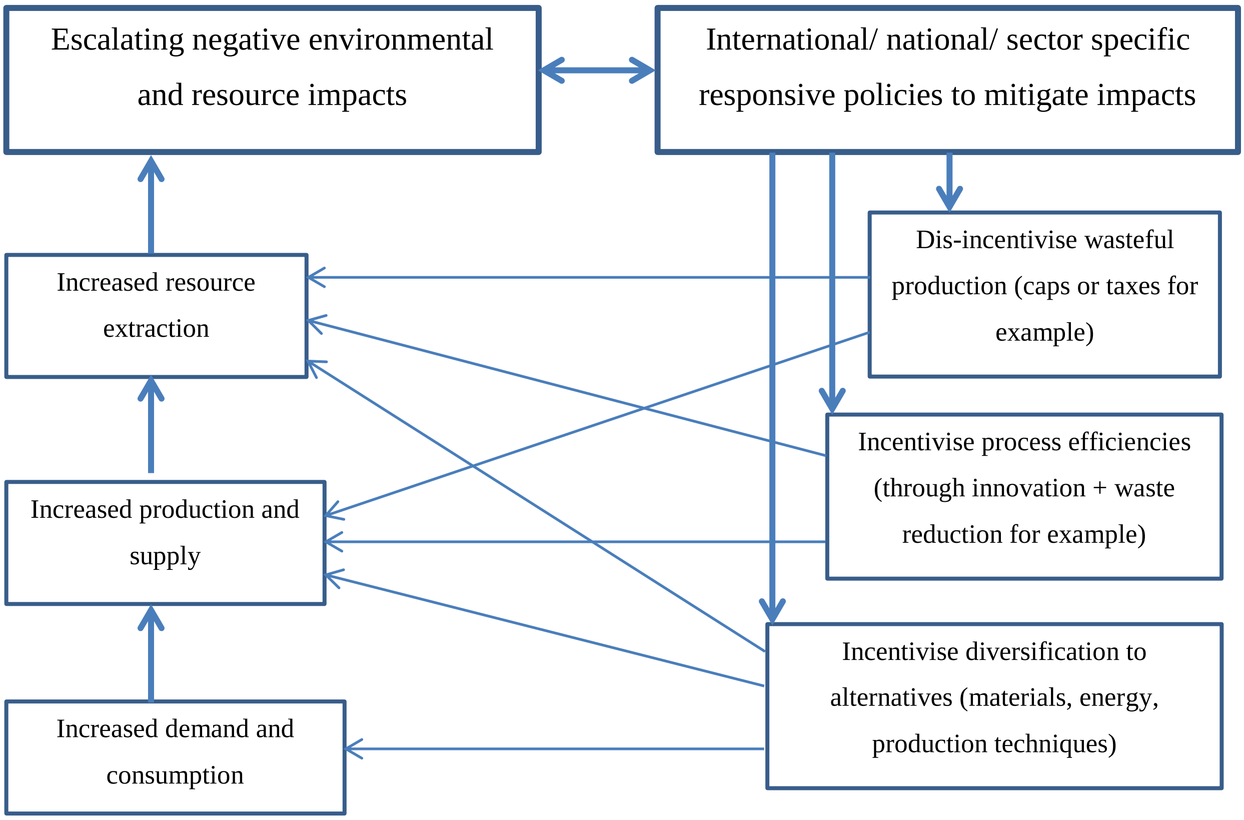


Figure 7.1. Conceptual diagram of the relationship between environmental impacts of the construction materials sub-sector and policy response.

