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Development of a Sustainability Management System for Petroleum Companies

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Declaration

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Abstract

Petroleum companies contribute to the largest proportion of environmental degradation in Libya. In support, the 2014 environmental performance index ranks Libya 120th out of 178 countries which suggest the country faces serious environmental degradation, unlike the developed countries. It is necessary to critically investigate the key environmental sustainability issues faced by the Libyan petroleum companies to develop a Sustainability Management System (SMS).

The research aims to develop a SMS for the petroleum companies through critical investigations of sustainability-related impacts, issues, and barriers to the sustainability approaches, and to develop suggestions for reduction of the adverse effects.

The mixed-methods approach involved a survey-based questionnaire and field visits for interviews (semi-structured) with a number of stakeholders. An Environmental Impact Assessment study (EIA) was also conducted as a case study in one of the field visits. Furthermore, a Life Cycle Assessment (LCA) study to Libyan crude oil. The survey questionnaire was used to collect data from the workers. The interviews provide insight into the concerns, barriers, and challenges from the policy makers, environmentalists, and industrial professionals at a senior level. The use of life-cycle assessment (LCA) has further outlined the environmental impact assessment (EIA) of the petroleum industry in Libya. Data analysis was performed through triangulation of the qualitative and quantitative approaches.

The LCA results show that there are diverse environmental impacts caused by the Libyan petroleum industry, which require the implementation of an SMS to minimise these impacts. EIA results revealed high levels of environmental impacts mainly associated with air emissions such as GHGs and hazardous H2S along with oil spillages, at the upstream and downstream levels of production. Interviews and the survey confirmed that there are issues/obstacles associated with sustainability in the Libyan petroleum sector which limits the provision of quality and efficient services. The current approaches adopted by companies are neither matched with the developments in the sustainability field in other developed countries nor fit, with the managerial or governance processes. The proposed SMS, applicable in developing countries, proposes the incorporation of environmental factors to increase the scope of stakeholders' participation in the process, as well as the environmental performance of petroleum companies.

Dedication

This Ph.D. thesis is dedicated to my daughter Yasmine, my dear wife and my beloved parents.

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيم

ALL PRAISE IS DUE TO ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

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List of Publications

Journal Articles

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Conference Papers

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2. Irhoma, A. (2014). Analysis of Environmental Impacts at the Midstream Petroleum Operations. In Breaking Boundaries Conference. Professional Research practice conference. 18th May, 2014, Nottingham, UK.
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Poster Presentations

1. Irhoma, A. (2014). Life Cycle Assessment of Libyan Crude Oil. Annual College research conference and festival, 20th June, 2014. Nottingham, UK.
2. Irhoma, A. (2014). Analysis of Environmental sustainability issues at the Libyan petroleum industry. Libyan Higher Education forum, 5th July, 2014, London, UK.

List of Abbreviations

AGOCO	Arabian Gulf Oil Company
AP	Acidification Potential
BOE	The barrel of oil equivalent
COEP	Crude Oil Extraction Plant
CSR	Corporate Social Responsibility
DALY	Disability-Adjusted Life Years [year]
EcS	Economic Sustainability
EIA	Environmental Impact Assessment
EMAS	Eco-Management And Audit Scheme
EMS	Environmental Management System
EoL	End oF Life
EPI	Environmental Performance Index
EP	Eutrophication Potential
EPSA	Exploration And Production Sharing Agreement
ES	Environmental Sustainability
FCC	Fluid catalytic cracking
GDP	Gross Domestic Product
GWP	Global Warming Potential
IEA	International Energy Agency
IMF	International Monetary Fund
IMPACT 2002+	Impact Assessment of Chemical Toxics and denotes the multimedia fate & multipathway exposure and effects model assessing toxic emission on human toxicity and ecotoxicity
IPCC	Intergovernmental Panel On Climate Change
ISO	International Organisation For Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LYDS	Libyan Dinners
MMT	Million Metric Tons

NGOS	Non-Governmental Organisations
NOC	National Oil Corporation (Libya)
ODP	Ozone Depletion Potential
OPEC	Organisation Of The Petroleum Exporting Countries
PAF	Potentially Affected Fraction of species
PDCA	Plan, Do, Check And Act
PDF	Potentially Disappeared Fraction of species
SD	Sustainable Development
SMS	Sustainability Management System
SS	Social Sustainability
TBL	Triple Bottom Line
TETP	Terrestrial Ecotoxicity Potential
TQM	Total Quality Management
UN	United Nations
UNEP	United Nations Environment Programme
VOC	Volatile Organic Compounds
WLGP	Western Libya Gas Project
WOC	Waha Oil Compnay
ZOC	Zueitina Oil Company

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Chapter 1
Introduction

1.1 Introduction

This chapter offers a guide to the research and the problem being investigated. It provides an overview of the work conducted in this research study, methodologies applied, the key findings and the contribution to the body of knowledge. The chapter is arranged into a number of sub-sections, which include the context and rationale of the research study, aims and objectives, an overview of the work done and the structure of the thesis.

