The Use and Diffusion of Life Cycle Thinking / Assessment to Ensure Sustainable Practices in the Developing African Economy: Status, Challenges, and Barriers

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Abstract

Faced with unprecedented global population growth and with unsustainable consumption, humanity needs to define and adopt new paradigms of development which will safeguard the human wellbeing and the earth's finite resources. Sustainable development has thus become a global urgency, and technology plays a key role in this context. In particular, bridging the technological gap between the industrialised and developing countries is a necessary step towards sustainable development. However, the transfer of technology from the developed to the developing world has a bumpy history and is characterized by great challenges. Life cycle assessment (LCA) is a tool which can facilitate the global sustainability agenda given its capacity to identify the most sustainable technologies and to support environmentally proactive decision making. This research uses the technology transfer framework to investigate the diffusion of LCA from developed to developed countries and addresses the challenges associated with this process. It uses the mixed methodology as the methodological approach. Interviews, document reviews, surveys, web reviews were combined in carrying out the study. The study shows that there is an increasing demand for LCA in Africa, mainly due to demands from donors and export markets. Despite the huge demand, there is a shortfall in human resource capacity on the continent. Collaborations between local and international training institutions; funding; collaboration between African professionals, relevant regulatory frameworks as well as access to quality data are seen as ways of addressing the challenges facing the diffusion of LCA in Africa.

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Ultimately, I thank God for his blessings. Ebenezer!

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Chapter 1   Introduction

Global Population growth coupled with increased economic activities tends to put more pressure on the available natural resources (Asif M., 2007). According to the United Nations Population Fund (UNFPA, 2013), current world population is estimated to be 7.2 billion and is expected to double by 2050.The high population growth rate coupled with unsustainable consumption practices exerts immense pressure on the environment and is an important contributor to environmental degradation (WorldBank, 1992). There is therefore global consensus that man has to be proactive in safeguarding the earth's resources to enhance wellbeing and also for the benefit of posterity.

1.1   Introduction to Sustainable Development

1.1.1   The Concept of Sustainability

In the early 1970s, the term "Sustainability" was used to illustrate an economy "in equilibrium with basic ecological support systems" (Stivers, 1976). Ecologists also referred to The Limits to Growth, (Meadows et al., 1972) and offered an alternative of a "steady state economy" as an approach to addressing environmental concerns (Daly, 1973).

The term "Sustainable development" is interpreted in several ways. However, the Brundtland Commission's report, Our Common Future, offers the most often-quoted definition of sustainable development as the development which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United-nations, 1987)

Fig.1.1 The Dynamics of Sustainable Development. Source: (WorldBank, 2001)
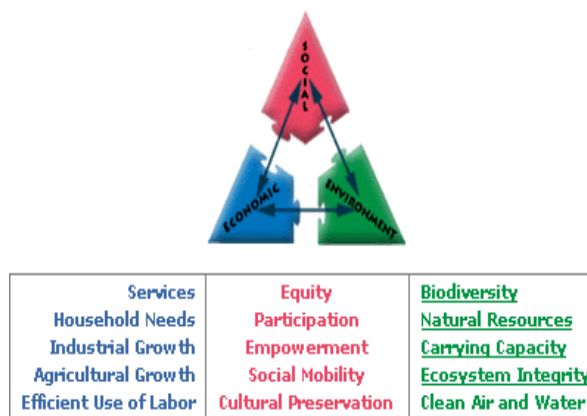
Figure 1.1 illustrates the various factors at play in understanding sustainable development. The definition of sustainable development contains some important concepts, such as inter-generational equity, needs and limits. Basically the primary issue established by the commission as most pressing when applying the principle of sustainable development, includes population and development, food security, species and ecosystems, energy, industry and the urban challenge (UNCSD, 2011). In effect, sustainable development surmises that the earth be considered as a system with finite resources. Consequently, sustainable development integrates respect for the carrying capacity of natural systems in meeting the social challenges of humanity (UNCSD, 2011).

1.1.2   History of Sustainable Development

The origins of sustainable development can be traced to the United Nations Conference on the Human Environment in 1972, which assembled both developed and developing nations to define the *'rights'* of humanity to a healthy and productive environment (UNCSD, 2011). This continued with several fora which sought to revamp man's connection with Nature, culminating in the formation of several institutions within the United Nations system which sought to promote the ideals of sustainable development.

In 1980, the International Union for the Conservation of Natural Resources (IUCN) released the *World Conservation Strategy (WCS*) which further pioneered the notion of *sustainable development*. The Strategy indicated that nature conservation must go in tandem with development to ameliorate poverty and misery of the world's populations and highlighted the mutual dependence of conservation and development whereby development is dependent on caring for the Earth (UNCSD, 2011).

At the World Summit on Sustainable Development the Johannesburg Plan of Implementation (JPOI) sought to revive the international commitment to sustainable development. Resolution (A/RES/64/236) of the UN General Assembly culminated in the United Nations Conference on Sustainable Development (UNCSD) in 2012 - also known as 'Rio+20'. RIO+20 revolved around three main goals: 'securing renewed political commitment to sustainable development, assessing the progress and implementation gaps in meeting already agreed commitments, and addressing new and emerging challenges' (UNCSD, 2011).The conference resulted in the report "*The Future*

We Want" which tackled a myriad of global challenges such as accessibility to clean energy, food security, water and sustainable transportation. Sustainable development has permeated all aspects of global business and become an issue of top priority.

1.1.3 The Pillars of Sustainability

The notion of sustainable development is decomposed into three core components: environmental sustainability, economic sustainability and sociopolitical sustainability. The pillars of sustainability therefore refer to the interdependent and mutually reinforcing themes of sustainability (UNCSD, 2011).

- ***Economic sustainability***: the chief objective of economic development is human advancement and the realization of individuals' full human resource potential. This pillar thus suggests need of a sustainable economic model that secures a fair distribution and efficient allocation of the earth's resources (WorldBank, 2002). This pillar indicates that our economic growth keeps a sound balance with our ecosystem.

- ***Environmental sustainability***: the earth's resources are finite and need the proactive involvement of each individual in protecting it. Thus each individual is supposed to act as an effective steward of our natural environment. This responsible stewardship is premised on the idea that each individual is an invaluable resource, and united we may address the challenges of an increasing population with innovation and invention. The objectives of development and environmental protection are not mutually exclusive but interdependent via a people centered approach (WorldBank, 2002). This pillar supports initiatives like: green energy, low fossil fuel consumption and emissions, sustainable agriculture and fishing, organic farming, afforestation, recycling, and enhanced waste management.

- ***Social sustainability***: social advancement is a necessity for a successful economy and environment. Daily necessities such as accessibility to clean water, sanitation, and adequate healthcare are vital for development. In asserting the basic human necessities, desires, and rights of each person, a common resolve to sustainable development is realized. Thus we have an ethical responsibility to address human inequality, social injustice, and poverty. This pillar

promotes initiatives like peace, social justice, reducing poverty, and other grassroots movements that promote social equity (WorldBank, 2002).

In recent times it has been opined that a comprehensive approach is to address sustainability from four perspectives; economic, ecological, political and cultural sustainability.

- *Cultural sustainability*; the prominence of culture is due to the increasing share of cultural goods, services and intellectual property in global trade including the challenges to cultural diversities and identities related with current globalization. In addition, there is further awareness that the preservation and enhancement of cultural diversity is essential to universal human rights, fundamental freedoms as well as engendering ecological and genetic diversity. According to Nurse (2006) sustainable development is feasible only when there is harmony regarding the goals of cultural diversity, social equity, environmental responsibility and economic viability.

One theme which can also be deduced from sustainable development theory is the underlining inequalities in development globally and the need for global partnership and concerted effort in bridging these gaps. The wide disparities in development levels are for example reflected in the notion of *developed* and *developing* nations. Whereby the former has achieved relatively high level of industrial and social wellbeing compared to the later.

1.2   *The Leapfrogging of Developing Countries*

"*Leapfrogging*" refers to how the use of cleaner technologies transferred from developed nations will increase human development in developing nations with minimal pressure on the natural environment; hence technology is a chief vehicle or bridge to this gap in development (Marschinski Robert, 2012).

The concept of 'leapfrogging' refers to the general development pathway that underdeveloped nations could chart without experiencing the negative environmental degradation which characterized the development of most developed nations. Rather, it suggests the developing nations realize cleaner development methods with limited environmental impacts (Gallagher, 2006).

The Environmental Kuznets Curve (EKC) hypothesis offers further insight into this phenomenon; the hypothesis draws a link between national income and pollution levels and indicates a correlation between income rise and environmental degradation.

Fig.1.2 The Environmental Kuznets Curve. Source: (Sauter and Watson, 2008)
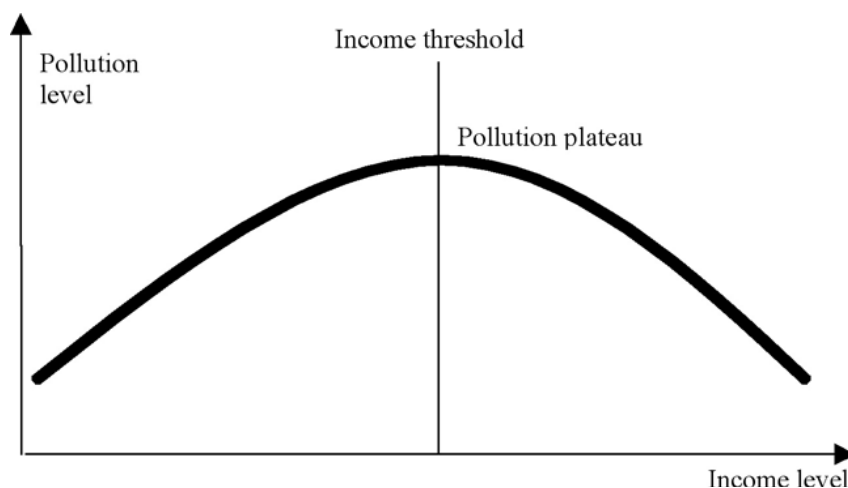
Fig 1.2 illustrates the EKC. It suggests a model whereby pollution increases with income, then stabilizes upon the realization of a 'threshold' income level and then ultimately falls. According to Sauter and Watson (2008), the EKC portrays adverse environmental impacts as a 'transitional phenomenon' instead of an unavoidable, consequence of economic development. In addition, Sauter and Watson (2008) suggest this phenomenon has several drivers, for example: environmental sensitization and resources to limit pollution are enhanced as incomes increase; the displacement of a pollutant by another with economic development; technological advancement.

The concept of technology diffusion which revolves around the theme of technical change is a vital component for the rapid development of less industrialized nations (Perkins, 2003). Countries which adopt a technology at later stage can benefit as they; evade implementing technologies in their initial phase where they could still undergo key improvements; and they gain accessibility to technologies which are relatively inexpensive and at a later phase of their development (Sauter and Watson, 2008). Sauter and Watson (2008) identify three patterns of

leapfrogging: 1) path-creating catching-up: the latecomer catches up with the frontrunner and then follows a new development path; 2) path-skipping catching-up: the latecomer skips stages of the frontrunners' development trajectory;3) 'simple' path-following catching-up" (Sauter and Watson, 2008).