However the study finds that both the burnt clay brick and cement industries in Uganda lack detailed life cycle inventories (LCI) that would provide a detailed understanding of their impacts and thus guide inter-sectoral interventions along their life cycle in order to mitigate their environmental impacts. The study also finds inadequate sectoral integration in decision making and policy formulation or implementation processes. In one key example, the priorities of the mining and industrial development sectors lack alignment to the requirements for environmental protection and reduction of carbon emissions. In addition, the relevant ministries shift/escape the responsibility of formulating policy specifications on key issues such as pollution standards to other ministries and in the long run no comprehensive policies or related regulations are eventually drafted or once drafted they are rarely enforced. This study also finds that fragmented and uncoordinated approach to SMM in Uganda can be attributed to limited financial resources, limited skilled manpower, dominance of the informal sector in materials production and usage as well as limited political will to create and implement controls that are wrongly perceived as likely to ‘stifle’ economic development.

Some of the key features of good and effective policy process practice is one that it is both evidence based and forward looking. This means that its formulation is guided by the existing as well as reasonably anticipatable circumstances so as to offer realistic and grounded guidance for now and the future (Office of the President, 2009). Most of the policies (environmental protection, industrial development, energy and quality standards policies, among others) meant to guide the sustainable development of the construction materials sector seem not to acknowledge the dominance of the informal sector activities along the life cycle and value chains of sector, right from mining, production to the use and disposal of related materials. Most of the policies may benefit formally organised operations such as in the cement industries but not the informally organised ones such as the artisan brick makers where they are the dominant players in the burnt clay brick sub-sector.

Some of the more contemporary environmental protection and clean development policies were drafted when Uganda become a signatory to some of the UNFCCC agreements such as the Kyoto Protocol (1997) and the Paris Agreement (2015). The study finds that it was subsequent to such international agreements that the government commenced on the drafting and implementation of responsive policies such as the Clean Development Mechanism project, the NCCP and the Renewable Energy Policy in order to demonstrate the country's commitment. However, it is questionable whether the policies and strategies drafted then were systematically cognisant of the prevailing state of the environment and nature of development and how they could effectively guide case specific low-carbon and low environmental impact development for Uganda into the near future.

Specifically, the study finds that for the construction materials sector, policies have not effectively evolved to guide the sustainable growth and development and especially with regard to the high environmental impacts of the commonly used cement and burnt clay brick industries. Whereas there are some overarching policies (such as the NEA, NFA, NCCP, the Renewable Energy Policy) which were drafted to guide the overall sustainable development of the country as well as the different economic sectors, such policies do not exist within a supportive framework of financial, technical and institutional infrastructure which would ensure successful implementation and adoption.

7.7 Recommendations towards policies for a sustainable construction materials sector for Uganda.

Based on the above findings from the direct observation during site visits as well as interviews and review of documents and reports, it is evident that there is a growing need to fully document and understand the country's construction materials sub-sector, its growth trend as well as environmental impacts. This data can effectively guide the governance of this sub-sector at both national and sectoral level to guide its sustainable low impact growth. For example the Department of Works at the Ministry of Works and Transport, in collaboration with other ministries, material producers, miners, contractors and industry professionals such as architects and engineers, needs to collect comprehensive data on the industry. Critical data such as the life cycle inventory of the different materials produced and consumed locally, the participants in this industry (both formal and informal), methods of production and construction, production sites and the stock of raw materials (both the rare and "non- rare") among others is not systematically being compiled. This kind of a living database would provide a guiding point for the critical areas along the life cycle of the construction materials that may need either restrictive or enabling policies in order to improve efficiency, reduce wastefulness and mitigate the diverse forms of the resultant environmental degradation.

More importantly, different government ministries need to understand the nature and role of the informal sector in the construction industry especially across the life cycle stages from mining, to manufacturing of materials to the construction works and the opportunities for recycling in order to optimise materials efficiency in the sector. Given the dominance of the sector and its operations, different government ministries should start planning collaboratively with the different actors (and local governments) in order to ensure responsive policies/regulations and systematic implementation.

With more comprehensive data collection, relevant government ministries could systematically identify and incentivise the adoption of good, yet isolated, practices being implemented by some actors across the life cycle of the construction materials sector. Some of the practices that were identified during the study were waste biomass substitution in both cement and brick kilns so as to reduce petroleum oil and wood fuel demand respectively. Such biomass wastes are abundant due to the dominance of the agricultural sector in the country's economy and they include coffee husks, rice husks, groundnut husks and maize cobs. However, this calls for a well-coordinated market system where the suppliers can easily link up with potential buyers.