1.2 Context of the Research

Since the industrial revolution and the discovery of oil on the face of earth, the oil industry became the main supplier of energy in the world. The world economy is highly dependent on oil (Ferrier and Fursenko, 2016). It is agreed that strong, fruitful, and efficient petroleum industry is vital to economic and social success. Frank et al. (2016: p. 1190) argued that the "*oil and gas industry is internationally recognized as one of the most economically important industries for society*". They stated that the petroleum industry contributes significantly to every economy; for instant, in 2008, U.S. petroleum industry was the largest source of energy, around 62% of the total energy consumed in the US (38% from oil and 24% from natural gas). In the UK, the petroleum industry covered 73% of the UK’s total primary energy and paid £11.2 billion in corporate taxes in the year 2012 (Oil & Gas economic report, 2012). The oil industry has not only contributed to the economy directly but also indirectly because of the large number of employees in the supply chain (Keane and Prasad, 1996).

Whilst there are clear commercial benefits associated with the petroleum industry, there are some problems as well. George et al. (2016: p. 197) stated that the "*oil and gas industry, despite being the mainstay of global economic progress, is known for damaging the environment, destroying habitats and adversely affecting the livelihood of communities living near operation sites*". The amount of carbon being emitted by the oil industry is far too high for the environment to sustain with a three- fold increase reported in the last 50 years due to increased demand for oil by industry and in transportation use, for example. (Saswattecha, et al. 2015). The Petroleum industry has been criticised by researchers, non-governmental organisations (NGOs) and environmentalists for its high environmental impacts, health and safety issues and environmental damages which is mainly attributed to the lack of effective sustainability management and processes to decrease the negative effects of it (Krupnick and Gordon, 2015). They believe that sustainability approaches and systems are essential for better-performed petroleum operations, less carbon dioxide emissions and more social, economic and environmental benefits. According to Fuchs (2007), advancement in engineering and technology, have improved petroleum operations' effectiveness in relation to production and sales, but sustainability has been neglected for quite some time.

However, more recent studies argue that "*oil and gas companies have become aware of environmental implications of their operations and as consumers have imposed increasing market demands for environmental safety and sustainability*" (Frank et al., 2016: p. 1192). This implies that petroleum companies have started initiating sustainability programs and approaches to tackle their sustainability issues. Omer (2008) adds, that with the increasing concerns from the international community and organisations such as the United Nations (in particular the United Nations Environmental Programme) and governments, many of the international petroleum companies have implemented sustainability approaches and practices as a response. Some of these approaches are the Environmental Management Systems such as the ISO 4001 and the Eco-Management and Audit Scheme (EMAS) (Anifowose et al. 2016; Iraldo et al. 2009). Other companies have created their own sustainability programs where they publish their performance in an annual sustainability report. These companies have adopted many approaches from internationally recognised systems to enhance their performance as well.

In developing and under developed countries there is evidence that many have not shifted to the concept of decreasing the environmental effect which this industry is causing (Hall, et al., 2013) and are still happy to put profit well ahead of environmental concerns. Many developing countries especially in the Middle East have made small progress in sustainable development when it comes to the petroleum industry. The Kingdom of Saudi Arabia has produced standards which ensure the sustainable development in the oil rich parts of the country and they have even introduced ISO 4001 in many organisations, which surely is a big step forward (Bag and Anand, 2014). However, many organisations in the country have not yet recognised and embraced sustainability.

Moreover, George et al. (2016: p. 197) explained that oil and gas companies "have been accused of ‘green washing’ in their marketing campaigns and corporate reports, and concerns have been raised over their sustainability policies and practices. Reduced profits have resulted in some oil and gas giants drastically reducing their spending on high capital renewable energy (solar and wind energy) to focus on investments with better returns, such as bio-fuel technologies and cleaner ways of using fossil fuels, which are far from ‘green’". This is true in many developing countries with weak environmental regulations including Libya.

When it comes to Libya, Zahari and Shurbagi (2012) believe that petroleum companies are very slow in implementing modern concepts and approaches of sustainability. Furthermore, Mohamed, et al. (2012) added that there is little research in the sustainability literature concerning Libya in general and the Libyan petroleum companies in particular. In fact, these research studies are just concerned with the renewable energy perspective. According to Busnaina and Woodall (2015), the Libyan economy is mainly dependent on the revenues of the petroleum industry, which create about 95% of export incomes, 80% of GDP, and 99% of government revenue. Libya has the highest revenue generation through the petroleum sector with the smallest population size in Africa, according to Bindra and Salih, (2014). This demonstrates the significance of the petroleum industry in Libya. Yet, sustainability and environmental management have been widely ignored at the Libyan petroleum companies as claimed by some scholars such as Emodi and Boo, (2015).