Perkins (2003) explains that certain conditions are needed to encourage leapfrogging. Thus motivations concerning clean technological is not enough to boost leapfrogging in developing countries. It must be combined with series of capacities which is essential for organizations to react to stimulus in the path of cleaner technologies. Nevertheless, knowledge, skills and expertise constitute technological capability required by local company to make the right choice of technology that can sustain the economy (Perkins, 2003). These capabilities coupled with incentives are required by developing countries in order to realize their potential in clean technologies. But it is important to note that there is low level of capacity in developing countries. So national government, private companies and other relevant institutions need to build up the local capacity in order to realize its leapfrogging potential (Perkins, 2003). Moreover, a substantial effort is still needed to address the problem of environmental degradation in developing countries. The difficulty is recognizing what strategies give preference to both environmental and developmental issues, while tackling the challenge of inadequate technological capacity in developing countries (Perkins, 2003).

Several nations in Africa fall under the category of developing nations for which leap-frogging is important for the benefit of sustainable development. The proceeding sections shed light on the problems related to the achieving sustained development in Africa.

1.3.   Development in Africa: the main challenges
The African economy is driven by commodity goods, for example mineral resources, oil, metals. Its main sources of revenue are agriculture, mining, fishing, manufacturing and services. In the advent of increasing industrial activities in Africa, one of the main challenges is to successfully transform its economy from mainly being agricultural-based to manufacturing- and service-based in a more sustainable pattern.

In the advent of increasing industrial activities in Africa, one of the main challenges is to successfully transform its economy from mainly being agricultural-based to manufacturing- and service-based in a more sustainable pattern (Darkoh and Rwomire, 2002).

Africa faces the deterioration of its environment caused by unsustainable exploitation of its natural resources related to the increasing demand to satisfy a rising population. At these points it is necessary to restrict the drivers for environmental degradation to few indicators. Population increase is one of these factors. Darkoh and Rwomire (2002) observe that large population growth often associated with urbanization leads to human congestion in more populated region. Increase human presence has more tendencies to lead to increase waste production leading to environmental deterioration.

Several literature sources suggest numerous reasons for the apparent stagnation of African economies. Among others, Ake (2006) lists these reasons: social pluralism and centrifugal tendencies, leadership corruption, poor labour discipline, low entrepreneurial skills, poor planning and incompetent management, inappropriate policies, unfavorable terms of trade, low levels of savings and investments..

These notwithstanding, the United Nations Development Programme (UNDP) surmises that the most pertinent challenge for Africa is to create people-centered development, producing well-being and opportunities for its people (UNDP, 2013). To achieve all this, African countries must enhance the private sector, generate jobs for the poor, boost social protection, and bolster food security. Furthermore, there is the need for Africa to build resilience by avoiding conflicts and consolidating peace so that the fruits of development are protected and built upon (UNDP, 2013).

In the face of the serious environmental challenges confronting Africa, it is necessary to integrate environmentally friendly practices to boost sustainable development.

1.4   Problem Formulation

In the context of increasing environmental burden cause by economic activities in Africa, Life Cycle Assessment could play a key role in environmental management and decision support.

Fig 1.3 describes the flow from the causes, core problems and effects. However it is not clear which African actors can effectively use LCA, in which areas and sectors of the African economy

is LCA applied and what kind of environmental challenges are usually addressed by LCA in the African context. The idea is that different kinds of barriers may limit the application of LCA in Africa, and these should be identified and removed.

The main research questions of the project are:

- What are the main challenges encountered during the implementation of Life Cycle approach in both private and public sector of the African economy?

- What measures are required to be implemented to overcome these challenges?

- How do we analyze these problems from the technology transfer perspective?

The study objective is to explore how LCA can be used as a tool to facilitate sustainable development in Africa and how the barriers to its adoption in Africa can be addressed.

Fig. 1.3 Problem Tree.

Effects

Waste, air, water pollution,
poverty,
Pollution in central areas,
Overexploitation, mining

Core Problem

Rate of exploitation of oil/mining/resource use is unsustainable

causes

Human resource, civil society
organization

LCA

Dirty technologies
And practice
Environmental regulation and
Enforcement

Competition in international
Market
Prices, profit
Many foreign companies
End consumer do not care

Source : (Researcher and Supervisor's own construction)

Chapter 2.   Literature review

2.1   Life Cycle Assessment

There is an increasing consciousness about how human activities impact on the environment. Producers and consumers are more concerned about natural resource decline and environmental degradation (USEPA, 2006). This has propelled a lot of businesses to be more sustainable in their industrial operations (USEPA, 2006). Environmental management plays therefore an important role in business and policy making (Finnveden et al., 2009). This has led to the development of different environmental management tool to evaluate the environmental impact of a product, activity, or process from a broad perspective (USEPA, 2006). Among these is Life Cycle Assessment (LCA).

LCA is a method used to determine the environmental profile of a product. According to the International Standard Organization, LCA is *"a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle"* (ISO14040, 2006). Frankl and Rubik (2000) define LCA as *a" tool for assessing the potential environmental impacts of product."* It measures this environmental burden from several viewpoints including the entire life cycle of the product or process (Frankl and Rubik, 2000).

Life cycle assessment is often referred to as "*the cradle to grave approach*" (UNEP, 2009). It begins with the evaluation of all environmental impacts from the raw material extraction, to the production of material, product making, transportation, use, product disposal and recycling of material. LCA provides a complete view of the environment profile of a product or process and possible alternatives to product or process, since it includes the entire burden across the entire product lifecycle (UNEP, 2009).

The major difference between LCA and other environmental assessment tool such as environmental impact assessment (EIA) is the expansion of the scope to account for the impacts and emissions to multiple stages (use, maintenance, end of life) of the product life cycle (Azapagic, 1999).

Specifically, LCA can broaden the scope of accountability in environmental management. The LCA methodology is scientific in nature. LCA inventory database is a collection several inputs from energy, natural resources, electricity, and outputs containing emissions of different product

system, coupled with information on different environmental impact categories such as climate change, land use, toxicity and fossil fuel depletion (ILCD, 2012). LCA as a holistic and robust tool used to address the issue of problem shifting in product systems. These occur in the process of fixing an environmental problem, creating another problem in the product system (ILCD, 2012; UNEP, 2009).

LCA is applied in the business and research world by engineers and environmental managers for: choosing best environmental alternative in the green design of products, keeping record of environmental impacts of products, and as a decision support tool in environmental management. Government institutions use LCA for schemes such as ecolabelling, green purchasing, and integrated product policy (ILCD, 2012).

2.2   Brief history of LCA

Early use of LCA was reported in the 1960 to approach the environmental problem of industries and support stakeholders to make decision on material selection for different products (UNEP, 2009). The Coca-Cola Company conducted a comparative study in 1969, which act as the basis for the present methodology of inventory analysis in the United States (USEPA, 2006). Other comparative study in Europe and United States conducted in the 1970's, employed the use widely available data since industrial data was missing (USEPA, 2006).

From 1970's to the early 1980's. Environmental concern was more focused on toxic pollutants, domestic waste product, toxic and several other production activities. Significance improvement in the studies conducted was noted, in terms of quality and quantity (ILCD, 2012; UNEP, 2009). However the issue of problem shifting across different life cycle stages of the product system was still a major challenge (ILCD, 2012).

Solid waste was the major global environment concern in late eighties, bringing a renewed interest in LCA study. Again the high use of this method due to rising environmental problems leads to its technical improvement. The quest to move further from inventory management to impact assessment was a major breakthrough in LCA strategies (USEPA, 2006).

In the nineties, Greenhouse gas emission was a global concern. The Society for Environmental Toxicology and Chemistry (SETAC) made several initiatives regarding the development and

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harmonization of the LCA methodology. In line with the ongoing gesture, the International Standard Organization (ISO) consolidated on the gains of SETAC, by introducing an international standardization procedure for LCA. Four standards (ISO 14040-14043) was developed, which provide the least condition for doing an LCA, including the framework (UNEP, 2009).

Between late 90's and early 2000's, "Life cycle thinking" was a new concept through UNEP/SETAC initiative, incorporated into businesses to promote sustainable practice. Life cycle thinking is an approach to harmonize the environmental, social and economic burden of a product over it whole life cycle. It is a further effort beyond the conventional impact evaluation process that is restricted to production activities within the factory. Other aspects like use, transportation, maintenance and end of life stages is put into consideration (UNEP, 2009).

According to Klaus Topfer, Life cycle thinking should be relevant to decision making process concerning production and consumption activities. This implies the supply chain of a product system from cradle to grave should endeavor to consider not only the direct cost, but also the spillover effects (UNEP, 2009). An important aspect of Life cycle thinking is that, it assists in averting problem shifting across the product life cycle coupled with facilitating more effective resource use (ILCD, 2012).

2.3   Life Cycle Assessment Methodological Framework

The ISO standards consist in two documents, i.e. the ISO 14040 (2006) containing Principles and Framework and ISOSO 14044 (2006) which showcases regulation and guidelines for each phase of the life cycle.

According to ISO standards, an LCA should be made up four different steps: (UNEP, 2009)

- Goal and scope definition,

- Inventory Analysis,

- Impact Assessment,

- Interpretation of result.

Goal and Scope Definition: goal and scope need to be defined in respect to the aim of the study. In accordance with ISO 14044(2006), the goal and scope must reflect the purpose for analyzing the product or services, and the main audience to which the study outcome will be conveyed to. The scope of the study contains crucial elements of the LCA study. In compliance with the study aim, the product system and system boundaries, functional unit and environmental impact are clearly highlighted.

Fig. 2.1 Life Cycle Assessment Framework
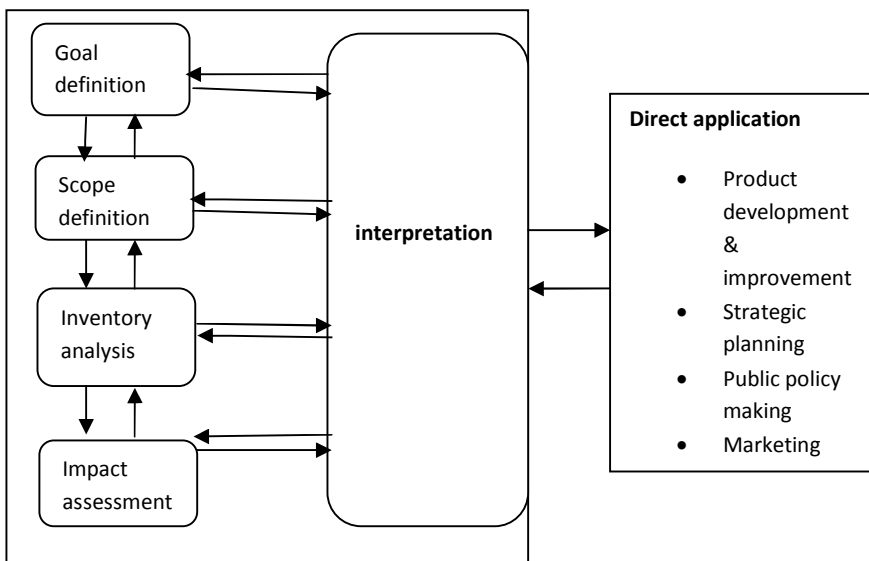
Source: (ILCD, 2012)

Inventory Analysis: inventory analysis phase determines and quantifies the material and energy inflow and outflow. A good inventory of all the inputs including water intake, energy, raw material consumption and the associated outputs such as emissions, waste, and water disposal is needed to guarantee a good inventory.