Another practice that could be mainstreamed by the government is the research into and incentivising the use of alternative low EE and environment impact materials such as;

- Compressed earth blocks and interlocking blocks
- Un-stabilised adobe and cob
- Compressed earth for walls and floors
- Bio-based materials (bamboo, reeds, sugarcane waste, cellulose, wood shavings, hemp and flax)
- Sustainably grown and sourced timber
- Recycled and re-purposed concrete and burnt clay bricks

These can be better adopted if there is inter-sectoral information dissemination and technical support especially between key actors such as the policy makers, industry professionals such as researchers, architects, engineers and quantity surveyors and most importantly the developers/ consumers (both formal and informal).

Furthermore, there is an urgent need to formulate and implement regulatory policies especially on critical issues such as mitigation standards of air, water and soil pollution. The National Environment Management Authority (NEMA) needs to work hand in hand with the Ministry of Energy and Mineral Development, the Ministry of Tourism, Industry and Cooperatives and also conduct research on similar standards that have been adopted in order to develop guidelines and specifications that are realistic, achievable and supported by the other ministries during the implementation/ enforcement process. Guided by these principles, other policies that need to be formulated include the sustainable materials policy, industry specific clean production mechanisms, site rehabilitation regulations, waste management regulations especially for construction waste and renewable energy adaptation strategies.

The government also needs to commit to a systematic implementation and on-going revisions of existing policies in order to ensure that they match the changing dynamics of the construction materials sector as well as the evolving challenges. This could be done through interventions such as committing financial resources to ensure monitoring and adherence to existing policies, training of skilled manpower such as material specialists, environmentalists and researchers in alternative low-carbon materials such as recycled concrete and local construction techniques as well as builders and professionals such as architects, engineers, quantity surveyors and contractors. This would be in a bid towards increasing efficiency, reduce wastefulness, empower the informal sector-workers with better skills and diversify the range of low-carbon materials in the country.

This study mainly focused on the co-evolution of policies in response to the environmental impacts of the construction materials sector in Uganda and therefore does not delve into the field of alterative low-carbon and low environmental impact materials or related construction industry practices. Further studies are required along this theme and especially with regards to the institutional requirements for the successful mainstreaming and effective adoption of those practices within Uganda's construction industry.

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Appendices

Appendix A: Interview guides, direct observation tool and permission letter.

Appendix A1: Official in National Environment Management Authority (NEMA).

i. What are the environmental concerns of the burnt clay brick and cement industries in Uganda?

ii. Which areas in Uganda have felt the most environmental impacts of these two industries?

iii. Are there any regulatory policies guiding the development of these two industries? Which ones? How often are they revised?

iv. How are these policies enforced?

v. What challenges do you face when enforcing the policies?

vi. What are your recommendations to construction industry professionals and manufactures of construction materials as regards the sustainable development of this sub-sector?

Appendix A2: Official of Ministry of Works and Transport

i. What is your view on the current trend of growth of the cement and burnt clay brick industries in Uganda with regards to their environmental impacts?

ii. What are the priorities or the vision of the ministry as regards the sustainable growth and development of the construction industry with construction materials as its key inputs?

iii. To what extent can the ministry regulate the production and supply of the construction materials sub-sector?

iv. How has it been regulated so far in view of the increasing environmental impacts of the construction materials sub-sector especially the burnt clay bricks and cement industries?

v. What challenges does the ministry face as regards regulating the sustainable development of the construction materials sub-sector with a low carbon footprint? How are these challenges being addressed?