Libya is a developing country, which has endured negative experiences in recent times due to several events in which the country’s development process was hindered. Libya witnessed wars, sanctions, invasions and instability which is still ongoing. Libya gained its independence in 1951 but it did not fully utilise its wealth as it was sanctioned by the UN for almost two decades, which has affected the country’s development. Due to these issues, in near past and coming future, the Libyan Government has tried to develop the economy of the country and the biggest asset in this respect is the petroleum industry. Keeping the sanctions in mind, the Libyan Government has focussed on the economic benefit and profitability of the petroleum industry and ignored the Environmental and sustainability part of it (Chikaire, et al. 2015). On the other hand, Busnaina and Woodall (2015: p. 786) argued that "*since 2003, and the lifting of UN sanctions, Libyan economic reform has progressed substantially, and the country has worked hard to re-integrate with the global business community*".

However, despite the recent economic developments, sustainability in the Libyan petroleum sector remains neglected. The government has not yet utilised the country's substantial financial resources to develop the national infrastructure or the economy, nor implement modern systems and technologies to boost the sustainability of the petroleum sector. The environmental performance index for 2014 ranks Libya 120th out of 178 countries (EPI, 2014), which suggests a country with serious environmental degradation. Considering that the main industry in Libya is the petroleum industry, this indicates that the major environmental issues stem from the petroleum operations. Biltayib (2006) states that major sustainability concerns in Libya relate to pollution, emissions from fossil fuels, flaring and other chemical wastes. He added that the Libyan petroleum sector suffers from various infrastructure damages, lack of technology and external political factors.

Other researchers such as Bindra et al (2015) argue that the key issues with the Libyan petroleum companies are related to humans i.e. lack of effective management, negative attitudes of employees towards the environment and poor sustainability awareness. Evidently, there is a clear gap in knowledge and implementation of sustainability approaches in the Libyan petroleum companies compared to the international petroleum companies in the developed world. Current literature tends to focus more on renewable energy utilisation in Libya rather than organisations’ sustainability performance (e.g. Bora, and Dubey, 2015; Ahmad, 2014). It is the intention of this research to develop a sustainability management system, which addresses sustainability issues and environmental impact in order to enhance current practice.

Recently, there has been a growing interest in sustainability research. Dresner, (2008) and Adams, (2006) argue that the history of sustainability is new and can be traced back to the 1970s. Wittgenstein (1953) states that the “meaning” of a word is defined by the way language used. It can have full meaning, some meaning, or may be empty of meaning, consequently, to explain a word, it is sensible to appreciate its history and its background. The term “sustainability” is given various definitions in the existing literature and many scholars have approached the meaning differently. The term “sustainability”, which literally means the “ability” to “sustain”, is presently a key concern that appears to have a vague interpretation by many academics and practitioners.

Largely, sustainability is professed to be ecology. The word “Eco” means “environmentally friendly” or “sensitive”. Ecology is defined by Oxford Dictionaries, (2014) as the “*the branch of biology that deals with the relations of organisms to one another and to their physical surroundings*”, whereas sustainability is derived from the Latin word “sustinere” – meaning to sustain. Many other synonyms like to keep in existence, to maintain, and to keep (The free Dictionary) are also provided demonstrating a clear difference between the words, whilst some are complementary. Mensah et al, (2012) stated that the current debate is about what may be termed sustinere-eco, which literally means to hold the environment or maintain the environment. Adams (2006) stated that the term 'sustainable development' isn't that new and can be traced back to a conference held 3 decades ago.

It is claimed that sustainability began from the United Nations conference on human environment when poverty was the key issue at the time (UNEP, 1972). A thoughtful statement by India's former Prime Minster, Indira Gandhi, argued that “poverty is the worst pollution” (Dresner, 2008; Adams, 2006). This statement changed researcher's understanding of sustainability. The social aspect of sustainability became as important as the ecological and economical aspects. The term eco-development was formulated at the first meeting as an intention to develop environmental protection. The concept of sustainability was first cited in the conference of Science and Technology for human development (World Council of Churches, 1974) and was a reaction to concerns of developing countries about deprivation and poverty (Dresner, 2008); poverty being the main theme of both conferences. In the 1980s and through the world conservation strategy, the term 'sustainable development' emerged (Adams, 2006).

It was in 1987 when the concept of sustainability and sustainable development became famous following the United Nations Brundtland report. This defines Sustainability as the *“development that meets the needs of the present without compromising the ability of future generations to meet their needs”* (World Commission on Environment and Development, 1987: p. 8). In 1992, business leaders and government institutions increasingly acknowledged sustainability at the United Nations conference on Environment and Development. Since then, research in the field of sustainability aimed to enhance the appreciation and understanding of organisations, societies and individuals in relation to the influence of economic activities on the nearby environments and society as a whole (Daily, et al. 1994). Still, however, practitioners and researchers in this field perceive the meaning of sustainability and sustainable development differently.