Impact Assessment: the impact assessment phase evaluates the potential environmental impacts of all the material inflow, including the energy, raw material, water usage identified under the inventory analysis.

Interpretation of Result: interpretation is the final phase of the LCA which analyses the outcomes from the inventory analysis and impact assessment phase. Consequently the better product or services is chosen, putting into consideration the uncertainty and assumption used in the study.

2.4   Use of LCA in Developing Countries.

According to World Bank (1995), the use of LCA in developing countries is still evolving since there is lack of quality data, inadequate know how on how to conduct LCA and limited LCIA methodologies that addresses the most pressing environmental problem in these regions. Unlike their western counterparts that have the required skills, high quality software coupled with good database inventory (WorldBank, 1995). There is need for relevant stakeholder including LCA expert, government, industries and research bodies to collaborate on developing new methodologies that can address environmental problems such as erosion, loss of land, water resources and salinization in these regions (Hauschild et al., 2005). However there are some new efforts to develop database and LCIA methodologies that would account for the environmental problems of this region (WorldBank, 1995).

2.5   Technological Transfer

"Technology is one of the means by which mankind reproduces and expands its living conditions. Technology embraces a combination of four constituents: Technique, knowledge, Organization and product."(kuada, 2003). Increasing population coupled with the desire to fulfill human needs constitute important drivers for technological innovation. Hence technological development is necessary in developing countries (many in Africa), since it addresses the problems associated with development in these societies (kuada, 2003). Successful Technology breakthrough in developing countries does not necessary mean a complete transfer of western innovation to developing countries. However, it also includes building the local capacity of developing countries (kuada, 2003).

Technology can be defined as "*A system of knowledge, techniques, skills, expertise and organization used to produce, commercialize and utilize goods and services that satisfy economic and social demands. Technology has most usage in industrial application* '.(UNIDO, 1995) A

technology can basically be decomposed into hardware and software components. The hardware components of the technology may exist in the form of production equipment, factory machinery, consumers items (Robinson, 1988). On the other hand soft goods existing in the form computer simulation form software. Each component of the technology or technical knowhow is preserved by means of copyright or institutions (Robinson, 1988).

Technology transfer is an avenue for bridging the technological gap between developing countries and developed countries. Technology transfer acts as a driver for promoting economic prosperity coupled with building up the local content in developing countries. International technology diffusion can occur through medium such as overseas training, hiring of expatriate, supply of machinery, sub-contracting, joint ventures agreement, vital partnership e.t.c. (UNIDO, 1995) Technology transfer does not only entail purchasing foreign knowledge, usage and replication of this new acquired skill is even more paramount. Localization of the newly acquired technology and adapting it to the institutional own objectives is hence necessary to make it remain relevant(UNIDO, 1995).

2.5.1 *International Technology Transfer Process*
For a successful technology transfer to happen, both the supplier and receiver of the technology must adapt the mutually beneficial condition of transfer (kuada, 2003).

Problems associated with transfer of technology often occur between the sender and the receiver. These problems can be addressed in a numbers of ways viz : adapting the technology to the prevailing circumstances of the receiver. Secondly the conditions of the receiver can be adjusted to that of the technology. Finally both the technology and the circumstances of the receiver are adjusted to meet each other conditions at a certain unknown point. (kuada, 2003)

(Robinson, 1988), suggests the main components of technology transfer includes: main technology in which all the processes and products is centered on, with supporting technology consisting of document, training manual, technical knowhow which provides the means of transfer of the technology (Robinson, 1988).

2.5.2   Technological Innovation Process

A broad system of innovation is required to boost national innovation process through good communication with all the actors as well as technological changes. A good interaction between the government, market forces and civil society will provide the needed motivation for positive technological changes. Kuada (2003) explains that the vital elements of technology comprise knowledge, technique, organization, and product. He adds that *"a qualitative change in any of the 4 elements of technology that effectively leads to a transformation move and thus change of the other elements, we denote a technological innovation."* (kuada, 2003). Furthermore it includes important components like organizations, means of assembling goods, support and relevant players. Suppliers of technology, markets for demand and supply, community, regulatory bodies, research and development teams constitute an effective innovation system (kuada, 2003). Conflicting Organizational culture is an important challenge in transferring technology from the Sender to the receiver. Kuada et al (2003) for example, highlight the case of fire explosion in a dairy processing plant transfer from Denmark to China (kuada, 2003). The fire explosion could be attributed to communication gap which was attributed to Chinese work ethics (kuada, 2003).

Some level of differences is noticeable between the suppliers and receivers of technological know- how, the so-called *"Areas of relative ignorance"* (kuada, 2003). This may occur due to lack of complete knowledge on the part of the receiver for instance. The supplier at the other end is believed to have total knowledge of the Technology. The assumption might stand in the short term, since the receiver may be well conversant with the social make up of the receivers environment(kuada, 2003).

According to Kuada (2003) assimilation of imported technology is likely to succeed *"only if a dynamic assimilation process of the technology transferred is initiated in the receiving enterprise and society, will the transfer result in a sustainable production capacity with long lasting effects''.*

2.5.3   Incompatible Technological System.

Kuada (2003) indicates that *consumption, application, formation, development* and *research* constitute the different means of transferring technology. For the purpose of this study, the scope

will be limited to research method. The level of skills and knowledge base increases from market assimilation to scientific assimilation. For a successful transfer and assimilation of the research to occur, all the actors should have a grasp of the complete technical know-out and principles of the technology. There have to be potential of moving the research skill and technical know-out to the to the receiver environment.

All the actors involved need to know their shortcomings, and engage in all aspect of the technology transfer process at their full capacity to avoid waste of resources (kuada, 2003).

2.5.4 *The International Transfer of Technology Theory, Issues and Practice*

UNIDO (1995) indicate that technology is an important vehicle for rapid economic development for developing countries. Information technology serves as an important means of transferring skills and knowledge in different sectors of the economy and between different countries. Moreover information technology can act as a driver for increasing productivity and better service delivery (UNIDO, 1995).

Knowledge acquired through research and development, technical assistance can quickly enhance transformation of the local industries, giving it a competitive advantage. This suggests that technology is important for economic development in the short and long term (UNIDO, 1995). Therefore government and private companies should endeavor to protect these technological gains. Some avenue to build up capacity includes funding national science and technology, government policy toward technological transfer.

Fig.2.2 Dynamic Assimilation of Technology Transfers.

Research	science →	Scientific Assimilation
Development	Know why →	Innovative assimilation
Formation	Know what →	Adaptive assimilation
Application	Know how →	Operative assimilation
Consumption	Know who →	Market assimilation

Social setting of supplier

Social setting of receiver
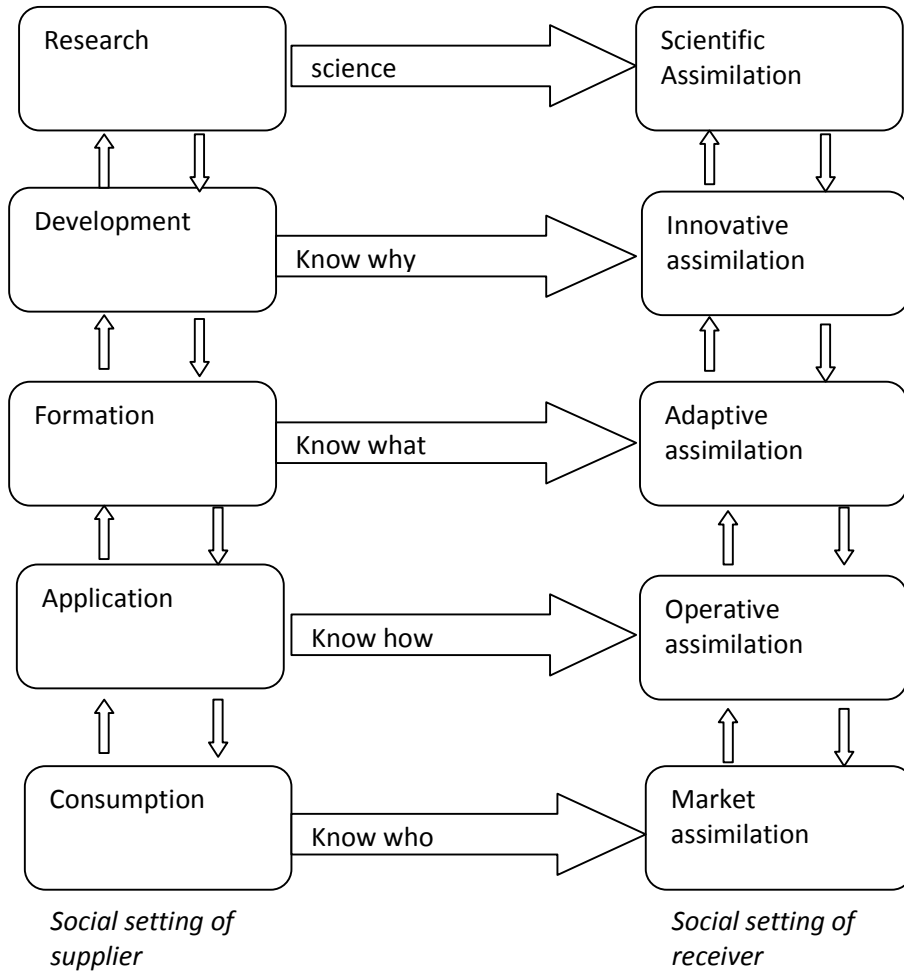
Source (kuada, 2003)

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Fig.2.3 Optimal strategy for achieving dynamic assimilation

Research	Science	Scientific Assimilation
Development	Know why	Innovative assimilation
Formation	Know what	Adaptive Assimilation
Application	Know how	Operative Assimilation
Consumption	Know who	Market assimilation

Social setting of supplier

Social setting of receiver
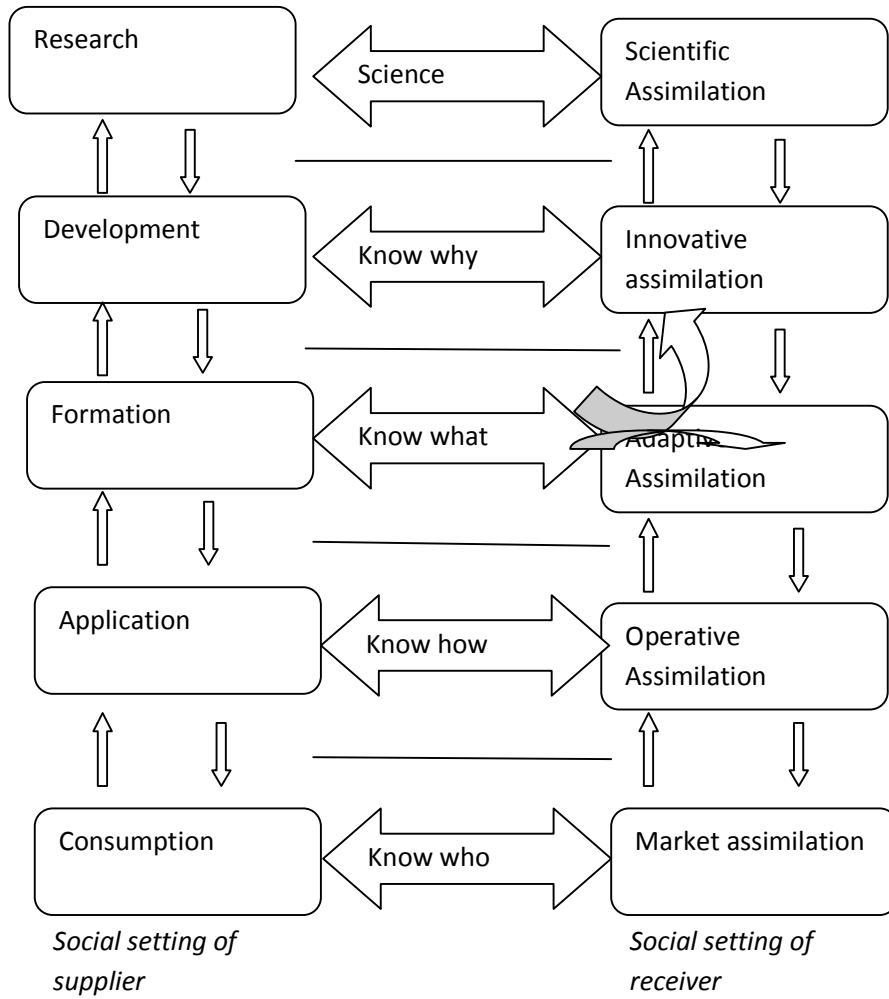
Source: (kuada, 2003)

2.5.5   Innovation and technological development.

Increasing the process of skill assimilation is a serious problem, associated with institutions operating in developing countries. The quest for international technology transfer usually occurs through means such as joint ventures, licensing agreements or sub-contracting understanding (UNIDO, 1995).