Appendix A3: Official from the Ministry of Trade, Industry and Cooperatives

i. What have been the contributions and the shortcomings of the cement and burnt clay bricks industries to the manufacturing sector in Uganda?

ii. How many producers of cement and burnt clay bricks are in Uganda? How much quantity do they produce?

iii. What is your view on the current trend of growth of the cement and burnt clay brick industries in Uganda with regards to their environmental impacts?

iv. What are the priorities or the vision of the ministry as regards the sustainable growth and development of the manufacturing sector especially for the cement and burnt clay brick industries?

v. Are there any policies or plans that guide the sustainable development of the construction materials manufacturing industries especially the burnt clay bricks and cement industries? Which are these policies or plans? How often are they revised?

vi. What challenges does the ministry face as regards regulating the sustainable development of the construction materials sub-sector with a low carbon footprint? How are these challenges being addressed?

Appendix A4: Official from Ministry of Energy and Mineral development

i. Is there a database of the quantities of reserves of limestone and clay deposits available in Uganda and the rate of extraction taking place?

ii. At the rate of development, how long can these deposits sustain the construction industry or Uganda’s economy?

iii. To what extent can the ministry regulate the rate of extraction of clay and limestone deposits and the choice of energy used?

iv. What are the environmental impacts associated with the current trend of clay and limestone mining in Uganda with regards to resource consumption and choice of energy sources?

v. What are the current sources of energy used for mining and manufacturing in Uganda? Why are they prevalent? What are the advantages and disadvantages associated with dependence on these sources of energy?

vi. Are there any policies or plans for the diversification of the energy sector portfolio towards sustainable energy for mining and production? Which policies or plans. How long have these policies been in place? How often are they revised and based on what?

vii. What challenges does the ministry face with regards to diversifying into sustainable sources of energy for the mining and manufacturing sector?

viii. Are there any policies or plans to guide the sustainable exploitation and extraction of Uganda's minerals especially clay and limestone? Which policies or plans? How long have these policies been in place? How often are they revised?

ix. What challenges does the ministry face as regards regulating the sustainable development of the mineral extraction and processing sector especially with regards to clay and limestone mining? How are these challenges being addressed?

Appendix A5: Registered architects and engineers (construction industry professionals)

i. What influences the choice of materials for your projects?

ii. To what extent do you consider the life cycle inventory of your construction materials? Is it currently possible to do that? How far along the life cycle of your materials can you trace the different processes the material has been through (from extraction to disposal)?

iii. To what extent do you specify burnt clay bricks and cement in your projects? Why do you recommend these materials? What are the disadvantages or difficulties associated with using these materials?

iv. Is it your practise to specify or guide on where materials for your projects are to be sourced and their production techniques?

v. What are the environmental impacts of using these materials that you have witnessed during your practice?

vi. What practises or policies can guide the sustainable development of the construction materials sub-sector?

vii. How can these be successfully implemented?

viii. Are there any alternative, more sustainable materials as regards their life cycle inventory that are appropriate for Uganda's context? In what ways are they sustainable? Have you tried using such materials and what are the challenges and opportunities of working with them?

ix. What challenges do you face as an architect as regards designing, specifying and managing projects to ensure sustainable and project phases with good life cycle inventories for the materials?

Appendix A6: Management personnel from the material processing companies.

i. What is the vision for the development of your company? How does sustainability rank in your priorities?

ii. How long have you been manufacturing this product, and depending on the quantities of raw materials present, for how long shall you be manufacturing the product? Where do you source your raw materials?

iii. What are your production techniques?

iv. What is you quantity of production annually? Who comprises the market for your product? Who is your biggest consumer?

v. What steps does the company take to produce a sustainable product? How has the company evolved in extraction and production techniques? Is there any internal company policy guiding your sustainable development? What would you consider as sustainable development for the cement industry and for your company?

vi. What are your major sources of energy? What quantities of energy are consumed annually if there are any records? Are there any sustainable energy sources used by your company?

vii. Are there any government policies guiding your operation? Which ones? Are there any that are guiding your sustainable development?

viii. What challenges do you face as extractors of raw materials and manufactures of the final product?