Some scholars view sustainable development is an oxymoron, as development appears to involve environment degradation. Some say that sustainable development is shrinkage and the word is used to cover up the continuity of destroying the natural world (O’Riordan, 1988). The perspective of Serageldin and Grootaert (2000) and Porritt (2007) is that the economy itself is a subsystem of human society, which in itself, is a subsystem of the biosphere (the totality of life on earth). In addition, no subsystem is able to expand beyond the capacity of the total system. Others from an economic perspective argued that sustainable development is too cautious and watchful for the future, which affects the economic growth for the sake of extreme anxiety about depletion of natural resources (Dresner, 2008).

Sustainable development is also defined as **“***a development that improves the quality of human life, while living within the carrying capacity of supporting eco-systems”* (Hill and Bowen, 1997). Adams (2006: p.2) sees the definition of Brundtland report as general and vague. He argues the concept gets individuals together but does not essentially aid them to decide on purposes; therefore, sustainable development debatably sums up meaning nothing. According to Dresner, (2008, p. 66) sustainable development is a “contestable concept”.

Researchers involved in complementing the Brundtland report and the debate of sustainability definitions argue that disagreement about the wording does not mean it is meaningless. The deviation of opinions debated above demonstrates the complexity of the concept and evidences that sustainability is vaguely defined. Thus, this study reached a conclusion that there is no clear and common understanding of the concept of sustainability, but there is a separate and overlapping theme of enhancing the economy and upholding the biosphere and human race. Sustainability in the petroleum industry is taken as a different and standalone concept.

Since the developments towards the concept of sustainability, there have been various Sustainability initiatives implemented to enhance individual organisations' sustainable development (Whiteman and Cooper, 2000; Savitz and Weber, 2006). Theoretically, the concept of sustainability includes three overlapping pillars: **the environment, the economy, and the society** (Katrinli et al. 2017; Karunasena et al. 2016; Galpin et al. 2015). Meaning that for an organisation to be truly sustainable, it has to exhibit exceptional environmental, economic, and social performances. Song et al. (2017: p. 100) defined sustainability in the context of supply chain management as "*a strategic, transparent integration and achievement of social, environmental, and economic goals in the systemic coordination of key business processes for improving the long-term economic performance of the individual company and its supply chains*".

A "triple bottom line" theory has been developed by Elkington (1997, 2004) which recommends that the only way to become truly sustainable is to concurrently and continuously balance social, environmental and economic objectives in a way that improves competitiveness and safeguards long-term survivability as well as thinking about the effect on future generations. In addition, sustainability is not only about the minimisation of environmental impacts, but also about smarter management of an enterprise's strategic, operational and organisational affairs. (Savitz and Weber 2006). Álvarez et al. (2017: p. 3890) argue that the concept of 'Triple Bottom Line' "*provides a new framework to manage the sustainable projects and its main objective is to improve the economic, environmental and social performance, simultaneously, and to contribute to the reintegration of the techno-sphere and natural ecosystems*".

Three concepts are provided. **Social Sustainability (SS)** which can be attained by systematic community participation and strong civil society (Goodland and Daly, 1996: p. 1003). The most important considerations stated are “moral capital” like diversity, sodality, sense of community, humanity, love, patience honesty etc.

Economic Sustainability (EcS) which is about utilising the assets available to the enterprise in an efficient manner, so that growth and profitability can continue overtime. Wise et al. (2016: p. 31) argued that the economic component of sustainability is concerned with "*regeneration, and its focus is often on income generation aimed at reviving and sustaining the economy*". Wise et al. (2016: p. 32) also stated that the "*economic indicators drive change and development. Economic development in its broadest sense not only considers urban income generation, but also how such developments create new cultural, social and employment opportunities*".

Environmental Sustainability (ES) is mainly about improving the welfare and social sustainability of humans by ensuring that raw materials are protected and risks associated with human practices are minimised to reduce the impact on mankind (Serageldin et al, 1994). In other words, Environmental sustainability means, “maintaining natural capital”.

Despite the fact that this research aims to tackle all sustainability issues in the Libyan petroleum sector, it gives more emphasis towards the environmental side of sustainability. Economic and social sides are not addressed in full in this study due to the need to ensure the research is specific.

Seuring et al. (2008: p. 1545) provided a more comprehensive view of sustainability and defined sustainable management in the context of operations management as the "*management of material and information flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e. economic, environmental and social, and stakeholder requirements into account. In sustainable supply chains, environmental and social criteria need to be fulfilled by supply chain members to remain within the supply chain, while it is expected that competitiveness would be maintained through meeting customer needs and related economic criteria*".

This definition doesn't just emphasise the importance of integrating the three pillars of sustainability, but also argues that the success of an organisation's sustainability efforts is contingent upon the involvement of key stakeholders and on meeting customers' needs, wants and expectations.