Role of national system of innovation in technology transfer: research center, educational institutions, financial centers and regulatory bodies, which make up important components of the national innovation systems tend to be weak in developing countries. These may be attributed to poor governmental policies and lack of motivation from organizations.

There is therefore the need to engage in training of more people coupled with necessary technical assistance, strengthening of institutions and optimizing the use of information technology in developing countries (UNIDO, 1995)

Elements of technology transfers such as skill human resources, machineries, imported raw materials, license agreements, and contracts have the potential to affect economic activities in the short run. However in developing countries, the real problem is how to use the technology transfer as a means of technological transformation and catching up with the advanced countries. (UNIDO, 1995)

Chapter 3.   Methodology

This chapter illustrates the several steps followed in this master thesis project to address the research questions as follows:

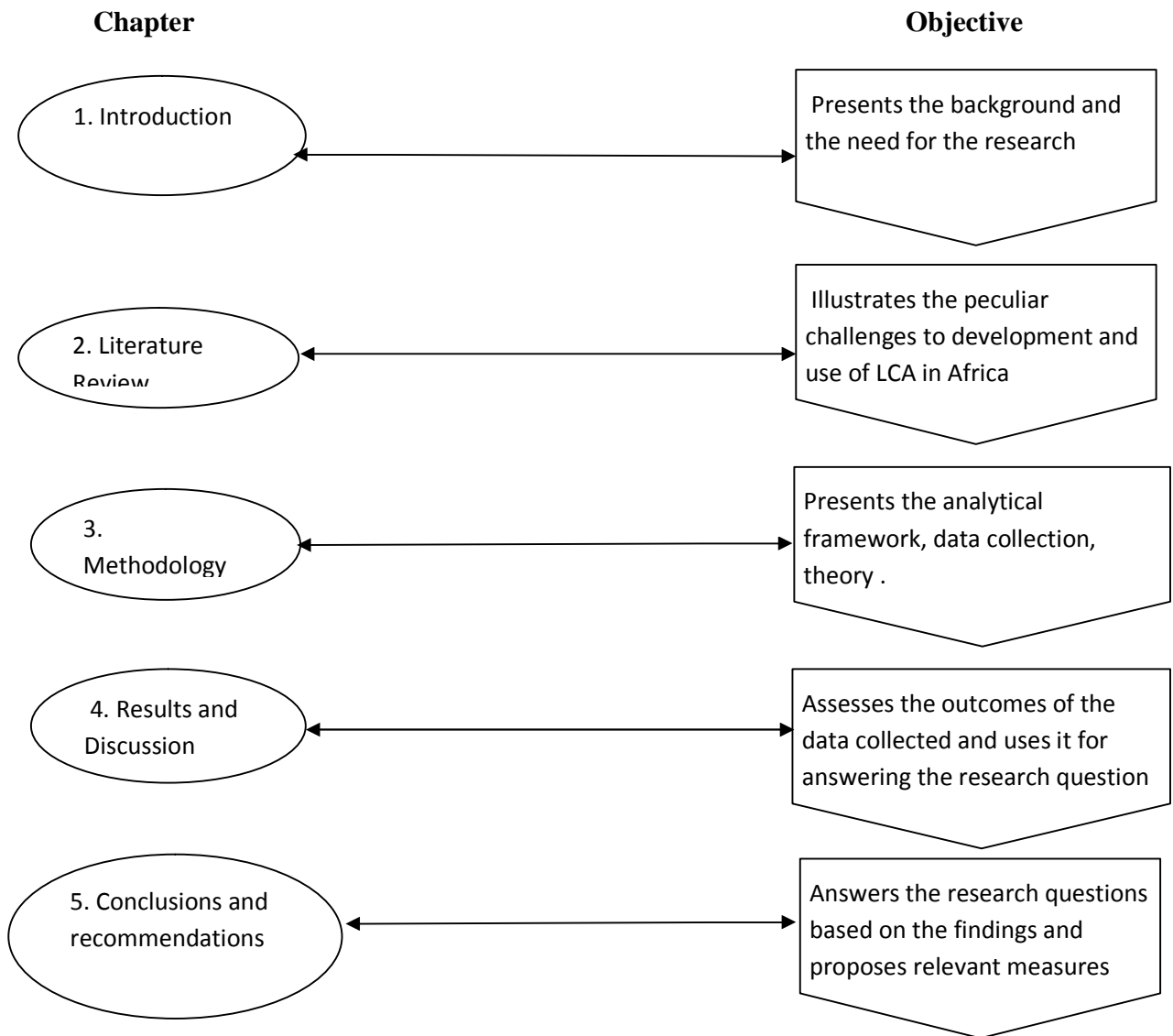3.1   Research Questions and project structure

- What are the main challenges encountered during the implementation of Life Cycle approach in both private and public sector of the African economy?

- What measures are required to be implemented to overcome these challenges?

- How can these problems be addressed from a technology transfer perspective?

The project structure is summarized in figure 3.1.

3.2   Research Design

Research methods often assume mainly a qualitative or a quantitative approach. While quantitative methods can be roughly described as methods that utilize numbers in describing the results of a study, qualitative research assumes an interpretative approach to the study of a subject under investigation, seeking to understand phenomena through the study of things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the sense people give to them (Kvale and Brinkmann 2009). Furthermore, qualitative methods are more flexible compared to quantitative methods and can be adjusted to suit any particular setting (Kvale and Brinkmann 2009) Consequently, theories, and data collection methods amongst others can be can be adjusted in the course of the research. Furthermore, qualitative research seeks to enhance comprehension of a subject matter through firsthand experience, written materials, and quotations of actual conversations inter alia. Hence qualitative research embraces a myriad of philosophies, research designs and specific techniques such as 'in-*depth qualitative interviews; participant and non-participant observation; focus groups; document analyses; and a number of other methods of data collection'* (Pope and Mays, 2006)

Fig. 3.1 Project Structure

Chapter	**Objective**

1. Introduction — Presents the background and the need for the research

2. Literature Review — Illustrates the peculiar challenges to development and use of LCA in Africa

3. Methodology — Presents the analytical framework, data collection, theory .

4. Results and Discussion — Assesses the outcomes of the data collected and uses it for answering the research question

5. Conclusions and recommendations — Answers the research questions based on the findings and proposes relevant measures

3.2.1 Mixed Methodology

Mixed methodology *is 'a research design with philosophical assumptions as well as methods of inquiry '* (Sage, 2006). As a methodology, it includes philosophical assumptions which steer the approach to gathering and analyzing data and the combination of qualitative and quantitative methods in different phases of the research. As a research design it is premised on collecting, analyzing, and merging "*qualitative and quantitative data in a single study or series of studies" (Sage, 2006)*. The combination of the two methods provides a better comprehension of a phenomenon than when each method is used separately.

(Sage, 2006) argues that mixed methods have advantages which offset the disadvantages of both quantitative and qualitative research (Sage, 2006). According to this author, quantitative research does not adequately enable an understanding of the context or setting of people's arguments. In addition the voices of research participants *"are not directly heard in quantitative research" (Sage, 2006)*. Moreover, the individual biases and interpretations of quantitative researchers are hardly discussed. Qualitative research may offsets these disadvantages, but has the demerit of the individual interpretations of the researcher, the associated bias, and the challenge of making valid generalizations due to the relatively less number of participants involved. Since quantitative research overcomes these challenges (Sage, 2006), the two methods complement each other when combined.

3.2.2 Combining data in mixed methodology

The hybridization of the data sets can be done in a number of approaches*: 'merging or converging the two datasets by actually bringing them together, connecting the two datasets by having one build on the other, or embedding one dataset within the other so that one type of data provides a supportive role for the other dataset' (Sage, 2006).*
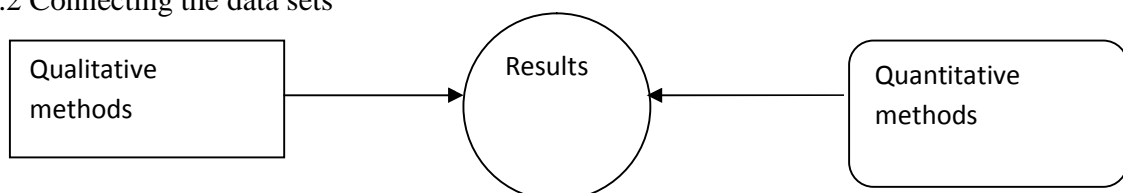
Fig. 3.2 Connecting the data sets

Fig.3.2 shows how the two datasets are employed in the study. In conducting the study, the qualitative and quantitative datasets were connected so they complement each other in assessing the results and making meaning of them.

3.3   Data Collection

In order to obtain first hand information on the diffusion of technology as per LCA in the African context, several approaches to data collection were used.

3.3.1   Document reviews

A document review combines summary and synthesis to discuss recent research findings on a subject of interest within a certain period. This method was used to gather useful data on the current status of the topic under investigation: how the technological diffusion can be realised within the framework of LCA in Africa. Several books, articles and web based reports were consulted in this vein to understand the barriers to the adoption of technological diffusion as per LCA and how these could be overcome. A criteria matrix was developed to review several LCA studies undertaken in Africa as part of the data gathering process and was also used in the analysis section.