Appendix A7: Direct observation template

Tool	Cement	Burnt clay bricks
Photography • The nature of raw materials • Production tools and processes. • Physical initiatives that show an effort towards sustainable production. • Physical signs of environmental degradation		
Notes • How raw materials are extracted and where they are extracted from. • The manufacturing process • Sources of energy • Sustainability and industrial ecology plans. • Quantities produced in a day, month and		

year.		
Sketches/ Maps • Location and sizes of industries and mineral extraction sites.		

Appendix B. Uganda Statistics

Appendix B1: Mean Per Capita Consumption Expenditure (2005/06 prices) per month

1 Us Dollar= 3700 Ug. Shilling

1 Za Rand= 288 Ug. Shillings

Table 0.1. Mean per capita consumption expenditure (2005/06 prices). Source: UBOS, 2017:38.

	2005/06			2009/10			2012/13		
	Rural	Urban	Uganda	Rural	Urban	Uganda	Rural	Urban	Uganda
Uganda	**33,170**	**81,463**	**40,586**	**38,244**	**97,755**	**47,184**	**40,283**	**87,213**	**50,892**
Central*	47,008	85,096	**51,677**	58,792	104,290	**67,466**	53,567	106,214	**73,060**
Kampala	n.a	109,224	**109,224**	n.a	131,618	**131,618**	n.a	129,134	**135,764**
Eastern	29,007	64,733	**31,803**	32,978	57,930	**34,892**	30,257	51,136	**35,906**
Northern	19,019	36,505	**21,518**	25,786	53,049	**28,400**	25,361	46,001	**31,140**
Western	35,282	76,756	**38,440**	38,826	85,423	**42,163**	44,614	70,697	**53,657**

*Note: Central * = Central region excluding Kampala city*

Appendix B2: Uganda's GDP by expenditure at market prices.

Table 0.2. Uganda's GDP by expenditure at market prices. Source UBOS, 2017:227.

Year	2012/13	2013/14	2014/15	2015/16	2016/17
Total (Billion shillings)	63,740	69,276	76,517	82,903	91,351

Appendix B3: Estimated mid-year population growth between 1991- 2017

Table 0.3. Uganda's estimated mid-year population since 1991. Source: UBOS, 2010 and 2017.

Year	1992	1995	2000	2005	2010	2014	2017
Population (‘000)	17,473	19,235	22,575	26,741	30,661	34,634	37,673

Appendix B4: Population distribution between the urban and rural areas.

Table 0.4. Distribution of population by residence and region (%). Source: UBOS, 2017:21.

	2005/06	2009/10	2012/13	2016/17
Residence				
Rural	84.6	85.0	76.5	75.5
Urban	15.4	15.0	23.5	24.5
Total	**100.0**	**100.0**	**100.0**	**100.0**
Region				
Kampala	5.7	5.0	3.7	4.2
Central	23.6	21.3	23.0	23.4
Eastern	25.2	29.6	28.9	26.1
Northern	19.7	20.0	20.9	20.8
Western	25.9	24.0	23.5	25.5
Total	**100.0**	**100.0**	**100.0**	**100.0**

Appendix C: Copy of ethics clearance certificate

SCHOOL OF ARCHITECTURE AND PLANNING
HUMAN RESERCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE
PROTOCOL NUMBER: SOAP069/06/2017

PROJECT TITLE:	Policy responses to the escalating environmental impacts of construction materials sector in Uganda. Case studies of burnt clay brick and cement
INVESTIGATOR/S:	Solophina Nekesa (Student no# 1748943)
SCHOOL:	Architecture and Planning
DEGREE PROGRAMME:	Master of Architecture -SEEC (MArch SEEC)
DATE CONSIDERED:	16 November 2017
EXPIRY DATE:	16 November 2018
DECISION OF THE COMMITTEE:	APPROVED

CHAIRPERSON ____________________
(Professor Daniel Irurah)

DATE: 20 - 11 - 2017

cc: Supervisor/s: Daniel Irurah

DECLARATION OF INVESTIGATORS

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to endure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

20 · 11 · 2017

Signature **Date**

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