Factors such as continuous improvement, organisational culture, personal and organisational responsibility are seen as vital to the success of an organisation and significant in approaching change and development (Kuipers et al., 2014). Kamal, et al. (2014) argue that continuous improvement culture is important for organisations to develop, and therefore, petroleum companies need to embrace a continuous improvement culture in all their systems and operations to maximise benefit. Kongsvik, et al. (2015) admits that Libyan petroleum companies have issues with organisational culture and accountability towards the environment. This research project sees continuous improvement culture and personal and organisational accountability as very significant factors, thus, related issues were investigated and addressed in this research.

The Petroleum industry is a very polluting industry and as advised by the Oil Industry International Exploration and Production Forum (E&P Forum) and United Nations Environmental Program (UNEP), there have been various models of sustainability developed. These models have mostly been extracted from the "triple bottom line" theory developed by Elkington (1997, 2004). Adams, (2006) argues that mainstream sustainability thinking has become a three dimensional idea i.e. environment, society, and economy. These have been displayed in numerous ways, as 'pillars', as concentric circles, or as overlapping circles (Figure 1.1).

The IUCN Programme implemented in 2005, used the overlapping circles model to establish that the three purposes ought to be better combined, with action to reform the balance among sustainability dimensions.

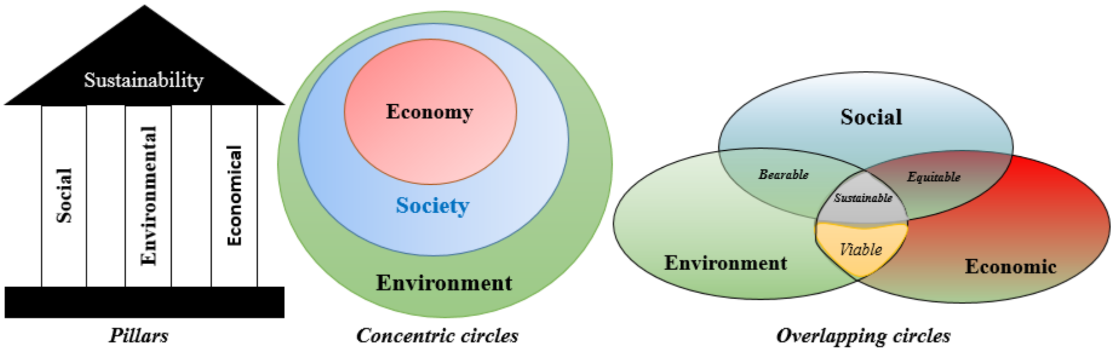

Figure 1.1: Models of sustainability (source: Todorov and Marinova, 2009)

There are many sustainability models present at the moment; Todorov and Marinova (2009) classify them as (1) quantitative models, (2) physical models, (3) conceptual models and (4) standardising models. These models are further investigated in the literature review chapters. Each of these models have their benefits and drawbacks, for instance quantitative models are criticised for being poorly equipped to provide a holistic perspective and address the local-global viewpoint or acknowledge the necessity for stakeholders' participation (Waheed et al. 2011). The most concerning drawbacks of the conceptual models is their inability to manage change and uncertainty.

There is no doubt that the current models of sustainability have major advantages and have triggered many debates with policy makers, yet, there is a gap for specific industries to have their own flexible models. For instant, the petroleum industry, a very important industry for the world economy, lacks effective systematic sustainability approaches. Todorov and Marinova, (2011) criticise petroleum companies for their "ineffective sustainability performance", others like Krishnaraj, (2015) claim that many of petroleum companies follow generic systems such as the Environmental Management Systems (ISO 4001) and Eco-Management and Audit Scheme (EMAS). Others still claim to have their own approach to address sustainability such as (McPhee, 2014).

Adams (2006) stresses that in spite of the accomplishments of the last three decades, the current models of sustainability and sustainable development are evidently inadequate. He adds that the key issue with sustainability concepts are not that the hopeful values they signify are wrong, but that they are "over-worked and tired" as presently expressed, as they are too loose to make effective change.

He is of the opinion that the efforts which are being made on this issue are becoming obsolete and as a consequence, .we need to introduce new and improved techniques.

Many other researchers agree with Adams, (2006) and criticise the present sustainability models and frameworks in that they are too optimistic and generic and they suggest that there is a significant need to create models and systems to tackle specific sustainability issues. Their effectiveness varies depending on factors such as the implementation drivers, the level of sustainability awareness and top management commitment.

In the case of Libyan organisations, Elhuni and Ahmed (2014) argue that there is massive lack of implementation of Sustainability and quality approaches in the Libyan organisations. Although considerable research has been devoted to quality (i.e. Lean, TQM and ISO 9001), less attention has been paid to investigate the low utilisation of sustainability methods and environmental management systems.

1.3 Synthesis of Recent Literature on Sustainability

Panagiotakopoulos et al (2015) argue that in recent years more emphasis on sustainable development should be placed on the individual organisation. They state there is a gap in the literature in relation to the ability to implement sustainability into every level of the organisation. In their evaluation of the currently available sustainability related standards such as ISO 26000, ISO 14001 and ISO 14044, they conclude that each standard can be regarded as a distinct management layer and an integrated approach to sustainability management is required. Other studies focus on the need to develop models that can integrate Corporate Social Responsibility with current management systems needing to be more stakeholder-driven (Ranänge and Zobel, 2014; Maas and Reniers, 2014).