To address the research question one, data on previously conducted Life cycle assessment studies and challenges encountered when conducting the studies in the respective African countries was required. Peer review of existing literature on Life cycle assessment in several African countries from diverse sector of the economy was conducted. The main source of data on the document review aspect of the project was based on scientific articles and journal. Systematic searches were specifically conducted on three scientific databases to identify relevant studies: (1) the *Web of Knowledge* (Wok) http://apps.webofknowledge.com; (2) *Science direct* http://www.sciencedirect.com; and (3) *Scopus* http://www.scopus.com/home.url. The three databases have an extensive and updated collection of scientific papers. To search the documents, specific keywords were used such as: *"LCA", "Life Cycle", "Africa" "developing countries"*, etc. These keywords were coupled with Boolean operators such as AND; OR; ( ); " ". Examples of searches are thus: '*LCA AND Africa*,' '*LCA AND "developing countries"*' '(*LCA OR "Life Cycle") and Africa*', "*LCA AND Ghana*", etc. About twenty different LCA studies relating to

Africa were found in the three databases. The numbers of studies to be reviewed was reduced to fifteen based on required location for the studies to be in Africa, since there were about five comparative studies which included Africa and other regions coupled with inadequate information required for the project. The articles were then reviewed to get data that will address the first research question for the master thesis project. In the document review, there was emphasis on the problems that could arise when performing Life cycle Assessment at both two stages i.e. inventory analysis and impact assessment phase. Several types of question were formulated to get relevant information regarding the various types of problem encountered when applying LCA to Africa and background of the studies.

Questions viz: *What is the name of the Study? Which Institutions are involved in the Study? What is the country of the authors of the Study? What types of data was used for the study? What is the location of the study? What is the study about?* Provide bibliographical information. The second list of questions including; *what is the goal and scope of the study? What is the name of the product/services analysed in the study? What is the functional unit of the study?* Provide information on the sector of the economy the study dwells on.

Furthermore a scale of 1 to 5 was used to ascertain the intensity of the problem under the Life cycle inventory analysis and impact assessment related challenges. Scale 1 represented most severe situation whereas scale 5 meant least serious problem. To gather information concerning problem faced at the Life cycle inventory phase, the relevant questions included: *What modelling approach is used (attributional or consequential)? Did the authors have difficulties in retrieving data about any process? Why and which process? Is the data representative of the local conditions (spatial representativeness)? Or have data from other locations been used (e.g. to describe a process), and Why? Do the authors report any problem related to uncertainty in the data representative of the African life-cycle stages/Processes/activities (parameter uncertainty)? Do the authors report any problem related to the modelling of the African system (model uncertainty)?* Concerning information on problems faced at the Life cycle impact assessment phase i.e. challenges related to the methodological approach, the relevant questions were: *What characterization methods/LCIA approach has been used in the study? Which impacts categories have been used /included in the study? Do the authors report any problem related to missing*

impact categories to account for a specific impact? Do the authors report of missing characterization/normalization/weighting factors? Do the authors mention that the LCIA method used is not representative of the local conditions (spatial representativeness)? Is YES, why? Are the Characterisation/normalization/weighting factors used country-specific?

After all the necessary information has been collected from all the fifteen papers under review, the information was documented in a Microsoft Excel document format known as the study matrix (figure 3.3). This full matrix is provided in the supplementary electronic material. Each row of the excel sheet contains a particular questions corresponding to an assessment criteria and a summary of the corresponding information was made for the fifteen articles reviewed. For each of the twenty questions in the assessment matrix, a summary was made covering the fifteen papers and was subsequently used in the discussion. Common patterns which emerged in the document review process were in fact identified and mapped out.

Table 3.3 Review matrix with criteria and related research questions. The full matrix with results is provided in the supplementary electronic material.

	Criteria	Question	LCA Study 1	LCA study 2
Bibliographical	References Author Institutions Author Nations Data Location Short summary	What is the name of the Study Which Institutions are involved in the Study What is the country of the authors of the Study What types of data was used for the study What is the location of the study What is the study about		
Topic	Goal and scope Production/ Services Functional Unit	What is the goal and scope of the study? What is the name of the product/services analyzed in the study? What is the functional unit of the study?		
		Magnitude of the challenge (5 =non serious: can be overcome easily) (1 = serious challenge, there is no solution at present, can't be overcome)		
LCA-related information	LCI - What are the limitations/chall enges/problems encountered in compiling the LC-inventory?	What modeling approach is used (attributional or consequential)? Did the authors have difficulties in retrieving data about any process? Why and which process? Is the data representative of the local conditions (spatial representativeness)? Or have data from other locations been used (e.g. to describe a process), and Why? Do the authors report any problem related to uncertainty in the data representative of the African life-cycle stages/Processes/activities (parameter uncertainty)? Do the authors report any problem related to the modeling of the African system (model uncertainty)?		
	LCIA - What are the limitations/chall enges/problems encountered in performing the LC impact assessment?	What characterization methods/LCIA approach has been used in the study? Which impacts categories have been used /included in the study? Do the authors report any problem related to missing impact categories to account for a specific impact? Do the authors report of missing characterization/normalization/weighting factors? Do the authors mention that the LCIA method used is not representative of the local conditions (spatial representativeness)? Is YES, why?		
		Are the Characterisation/normalization/weighting factors used country-specific?		

Source : Researcher and supervisor's construction

3.3.2   Interviews

Qualitative research interviews can illustrate and add meaning to the key themes of a study based on the information divulged from the subjects (Kvale, 1996). Semi-structured interviews reflecting the core research questions were used to outline the areas under investigation. This method was found useful as it helped to probe further where more detail was needed. Moreover the interview helped in answering the three research questions. Key-informants (resource-person) deemed to be experts on LCA studies in the African context were identified and consequently contacted for their views on aspects of the study by way of interviews. A total of six researchers were contacted. These were selected among the authors of the papers retrieved in the literature review. The list of resource persons contacted include: (1) Alan Brent Colin, a Professor at the sustainable development programme of the school of public management and planning of Stellenbosch University South Africa. He has vast amount of experience conducting LCA in South Africa and Mauritius coupled a series of Publications of Scientific Journals on LCA use in different sector of the South Africa economy. (2) John Frank Eshun, an LCA expert currently the Vice-president of Takoradi Polytechnic in Ghana was another resource person contacted. He worked previously with Rik Leemans and Jose Potting as part of his PhD at the research centre, environmental systems analysis group, Wageningen University Netherlands. They together performed the LCA of the timber sector in Ghana. (3) Jose Potting, a renowned LCA expert. working as a visiting professor at the royal institute of technology (KTH), division of environmental strategies research Stockholm and a professor research centre, environmental systems analysis group Wageningen Netherlands. She worked with four Africa students on LCA projects in Ethiopia and Ghana. (4) Rik Leemans, also a Professor of environmental science at research centre environmental systems analysis group Wageningen University Netherlands. (5) Teslim Giwa, an African researcher at University of Sheffield, United Kingdom performed LCA of the building sector in Nigeria. (6) Trakarn Prapaspongsa, a researcher at Aalborg University, who works with LCA in Thailand.

Specific questions for the interview were prepared to get detail information about the nature of the problem encountered and the various approaches to the problem. Interviewee perspectives were considered important since they have lot of experience and know out on how to perform

LCA in Africa. The questions were divided in two groups: a first group related to the experience with LCA in Africa, and a second group related to the technology transfer perspective. The first group of questions considered included: *What is your experience with LCA applied in an Africa Context (Case study about Africa or working with African researchers on LCA); Why did you think LCA is relevant in the Africa Context?; Which sectors of the Africa Economy is LCA most relevant? In general, what are the major barriers to the Application of LCA in Africa? (E.g. South Africa, Nigeria.); from your experience, how do you think these barriers can be overcome for the benefit of sustainable development in Africa? How do you obtain spatially representative data relevant to the African Condition?* The second group of questions included: *What are the key factors that have to be considered in diffusing LCA from developed to developing countries?; Was there institutional collaboration between develop and developing countries in the study you perform?; Did you encounter similar challenges conducting LCA when moving from one African country to the other?; What is the reaction of the stakeholder/People to the assimilation of LCA in the African country you perform the study?; Did you encountered economic challenges when performing the study in African country?*

The interviews were conducted via various media such as Skype and telephone. These were then recorded and transcribed. The salient aspects of the interview were then summarized for the purpose of the study. These are provided in Appendix. In all, a total of three interviews were performed in the study.

3.3.3 Survey

This is a qualitative approach used to gather information which could not be readily found in the document review, but considered vital for the purpose of the study. Data from the survey was needed to address the three research question. Questionnaires were deemed necessary to extend the scope of information for the project. A survey was sent to different respondents via email and the survey link which was attached to the mailing list. The interviewees were excluded from the survey mailing list to avoid replication of data. An online survey platform was designed via http;//www.surveymonkey.com, to collect samples from different respondents. The choice of questions for the survey was based on the need to get information including, source of funding

for the research, motivation for conducting the LCA study, institution involved and the types of challenges encountered when conducting the LCA study. The group of selected authors from the document review process were contacted to share their knowledge and experience on certain aspects of the previously conducted LCA study from the articles with inadequate information. These authors were selected due to their in-depth experience on conducting LCA in African countries. This information was gathered from the scientific journals they published from the three selected database earlier stated. Also for the survey, 10 questions were formulated and divided in two groups: a first group related to the background of the LCA study, and a second group related to the challenges encountered. The first group of 5 questions included: *What were the main motivations for conducting the African LCA case-study/project? Was the project/study funded by a local (African) institution or by foreign one (non-African)? Were any stakeholders involved in the project, and which ones? Was the study part of any collaboration between non-African and African institutions? What is the reaction of the stakeholders/public to LCA case-study/project in the African country where you perform the study?* The second group of 5 questions included: *What were the major barriers/challenges/obstacles that you encountered when conducting the African LCA case-study/project? How did you overcome these challenges? Did you encounter the same challenges when conducting other non-African LCA case-studies/projects? What is your view on transferring LCA as a technology between developed countries (e.g. North America, Europe) and less developed countries (e.g. African ones)? What are in your opinion the key factors that should be considered in diffusing LCA from developed to developing countries?*

Table 3.2 Summary of Methods

Research Question	Information	Method
RQ 1	Problems faced in conducting LCA in Africa	Document Review
RQ 2	Solutions that address LCA	Questionnaire/survey and interview
RQ 3	Using Technology Transfer to facilitate the diffusion of LCA in Africa	Questionnaire/survey and interview

Source: Researchers construction

3.4 Data Interpretation

3.4.1 Content Analysis

Content analysis or textual analysis refers to the study of textual content of a material. According to (Holsti, 1969), the content analysis is *"any technique for making inferences by objectively and systematically identifying specified characteristics of messages"* (Holsti, 1969). The process involves reading the whole text to afford a general overview; synthesis of the key themes; and finally producing a descriptive text (Kvale and Brinkmann 2009).

3.4.2   Analytical Framework

In this section some key aspects of LCA are addressed, that can help in analyzing the data obtained. The several literatures perused during the study all indicate that access to information, human resource and regulation and adequate funding are key for ensuring the success of LCA in any setting. The analytical framework will therefore revolve around these four core factors: (1) Regulation (2) Access to good quality data (information) (3) Human resource capacity (4) Funding.

3.5   Project Limitations

In carrying out the study some hurdles were faced. Due to time constraints few resource persons were interviewed than anticipated, a wider sample space would have further enhanced triangulation. There as difficulty in finding empirical data in some of the scientific articles reviewed which could have enabled more informed discussions to be done.

Chapter 4   Results and Discussion

A total of fifteen papers were reviewed as follow: (Eshun et al., 2010), (Eshun et al., 2011), (Brent et al., 2010), (Sahle and Potting, 2013), (Brent and Hietkamp, 2003), (Friedrich et al., 2009), (Achten et al., 2010), (Mashoko et al., 2010), (Foolmaun and Ramjeeawon, 2012), (Ewoukem et al., 2012), (Ramjeawon, 2008), (Melamu and von Blottnitz, 2011), (Afrane and Ntiamoah, 2012), (Nzila et al., 2012), (Botha and von Blottnitz, 2006) and (Friedrich et al., 2007).