Lozano (2012) argues that corporate leaders and employees have a vital role in sustainability in which many different voluntary approaches, tools, initiatives and standards have been developed to assist corporation engage sustainability. However, he suggests that there has been a lack of clarity in determining how the initiatives address different elements of the overall company system i.e.

operations, processes, management strategy, communication etc. and how they contribute to the sustainability dimensions. In a study carried out by Lee (2015) which explored the extent to which Korean companies adopt energy efficiency in manufacturing production, it was found that the main drivers for sustainable energy management include organisational and individual factors such as top management and energy taxes.

In an extensive literature review carried out by Engert et al (2016) to explore the integration of corporate sustainability into strategic management, they found that legal compliance and stakeholder disengagement, as well as lack of organisational learning and knowledge management are among the main barriers that hinder the integration of corporate sustainability into strategic management. On the other hand, several scholars have discussed the importance of having laws, regulations and legal frameworks in the context of incorporating sustainability as a source of pressure to push companies towards corporate sustainability (Gond et al., 2012; Van Bommel, 2011; Schaltegger, 2011).

Moreover, Abdulrahman et al (2015) examined one of Egypt's recent sustainability improvement initiatives associated with refinery flare gas recovery within the Egyptian Oil and Gas industry and found that technological, administrative and operational considerations have limited the efficiency of the new flare gas recovery project. Amongst the barriers that were identified is the inadequate internal capability and experience of operational staff as well as reliance on low quality equipment. In another study carried out by George et al (2016) to identify the barriers and enablers of sustainability integration into performance management systems of an oil and gas company, it was found that among the barriers are lack of key performance indicators and minimal stakeholder engagement as well as the absence of an innovation culture for sustainability. In terms of enablers, the study found that expanded sustainability planning and top management commitment as well as stakeholder engagement and feedback are critical for successful sustainability integration into corporate strategies.

Similarly, Saeed et al (2016) assessed sustainability practices in the energy sector of Iraq and found that Iraq suffers an unprecedented rise in the amount of the greenhouse gas emissions and no governmental efforts are being taken to integrate sustainability practices within the sector. Dubey et al. (2015) argue that leadership plays a significant role in integrating Total Quality Management systems within organisations to help achieve better environmental performance. Having a clear strategy in regards to sustainability was seen by White (2009) as essential for overall improvement of sustainability across organisations.

Sustainability has also been examined in relation to supply chain management (e.g. Wilhelm et al., 2016; Seuring and Gold, 2013; Meixell and Luoma, 2015). These studies affirm the need to develop appropriate performance measures, stakeholder engagement and the need for supplier partnership standards in order to successfully integrate sustainability into supply chain management strategies.

Corporate Sustainability Management is another concept that has been introduced by researchers which was described as an easy to understand concept but difficult to implement (Ameer and Othman, 2012; Kiron et al., 2012). It is concerned with "*how sustainability issues are dealt with in practice. In profit-oriented organisations, these usually form a subset of the corporate competitive strategy. One essential item here is the advantage that is identified by the management board while pursuing sustainability, that is, the strategic reason stated for developing and implementing a specific corporate sustainability strategy*" (Baumgartner and Rauter, 2017: p. 82). The basic assumption of the Corporate Suitability Management (CSM) is that for organisations to survive in the long term, they need to have a balance between financial, environmental and social performance (Rahardjo et al., 2013).

However, there is limited scope to its applicability. For example, Vnoučková et al (2014) point out that for the CSM to be successfully incorporated within organisations there are several factors that should be taken into consideration which include; the amount of commitment of shareholders to encourage the management to be involved in social and environmental issues, the corporate culture, stakeholders' engagement and organisational as well as individual factors.

Sustainability culture was also another area examined by scholars in the field in which they emphasise that having a sustainability culture is vital in creating a strong corporate sustainability (Linnenluecke and Griffiths, 2010; Robinson and Boulle, 2012; Arevalo et al., 2011; Aris et al., 2016; Busch, 2016). The initiatives needed to create a culture of sustainability can be summarised to include; integrating the organisation's vision and strategy with sustainability corporate employee involvement and participation in planning process, creating a learning organisation which allows for continuous improvement and building an inspiring and proactive leadership towards sustainability management. This argument is supported by Matinaro and Liu (2017: p. 3186) who stated that "*there are variety of causes that are against strategic sustainable development. These causes include ineffective leadership, ingrained cultures, outdated technologies, and poor logistics*".

A Sustainability culture requires "*radical, systemic shifts in values and beliefs, patterns of social behavior, and multilevel governance and management regimes*" (Olsson et al., 2014). Hence, recent literature on sustainability management triggers the need for having a robust and comprehensive sustainability management system that takes into account the organisational, environmental and human factors based on empirical collection of data, which was the purpose of this research study.