A total of three key informants were interviewed: Alan Brent, Jose Potting and Teslim Giwa.

There was a total of three respondents to the survey: Wouter M.J. Achten, Rajendra Kumar Foolmaun and Thomas Efole Ewoukem.

The details about the respondent to the interviews and surveys are provided below in Appendix 1.

The following sections will perform an assessment of the study results and lead to the research findings. The discussion is largely based on the analytical framework outlined in the Theory chapter. The first part of the discussion (4.1) addresses the first two research questions:

- What are the main challenges encountered during the implementation of Life Cycle approach in both private and public sector of the African economy?

- What measures are required to be implemented to overcome these challenges?

Whilst the second part of the discussion (4.2) relates to the final question:

- How do we analyze these problems from the technology transfer perspective?

4.1   Analysis of the four core factors

4.1.1   Regulation

Strict enforcement of regulation is necessary for the industry players to integrate LCA in their practices for sustainable development. Thus soft legislation backed with compliance to environmental management practice is needed to achieve accelerated LCA uptake in Africa (Giwa, interview). Brent (interview) states that though there is national environmental management act that is based on the principles of cradle to grave principle, it needs to be well

enforced so as to achieve its intended purpose (Brent, interview). According to Brent (interview), from a top down perspective, government should actually drive the development and establishment of national inventory databases backed by the necessary regulatory framework. In similar vein he surmises the United Nations Environmental Program me (UNEP) as well as the Life Cycle community will have to lobby and pressurize governments on the African continent to adopt and enforce LCA regulations.

In the absence of a national law enforcing LCA in South Africa, Brent et al (2002) explain that "*LCA methodology has been limited to forward thinking organizations, as there is little incentive to use LCA at the national level. No government pressures* with *respect to use of LCA therefore mainly voluntary and motivated by internal benefits*". This suggests that implementation of regulations relevant to LCA is low as environmental management is of little priority to industry. On the contrary sound environmental practices are motivated by the desire to satisfy international trade requirements or by parent companies. Consequently, Brent (interview) opines LCA use in South-Africa and Africa in general is driven by information requirement for sustainable products from customers in Europe and other developed countries. In the South African context, LCA is mostly driven by the mineral/petrochemical industries with the support of other parts of the supply chain including electricity, fertilizer, and diesel industry (Brent, interview). The matrix developed in carrying out the study (see appendix) also shows sugar and water industries which gained LCA attention in South Africa. According to Giwa (interview) there is no specific policy or commitment toward LCA in Nigeria, but LCA is applicable within umbrella policies like the environmental impact assessment policy. For example, under the federal ministry of environment, there is a law concerning the performance of environmental impact assessment. The law stipulates that concerning certain types of project, an Environmental impact assessment is needed to be perform before embarking on the project. LCA can be under this particular law (Giwa, interview).

4.1.2   Access to good quality data

Accessibility to good quality data is a prevailing challenge in terms of conducting LCA in most African countries. Availability of good quality national database inventory for Africa and efficient way of verifying third party data is needed to diffuse LCA from developed to developing

countries as it is well known that third party data not coming directly is very hard to verify (Giwa, interview). Brent et al.,(2010) also asserted that at the life cycle inventory phase, there was difficulty in getting industry and national data coupled with data uncertainty in some of the activities. Potting (interview) argues that whilst there is good quality data in the United States, Europe, and some part of Asia including china and Japan, the same cannot be said of Africa. Thus whilst there is an existing knowledge infrastructure due to over 20 years of practice, there is practically no such knowledge infrastructure in Africa. Brent (interview) adds that often industry players are unwilling to share data as they do fear it might be used against them. Landu and Brent (2006) furthermore noted that some important industry specific data was missing from the inventory database creating data gaps, which can be attributed to confidentiality concerns from the industry. Also there is only a small number of companies which produce data usable in LCA format however its compilation demands a lot of investment in time and effort (Brent et al., 2002). Foolmaun (survey) explains further that in using Eco-invent software, many of the data categories were unavailable thus he was forced to rely on several assumptions. Both Achten (survey) and Ewoukem (survey) agree with this point. From Africa point of view, it is necessary to have the appropriate inventory data that are reflective of the technology in that region (Potting, interview).Afrane and Ntiamoah, (2012) and Friedrich et al., (2007) noted that the inventory database is Eurocentric and might not be representative of the Africa conditions. Potting (interview) adds that with Africa still developing, the improvement of LCA databases should start with sectors which are expected to grow and renew in the coming decades. In the review were identified challenges of low quality and inadequate data provided from the industry (Brent et al., 2002). In these cases, inventory database was used to complement most of the industry-specific data with low quality. Some few studies also resorted to international publication in the absence of inventory data representative of local industries. In the face of these challenges, there was an initiative a decade ago to develop a national database inventory for Africa which is still in progress. The life cycle community and UNEP will need to be proactive in making this a reality (Brent, interview). Potting (interview) suggest that one of the key to conducting a good LCA is accessed to good quality data and having a right background in the product area.

Brent et al. (2002) suggest that the available software platform at the disposal of industry players in Africa such as TEAM, SIMAPRO, GaBi3 and PEMS originate from foreign locations and thus

their application in other geographical regions like developing countries presents difficulty since they were design to address environmental problem in developed countries. This may be a source of error owing to the disparities in data from different geographical locations and the associated differences in techniques. The relevance of impact assessment methodologies is also of concern as the impact assessment categories currently use in Africa were developed to address the peculiar environmental challenges in Europe (Brent et al.,(2002); Brent, interview). Thus high priority is given to air pollutant and green house gas emissions whereas some other certain environmental categories are not well represented in the LCIA methodology. For instance according to Brent (interview) in South-Africa water resources and land use are important impact categories which are not well represented on the current LCA methodology. For Brent (interview) water and land are more important than some pollutants from the South-African point of view. Eshun et al (2011) and Mashoko et al (2010) support Brent assertion on the issue of exclusion of important local impact category such as land, water, biodiversity loss in the LCIA methodology from Africa perspectives. CML 2000 methodology used in some of the study is considered not too relevant to Africa situation since it does not address the most pressing environment problems affecting the region (Friedrich et al., 2009; Sahle and Potting, 2013).

Furthermore, ninety percent of South-African electricity is based on coal whereas the situation is different in Europe; this introduces disparities in electricity profiles and translates into difficulties when European LCA professionals come to South Africa to apply their database for environmental profile for electricity consumption and vice versa (Brent, interview). It is therefore imperative to tailor impact assessment methodologies to address local environmental problems in Africa. (Potting, interview) also reiterated that " *the current LCIA methodology is tailored to the European and United states perceptions that environment problems are the same here as in Europe and North America. But in Africa the environment problems are different; therefore an adjusted environmental impact methodology might be needed for Africa*"(Potting interview). According to potting (interview), there is need to start research project of developing new methodologies for Africa. For instance, the PhD student under her supervision looks apparently in impact assessment methodology that can be suitable for the timber industry in Ghana.

4.1.3 Human resource capacity

Ramjeawon et al. (2005) observe that in contemporary times, there has been a gradual appreciation of the value of LCA in Africa. This is reflected in critical policy documents such as the New Partnership for African Development (NEPAD). The NEPAD which serves as Africa's development blueprint envisions a yearly national growth rate of 6% which calls for the necessary human skill base to steer such development in line with sustainability informed by life-cycle thinking (Ramjeawon et al., 2005). Consequently, *"there is thus an urgent need to develop a critical mass of personnel who would take lead in disseminating the LCA concept in key development sectors and programmes in Africa"* (Ramjeawon et al., 2005).

The growing interest in LCA by industry and governments is partly fuelled by the desire to enter the export market as well as be internationally inclined. This has led to gradual development of competency in LCA (Brent et al., 2002).

The availability of skilled human resource to enhance the diffusion of LCA cannot be overemphasized. The poor options for critical review in Africa generally forces industry to make expensive reviews in developed nations even in the face of higher exchange rates (Brent et al., 2002). Having people who know enough about how to make proper LCA is an important avenue to achieve good inventory and this should come with a good control system on data quality (Potting interview).

This low skill base in LCA emphasizes the urgency in capacity building to enhance knowledge in the use of LCA as per the peculiar context and development priorities of the continent. Capacity building institutions will have a critical role to play in enhancing human resource skill base of countries in Africa, however Ramjeawon suggests these institutions are not adequately equipped to perform their roles in training professionals (Ramjeawon et al., 2005). Potting (interview) explains that with collaboration between African and European educational institutions this gap between the industry and the human resource base can be bridged. The collaboration between her university (Wageningen University Netherlands) and the Takoradi Polytechnic (Ghana) has been fruitful: the students who received the LCA training are now well equipped to undertake proper LCA studies back home as well as advance the use and skills of LCA in Africa. Foolmaun

(survey) is particularly in favor of the cross-pollination of LCA technology between European and African institutions.

Building networks on the continent amongst the LCA community will go a long way to enhance mutual sharing of experiences and knowledge building. The study matrix shows most of the LCA studies were carried out in South Africa, which suggests it is relatively more entrenched in South Africa compared to the rest of Africa, hence South Africa may have a leadership role to play in the diffusion of LCA on the continent. Brent (interview) indicates he has collaborated with LCA practitioners both within and outside South Africa. Thus his work on LCA with colleagues from other African countries such as Mauritius, Kenya, as well as within South Africa have been mutually stimulating and rewarding. The study matrix reveals that educational institutions are critical to the diffusion of LCA methodology as most of the study were carried out by people affiliated to universities. The respondents to the questionnaire by mail also share similar views (Achten, Ewoukem, Foolmaun, survey). This emphasizes the fact that educational institutions are vital to producing a continuous stream of skilled professionals to manage LCA data as it is evidenced at the University of Cape Town, Pretoria, KwaZulu-Natal, and Durban (Brent, interview).

Another issue related to human resource capacity regards how to present the outcome of LCA studies to policy decision makers. Brent (interview) states that it is difficult to present LCA results to policy makers in South-Africa, unlike what is obtained in Europe where policy makers really understands the value of LCA. The educational and capacity building institutions as well the LCA community has a role to play in educating policy makers on the importance of LCA. According to Giwa (interview), there is the need to adopt a top down policy formulation approach, serving as a push mechanism. It will have the capacity to push people to action. In his opinion, top down approach is necessary for African society, since people still don't understand the scientific reason behind LCA. Due to the widespread subsistence practice in Africa, people are yet to appreciate the purpose of LCA application in business and economic activities.

4.1.4   Funding

Financial investments are important to building up the knowledge and expertise in several African countries. African people may need financial support to come to western countries to learn and get the needed experience in LCA (Potting, interview) as well as build local capacity of training institutions. The review matrix supports Potting point on the important of joint collaboration between Western and African institutions, as several of the LCA projects were as a result of joint ventures between European and African institutions.(Mashoko et al., 2010; Nzila et al., 2012) Though in the long term perspective, access to LCA software, LCA databases, and project to continue developing, funding will greatly expand the knowledge and expertise that is needed in African countries (Brent interview). Public private partnerships will very much help in this vein as exemplified by a Swiss funding to develop generic data for South Africa. The review matrix also support this idea of joint funding between Africa and European partners ((Mashoko et al., 2010; Nzila et al., 2012; Sahle and Potting, 2013). Brent (interview) explains that though South Africa initiated moves towards an African life cycle database inventory, it was difficult due partly to electronic online communication at that stage. The review matrix shows that both African and European institutions have provided funding for LCA research on the African continent.