In a study carried out by Esquer-Peralta et al (2008) exploration of the perception of different experts in regards to having a holistic systems approach to environmental, social and economic elements was conducted. The study found that management systems were useful for sustainable development but did not provide a framework for the integration of sustainability practices into one system.

In summary, there has not been an integrated and a holistic approach to sustainability management within the oil and gas sector and the current EMS systems cannot fully achieve sustainability as argued by Panagiotakopoulos et al (2015). In the Libyan context, there haven't been *any* studies that aimed to explore sustainability practices in the petroleum sector.

The issues in the Libyan petroleum companies differ from those at other international petroleum companies but these have not been fully investigated and consequently, no holistic system has been developed to address them and improve current sustainability practices. Concerns include all kind of practices from creating a system, to training people to following it in an appropriate way to get the best out of it. Hence, this study sets out to fill this gap in the sustainability literature.

Key Rationale Points:

1. The Petroleum industry contributes significantly to every economy, it impacts every person, especially where they live or work. The management of sustainability is essential for having a green, efficient and vibrant economy and society. Equally, the petroleum industry is the highest contributor to emissions and other environmental degradations. Therefore, effective sustainability management is crucial to every society, economy and environment.
2. The integration of sustainability principles which consider environmental, economic and social factors is extremely significant to the success of the petroleum industry.
3. Continuous improvement culture is crucial for any organisation to adopt sustainability approaches. It eases the implementation process of any development approach (Environmental management approach, quality improvement approach or sustainability system) in any organisation.
4. Not only the systems are required to be introduced in many countries, but also the employees and all other stakeholders are required to be trained to use those systems. There are many countries or organisations where they have introduced good systems on sustainability but stakeholders are not trained which resulted in poor results.
5. In sustainability management, numerous empirical and professional studies have established the significance of effective sustainability approach, where environmental sustainability is recognised as a major contributor to the reduction of emissions and meeting the UNEP requirements. Many researchers stress the significance of a sustainability management system for petroleum companies which could be tailored to specific organisation situations.
6. In spite of numerous research studies into sustainability, there are few for the Libyan petroleum industry specifically and limited sustainability and environment management systems in both the literature and practice. Even though existing approaches have been criticised as insufficient and limited, they cannot be replaced since there is no better replacement yet established.

- The existing approaches such as EMS ISO 4001 and EMAS are generic approaches and are not specific for petroleum companies.
- There is a lack of effective identification of problems and barriers to the implementation of new approaches.
- No systematic approach to implement new concepts of sustainability.
- Lack of will to work on this concept by the higher authorities.
- Poor awareness of sustainability in developing countries.
- Lack of training and professional continuous development.

1.4 Aim, Objectives and Research Questions

1.4.1. Aim

The aim of this research is to develop a sustainability management system (SMS) for petroleum companies in Libya. Critical investigations will be conducted with the purpose of identifying, and subsequently minimising, environmental impacts and the barriers to SMS implementation leading to enhanced sustainability practices.

1.4.2. Research Objectives

To achieve the research aim, the study addressed the following objectives:

1. To critically review the literature on the concept of sustainability, environmental sustainability and environmental management systems as it applies to the petroleum industry.
2. To empirically investigate the sustainability situation in the Libyan petroleum sector to identify and assess relevant issues and environmental risks.
3. To identify and critically analyse the barriers and success factors of implementing sustainability approaches and environmental management systems in the Libyan petroleum industry.
4. To explore the extent to which sustainability is being practiced in the oil and gas industry in Libya through quantitative and qualitative approaches and using case-studies.

5. To develop a Sustainability Management System (SMS) for petroleum companies operating in the oil and gas industry in Libya.
6. To evaluate and validate the developed SMS and create guidance to support its implementation.

1.4.3 Research Questions

The research sought answers to three main questions:

Q1. What are the sustainability problems and challenges associated with the Libyan petroleum operations, and what are the major environmental sustainability impacts in the Libyan petroleum industry?

Q2. What are the barriers to the implementation of sustainability approaches and environmental management systems at the Libyan petroleum companies and are there examples of recognised good practice that can be shared?

Q3. How can the sustainability problems and challenges identified in Q1 and the barriers and success factors identified in Q2 be addressed in an innovative sustainability management system to enhance current practice? Moreover, how can the new SMS be implemented to maximise performance and reduce environmental impact?

1.5 Rationale of the Study:

1.5.1 Theoretical Rationale (Scientific Relevance):

It is argued by Goodland (2008) that Libya lacks scientific studies on sustainability but the country has the potential to become an environmentally sustainable nation. There is no published literature about sustainability management in the petroleum sector in Libya. Previous studies about Libya have focused on the environmental aspect of sustainability in the manufacturing, transport and food sectors (Emhemad et al, 2014; Maatugh, 2016; Abogrean and Bindra, 2015; Saad, 2016).