Institutions like UNEP (United Nations Environmental Program) with its high quality database, representative of certain regions coupled with good source of funding can support more initiatives and research on building national data base for African countries. For instance LCA experts working on forestry can look for some of the project that have done on forestry. Other groups like World Wildlife Foundation (WWF), Global Footprint Network are good funded research program (Giwa, interview).

4.2   Technology transfer and LCA in Africa

According to Muller (2003) although international technological transfer can serve as a vehicle to supplement the technological capacities of host nations, attempts at international technological

transfer particularly between the North and the South have often registered failed results (Muller, 2003).

This is in line with the debate that each nation has a number of social, cultural, political and economic institutions which steer the peculiar nature of the technological development process. Thus local systems need to be enhanced endogenously to produce tailored solutions to particular social challenges alongside imported technology (kuada, 2003).

Whiles culture offers stability in a people's way of life, it also hampers technological development. However innovation encourages the avoidance of old ways of doing things in favor of new ones and this challenges stability. Consequently upon the introduction of new practices into a society or organization which runs counter to established patterns of conduct; they are highly probable to be refused by preservers of the former culture. Effective cultural management is thus necessary for broad success of technological transfer (kuada, 2003). This cultural change may be facilitated by the dissemination of novel information to stimulate interest and challenge prevailing cultural practices. The more diverse the society, then the more embracing sections of the society is to novel ideas.

LCA as a technology comes with adopting new practices contrary to the former ways of doing things. Thus LCA may be challenging the current business ethics in Africa and thus its application in Africa needs to be facilitated by recognizing the local setting as an integral component for it to succeed.

Muller (2003) explains that successful international technology transfer may assume three main approaches:

- The technology is fully adapted to the social setting of the receiver
- The social setting of the receiver is fully adapted to the technology
- Both the technology and the social setting are changed or moved to fit each other at some point, which hardly can be predetermined.

Muller's first two propositions are rejected in the context of this study because LCA is '*Euro-centric*' according to Brent (2013). Thus it is not adapted to the social setting of the recipient, African society and vice versa.

The third approach from Muller's prescription as per the successful international technology transfer is relevant and appropriate to this study. There is need for changes from both the direction of the technology and the social setting to produce the needed synergy. These changes need to be founded on credible information which can serve as the basis for any adjustments. Thus LCA relies very much on the availability data. However, several of the interviewers and also the literature review indicated that the access to data is a huge problem in Africa. For example, Brent (interview) states that in South Africa: *"private industries are reluctant to release environmental data information, since they feel this information will be used against them"*. He explains further that the power sector for example is not allowed to divulge data to the public. This suggests industry has a negative culture regarding the release of data which is inhibiting the development of LCA in Africa.

Brent's observations in South Africa are not in isolation. Giwa (interview) in prescribing a remedy to this challenge suggests a top-down approach. The top-down method will be relevant in the African context, because unlike Europe where market forces have created a niche for LCA, the same cannot be said of Africa. Thus for LCA to have the desired impact in Africa, governments will have to be proactive and provide the necessary regulatory framework to give it the needed push.

Chapter 5   Conclusions and Recommendations

The aim of the study was to investigate whether LCA is facilitating sustainable development in Africa and what are the barriers and challenges to its adoption and implementation in Africa.

Technological transfer model can serve as a vehicle for catalysing the use of LCA in Africa to limit environmental degradation and enhance sustainable development on the continent. Furthermore, it will also serve as a sustainable vehicle for development leapfrogging by developing nations. The advantages of the LCA technology notwithstanding, its diffusion faces some hurdles which are addressed by this study.

Literature reviews, interviews and surveys were employ to collect data from key informant.
The poor quality of data as well as the not so relevant impact assessment categories suggests that the development of local LCA inventory databases and relevant impact assessment methodology would make LCA more effective at addressing local African challenges. Associations within the different sectors of the economy can help to reduce the difficulty associated with unwillingness of industry to release data. Developing the appropriate regulatory framework will also serve as an incentive for the adoption of LCA by industry players on the continent. Moreover soft legislation supported with conformity to environmental management practice is necessary to achieve accelerated LCA uptake in Africa.

Funding together with other incentives will enhance the capacities of training institutions to supply the necessary human resource capacity needed to manage and sustain the development of LCA in Africa. Joint collaborations between institutions on the continent as well as partnerships between African and foreign institutions will go a long way to enhance the diffusion of LCA on the continent.

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Chapter 6   List of Appendices

Appendix 1 – List of Resource Persons interviewed directly or via survey

Name of Resource Person	Contact of Resource Person
Alan Brent (interview)	Professor, Stellenbosch University South Africa acb@sun.ac.za
Jose Potting (interview)	Professor, Wageningen University Netherlands jose.potting@wur.nl +31 317 482983
Teslim Giwa (interview)	Researcher University of Sheffield , United Kingdom Teslimg@yahoo.com
Wouter M.J. Achten (survey)	Researcher Katholieke Universiteit Leuven Belgium Wouter.achten@ees.kuleuven.be
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Thomas Efole Ewoukem (survey)	Researcher University of Dschang, Cameroun Efole_thomas@yahoo.fr +23799073098

Transcription of interview 1, Teslim Giwa

His experience with LCA in African countries is basically in Nigeria. He haven't work with any particular set of African researchers doing LCA, however what He was doing is trying to pioneer LCA in terms of his own particular research. His research focus was application of LCA in buildings and their associated environmental impact from the perspective of environmental assessment, building and African society. LCA has the capacity to assess environmental impacts at different scales: local, national and regional scale. It can assess impact since it is a scientific process that can be applied in complex environment in developing countries like Africa environment, with different type of developmental problems. Africa is considered to be a natural resource driven continent with lot of minerals deposit everywhere. These large deposit of resources emphasize the relevance of LCA application in the process industries, since it addresses the root of the impact. For example, when he was looking at building materials, effort was made to know the process of getting bricks that was use in the building. Furthermore the process of extracting natural resources (gravel, late rite) from the earth crust and transforming these resources into building material. Basically the process industry in Africa is where the mining and use of raw material take place. The greatest challenge to LCA application in Africa was getting transparent and reliable dataset. There is need to adopt a top down policy formulation approach, serving as a push mechanism. It will have the capacity to push people to action. Top down approach is necessary for African society, since people still don't understand the scientific reason behind LCA. Due to the widespread subsistence practice in Africa, people are yet to appreciate the purpose of LCA application in business and economic activities. Institutions like UNEP (United Nations Environmental Program) with it high quality database, representative of certain regions coupled with good source of funding can support more initiatives and research on building national data base for African countries. For instance LCA experts working on forestry can look for some of the project that have done on forestry. Other groups like World Wildlife Foundation (WWF), Global Footprint Network are good funded research program. Even currently a group called International Council for Local Environmental Initiatives (ICLEI) is encouraging sustainable practice in big cities. Most of their information relies on LCA processes. These initiatives indirectly encourage the use of LCA.

LCA knowledge has been there since a long time. The task now is how to apply the knowledge in ensuring sustainable development in African countries. The level of sophistication has to be considered from region to region. LCA support some of the investigation that was made to determine how green a building is. Availability of reliable database and verifiable third party data is needed to diffuse LCA from developed to developing countries. For example during field operation, he traces all the necessary data, since he can't rely on people to verify the data for him.

It is well known that third party data not coming directly is very hard to verify. There was no institutional collaboration on this particular research, but there have been partnership concerning other previous studies. Nigeria was the only country he performed LCA studies basically in the building sector, focusing on the environmental impacts attributable to building materials. The academic communities were interested in the LCA uptake, however mixed reaction from other sectors of the economy in Nigeria. There is no specific policy or commitment toward LCA in Nigeria, but LCA is applicable within umbrella policies like the environmental impact assessment policy. For example, under the federal ministry of environment, there is a law concerning the performance of environmental impact assessment. The law stipulates that concerning certain types of project, an Environmental impact assessment is needed to be perform before embarking on the project. LCA can be under this particular law. In the meantime, LCA is currently applied only in oil and gas energy sector to meet international commitment. The driving force toward these gestures is solely from the international organization. There was a lot of challenge encountered in terms of funding. The University of Sheffield funded the research through, another UK company more interested in sustainable building, not LCA in particular.

Legislation might be needed to boost compliance level of LCA use in developmental project in African countries. There is a lot of political surrounding business activities in African. From an African perspective, people comply more with legislation and policy regulation. Soft legislation back with compliance to environmental management practice is needed for LCA uptake. There was a lot of challenge encountered in terms of funding. Legislation might be needed to boost compliance level   of LCA use in developmental project in African countries.

Transcription of interview 2, Alan Brent

Alan Brent has been working on LCA in two African countries, namely South-Africa and Mauritius since the early nineties. Furthermore he has some level of partnership with other LCA colleagues at the University of Cape Town, Pretoria, KwaZulu-Natal, and Durban. He also has some interaction with other African LCA authors mainly in Mauritius and Kenya. South Africa started an initiative to build an African Life Cycle Assessment network and tried to develop African life cycle database inventory, but this initiative was short-lived.

The main challenge about LCA is that it is very data intensive; the kind of data LCA requires is not readily available now. Some Swiss funding to develop generic data for South Africa was unsuccessful partly due to partnership problem between the private and public sector. Another challenge noticed in South-Africa is that private industries are reluctant to release environmental data information, since they feel this information will be used against them.

Obviously LCA use in South-Africa is driven by information requirement for sustainable products from customers in Europe and other developed countries. South Africa mainly exports

mineral resources. In the heavy industries such as mineral industries and petrochemical industries, a lot of LCA has been done. LCA is driven by other parts of the supply chain including electricity generation, fertilizer production, and diesel industry. LCA is mostly driven by the mineral industries, in South-Africa.

The main barrier to LCA use in Africa is obviously data information on product specific supply chain. The LCA framework is geared toward Europeans priority. The inventory database is Europe-centric. High priority is given to air pollutant and carbon dioxide emissions. Some other environmental categories are not well represented in the LCA methodology. For instance in South-Africa water and land are important impact categories which are not well represented on the current LCA methodology. Water and land are more important than some pollutants from the South-African point of view. Another issue concerning LCA is how to present the outcome to a policy decision maker. It is difficult presenting the outcome to policy makers in South-Africa, unlike what is obtained in Europe where policy makers really understand the value of LCA.

Concerning the issue of data availability, there is information act in South-Africa which states that power sectors cannot reserve information for the general public. In his opinion from a top down perspective, Government should actually drive the development and establishment of national LCA inventory databases. There is need for a concerted effort from the LCA community as was attempted ten years earlier to develop a national database inventory for Africa. Through similar initiatives like UNEP life cycle initiative which we all be part of, UNEP have to put more pressure on African national governments to participate to initiate the process of building database inventory.

By getting information from the industry, many companies are quite reluctant to provide information. Some companies believe it is risky to release environmental details to the public. Access to company specific details, which was attempted in the past through platforms like the steel manufacturing association need to be encourages. He thinks that the European countries or businesses have gone through so many challenges, to ensure that their environmental performance was improved and willing to release data on their environmental practices.

He has been working on LCA with the European countries for more than two decades. LCA is pretty straightforward. The best LCA he has seen was done with excel spreadsheets, access to data, ISO standard and software. The big concern is the market for LCA. There is a very small demand in Africa to do LCA.

There is need to understand the difference between African and western economies coupled with the profiles of their technological system. For instance Europeans come to South Africa to apply their database for environmental profile for electricity consumption; obviously there is a difference in the electricity profiles. In South-Africa ninety percent of the electricity is based on coal whereas the situation is different in Europe. This means, there is need to develop LCA models for African countries to reflect the local environmental condition e.g. use of land and

water in South Africa. In transferring LCA from Europe to Africa, the shortcoming of the framework has to be considered. These include technology system, current software packages are inappropriate in the Africa context, since the current database did not take account of Africa conditions.

Yes there has been continuous collaboration with the Dutch and German, Academies, and with all the major LCA software houses, for example Simapro. Lot of the European partners are still around and they come to South-Africa annually. Some of the institute and consulting firms have their office in South Africa. There have been other collaboration in USA, but most of the partnership is from Europeans.

According to Alan Brent, South Africa is long way ahead of Mauritius, since all the industry people in South Africa have develop their own LCA capability. South Africa is more involved.

The stakeholder were not anxious to use it, people use LCA in South-Africa because there has been pressure from western customers to understand the environmental performance of local product and services. In the early years of LCA in South-Africa, there was problem of funding, but it has improved of recent. According to Alan Brent, only two consultancy firms manage to make a living out of LCA. Actually there is national environmental management act that is base on the principles of cradle to crave principle, but it needs to be well enforced.

Transcription of interview 3, Jose Potting

Jose Potting has worked with four LCA cases in Africa. She supervised a PhD student on LCA in the timber sector in Ghana. Moreover she also supervised three Ethiopian students on different subject including rose cultivation, leather production and farming. She was of the opinion that LCA was relevant to the African Society the same way it is relevant to united state and Europe.
According to her, LCA is powerful tool to make system evaluation from cradle to gate of a product system and to identify the main improvement options. Since Africa is a developing continent, then it has the chance to avoid the same type of mistake that was made in the developed countries. This mistake can be avoided by summing LCA in a bit more preliminary stage. In principles, LCA is useful in all sectors of the African economy. If she had to distribute her resources, then it will start with sectors which are expected to grow and renew in the coming decades, because in these sectors decisions are to be made about the appropriate type of technology to choose and type of product to produce. LCA will be applicable to a sector that will continue to functions for years to come.
The main challenge is to have good quality inventory data. There is good quality data in the United States, Europe, and some part of Asia including china and Japan, whereas in Africa there is nothing. Another major challenge is having the right competencies locally, i.e. having African people who know enough about LCA to make proper LCA. There is need to start doing LCA in

Africa, continue the LCA practice with a good control system on data quality. There is need to establish a database for Africa. Inventory database can solve the inventory barrier and the other thing is to educate African people. For example, in her university (Wageningen University Netherlands) they have a lot of people coming from abroad doing their Masters or PhD. In these contexts, she supervised these three students on their Masters thesis. They now know how to conduct a proper LCA and they take this learning home, and she hopes that they are going to do something with that at home. The PhD student by the name John Frank Eshun from Ghana is now the Vice-president of his university in Tukari. With his current position, he has the possibility to advance the use and skills of LCA in Africa.

Spatial representativeness is relevant both in the inventory phase as well as the impact assessment stage. In the inventory phase, what is needed is inventory data which are representing the technologies that are been used in Africa. Whereas regarding the impact assessment phase what is needed is relevant life-cycle impact assessment methodologies (LCIA) for the African continent. The current LCIA methodology is tailored to the European and United states perceptions that environment problems are the same here as in Europe and North America. But in Africa the environment problems are different; therefore an adjusted environmental impact methodology might be needed for Africa. The solution is to start research projects to develop new methodology for Africa. The PhD student from Ghana also looks apparently into impact assessment in Africa.

It is important for African student doing their M.sc and PhD in Europe learn how to do LCA and it worthwhile to know what it can bring and how it is used. She was of the opinion that by this can be done by enabling people to come to Europe or United states to get the experience to learn. Of course there is need to build up the knowledge and expertise in Africa, as soon as this is done, then universities need to transfer this knowledge to the African students. But for time being, building up the knowledge and expertise in several African countries is necessary. As a matter of importance, people need financial support to come to western countries to learn and get the needed experience.

From the long term perspective, access to LCA software, LCA databases, and project to continue developing, expanding knowledge and expertise is needed in African countries. Private and public stakeholders are interested in LCA result, not sure if African countries have formal policy requiring LCA. Recently policy is moving in this direction, since LCA is one of the tool providing support and information. For example for the rose cultivation LCA that they did, some of the push came from organizations, which have a certification program, which considers life cycle performance of rose cultivation. Obviously for this reason, they want to have the LCA result. Therefore, one of the main drivers behind it is that their main customers are situated in Europe and other developed countries. Thus, these countries ask for environmental information on sustainable product. To have a sustainable product, it is necessary to look into the Life Cycle environmental performance of the product.

There was always cooperation between her home university and Tokai University. According to her, it was great to have African student at her home university, because usually they performed

LCA on a product they were familiar with. The PhD student doing the timber sector in Ghana LCA, he has been working within the timber sector and he has good access to their data. Also for the rose cultivation LCA, the student has been working within the rose sector coupled with excellent access to data. Similar situation was observed in the leather the student had a good contact with the leather industry in Ethiopia. For the diary LCA, good access to data was noted. By and large, the presence of students at Msc and PhD level created a partnership based on mutual benefit. Since they were able to collect really good quality LCA data and she provided them with knowledge about how to do an LCA, and use those data properly.

An important barrier with LCA is always to get good quality data. So the more one is familiar with the sector, the easier it is to get good quality data. For example someone who knows the right people coupled with some knowledge about environmental issue at stake, the person will know how the processes are running. According to Jose potting, having just background in a specific product area can still enhance one to do an LCA in Europe. Apart from getting good quality data, background in a product area obviously make it easier to get the right data in a shorter time.

Jose potting noted that the major obstacle for African presently is that there is no knowledge infrastructure to learn about doing and making proper LCA. It is an important difference between developing and developed countries. She stressed that LCA has been conducted for over twenty years in Europe. Apparently there is infrastructure for people to learn about how to do proper LCA, which is not present in Africa. The people considered LCA useful in the places it was conducted. She will like to continue doing studies in Africa countries together with African people, of course it is a subjected to getting funding.

Questionnaires/Surveys

Wouter M.J. Achen Researcher Katholieke Universiteit Leuven Belgium
Article: Life Cycle Assessment of a Palm Oil System with Simultaneous Production of Biodiesel and Cooking Oil in Cameroon 2010

Q1: What were the main motivations for conducting the African LCA case-study/project?
to evaluate the environmental performance of the biofuel case study - does land use conversion for biofuel makes sense? - Interest from the company

Q2: Was the project/study funded by a local (African) institution or by foreign one (non-African)?
Non-African: - foreign company - University development cooperation fund

Q3: Where any stakeholders involved in the project, and which ones?
Yes, a oil palm company

Q4: Was the study part of any collaboration between non-African and African institutions?
Collaboration between the University and a Company active in Africa.

Q5: What is the reaction of the stakeholders/public to LCA case-study/project in the African country where you perform the study?
The company was interested in the research

PAGE 2: Challenges encountered
Q6: What were the major barriers/challenges/obstacles that you encountered when conducting the African LCA case-study/project?
- Data collection on land use impact assessment - Background database did not contain African data

Q7: How did you overcome these challenges?
- Three months field work - Database remains largely unresolved.

Q8: Did you encounter the same challenges when conducting other non-African LCA case-studies/projects?
- Land use: yes - Database: yes for other non-European cases

Q9: What is your view on transferring LCA as a technology between developed countries (e.g. North America, Europe) and less developed countries (e.g. African ones)?
I think it is good to transfer the whole life cycle thinking concept and the assessment techniques. On the other hand, the data problem makes good assessments difficult.

Q10: What are in your opinion the key factors that should be considered in diffusing LCA from developed to developing countries?*The life cycle thinking concept as a whole. To evaluate products or systems, it is good to look to the whole chain, and not only to a part (e.g. processing) of the life cycle. *The method standards *the potential of LCA to identify improvement options

Thomas Efole Ewoukem University of Dschang Cameroun
Article; Environmental impacts of farms integrating aquaculture and agriculture in Cameroon 2012

PAGE 1: Background and institutions
Q1: What were the main motivations for conducting the African LCA case-study/project?
Apply new tools, help policy makers

Q2: Was the project/study funded by a local (African) institution or by foreign one (non-African)?
Foreign institution

Q3: Where any stakeholders involved in the project, and which ones?
Farmers, local administration

Q4: Was the study part of any collaboration between non-African and African institutions?
No

Q5: What is the reaction of the stakeholders/public to LCA case-study/project in the African country where you perform the study?
good tools

PAGE 2: Challenges encountered
Q6: What were the major barriers/challenges/obstacles that you encountered when conducting the African LCA case-study/project?
data

Q7: How did you overcome these challenges?
Personal experiment and observations

Q8: Did you encounter the same challenges when conducting other non-African LCA case-studies/projects?
no

Q9: What is your view on transferring LCA as a technology between developed countries (e.g. North America, Europe) and less developed countries (e.g. African ones)?
good thing

Q10: What are in your opinion the key factors that should be considered in diffusing LCA from developed to developing countries?
Help of decision, improvement tools

Rajendra Kumar Foolmaun   Researcher University of Mauritius, Mauritius
Article: Disposal of post-consumer polyethylene terephthalate (PET) bottles: comparison of five disposal alternatives in the small island state of Mauritius using a life cycle assessment tool 2011

PAGE 1: Background and institutions

Q1: What were the main motivations for conducting the African LCA case-study/project?
The aim of my project was to find a sustainable solution for disposal of post consumer PET bottles in Mauritius. Part of the project also dealt with determining the environmental impacts of using PET bottles in Mauritius

Q2: Was the project/study funded by a local (African) institution or by foreign one (non-African)?
Yes it was funded by the Tertiary Education Commission (Mauritius)

Q3: Where any stakeholders involved in the project, and which ones?
Yes, the bottling companies, the waste collection companies

Q4: Was the study part of any collaboration between non-African and African institutions?
No

Q5: What is the reaction of the stakeholders/public to LCA case-study/project in the African country where you perform the study?
was quite positive and welcomed the outcome of the study

PAGE 2: Challenges encountered

Q6: What were the major barriers/challenges/obstacles that you encountered when conducting the African LCA case-study/project?
Availability of data- the data was not easily accessible and even if available were not in the form required (ie either aggregated or at times were considered as trade secret). many data were not available so I had to rely on the database of the software like Eco-invent

Q7: How did you overcome these challenges?
I used the data in Eco-invent with certain assumptions

Q8: Did you encounter the same challenges when conducting other non-African LCA case-studies/projects?
basically it is the same

Q9: What is your view on transferring LCA as a technology between developed countries (e.g. North America, Europe) and less developed countries (e.g. African ones)?
This should be greatly encouraged

Q10: What are in your opinion the key factors that should be considered in diffusing LCA from developed to developing countries?
developing a proper database of the country or at least for the African continent. There should also be training on how to use LCA and companies should be encouraged to use such tools in evaluating there performances