Hence, the theoretical rationale of this study arises from the fact that no previous studies were carried out to examine the challenges faced by petroleum companies in Libya to adopt sustainability practices. This study will, therefore, make a significant contribution to the academic literature especially in the context of developing countries and the oil industry in particular.

There are different levels of research undertaken in this study which helped the researchers obtain feedback from the stakeholders of the petroleum industry and add it to the literature (from the Libyan prospective). As explained earlier, there was no academic research being undertaken in the area of sustainability implementation in Libya at the time of starting this research, so this surely was the rationale behind the study. The study did not only involve social research, but also adopted scientific research as part of the methodology. Life Cycle Assessment (LCA) and Environmental Impact Assessment were part of the study and the results from them will give future researchers some basis for their studies in the Middle East. The study concludes by creating a Sustainability Management System (SMS) which is aimed at helping the petroleum industry in Libya implement a system which will ensure employees and other stakeholders decrease the adverse effects of the petroleum industry on environment.

1.5.2 Practical Rationale (Societal Relevance):

Both petroleum exploration and production pose significant risks to the environment (Kharaka and Dorsey, 2005). In Libya, the petroleum industry is the country’s main source of revenue (Mohamed et al., 2009). Hence, and based on the researcher’s own practical experience in the petroleum sector in Libya, there is a need for a robust system to be put in place to ensure that environmental impacts are minimised. This emphasises the need to investigate the problem in its natural setting. Thus, the practical rationale for this study arises from the fact that it is based on a case-study design to explore and investigate the issues that face the petroleum industry in Libya from the perspectives of industry-specific professionals and policy makers in the country along with using methodological approaches to acquire scientific evidence.

Environmental sustainability is among the goals of the United Nations Millennium Development Goals (UN, 2010). All countries are required to improve their environmental sustainability. Thus, this study focuses on ensuring that the petroleum sector in Libya adopts an integrated approach to environmental management that aims to reduce environmental impacts such as the reduction of harmful gas emissions and achieving economic benefits.

Moreover, the study has focused on important issues related to the Libyan economy since the growth and development of the national economy relies on urgent and sustainable improvements in its oil and gas industry.

1.6 Organisation of the Succeeding Chapters

Chapters 1 to 3 have focused on the existing knowledge and information using various literature sources such as books, e-books, journal articles, professional and government website etc. to provide the solid basis for this research. The literature review chapters have also highlighted a gap of knowledge and established the context of this study, in other words, the first chapters focused on secondary research (stage 1). This chapter (4) has provided the research methodology followed to achieve the research goals. The subsequent chapters are concerned with the primary research, in which the results of each stage are presented and discussed. These pave the way for the development of the SMS model as well as presenting the key conclusions and recommendations of the study in the final chapter. Chapter 5 presents the findings of the qualitative study that was carried out in Libya using semi-structured interviews. Chapter 6 presents the results of the quantitative approach that used a questionnaire survey which was distributed among employees working in the oil and gas sector to understand their concerns, awareness and challenges that face the oil and gas industry in Libya in terms of sustainability and environmental management. Chapter 7 presents the results of the Environmental Impact Assessment (EIA). EIA can be described as a procedure that aims to assess, analyse, and inform, all possible effects which any new project, process or development has on the environment.

To further explore the issues associated with environmental management and sustainability in Libya, EIA was carried out to assess various impacts in Libya so that sources of these impacts can be identified and mitigation measures proposed. Chapter 9 presents the results of the Life Cycle Assessment (LCA) that was carried out in Libya. The LCA study has been designed to appropriately identify the best actions to undertake in order to minimise the environmental footprint of the crude oil extraction process. Chapter 10 presents the Sustainability Management System that was developed as part of this research. The chapter presents and discusses in detail the process that was adopted to develop the proposed system and also elaborates on the different system components.

Sustainability management in the oil and gas industry requires a systematic approach that aims to integrate policy-making, technology, organisational and individual factors. This chapter further provides a detailed explanation of the benefits of the developed system and its application in the Libyan context taking into consideration the barriers and challenges. It also presents the results of the validation study that was carried out to test the usefulness and suitability of the proposed SMS model to the Libyan context. Chapter 10 presents the conclusions of the study and discusses whether the research objectives have been achieved. The chapter also lists specific recommendations to the policy makers in Libya and discusses the research limitations and ideas for future research.

1.9 Chapter Summary

The purpose of this chapter is to provide a summary of the overall thesis. It presents the problem statement followed by the aim, objectives and research questions. It also gives the thesis structure.

Chapter 2

Literature Review

2.1. Introduction

Sustainability is not a new topic but researchers are working hard to find the exact meaning of it and that of sustainable development in relation to different subject areas. This chapter explores the term “sustainability” and how it has been interpreted by various scholars. Initially, the chapter gives an overview and background of the sustainability definition. It will discuss the evolution of sustainability and the debate surrounding its definitions before briefly reviewing the models of sustainability. This chapter concludes with the establishment of a clear understanding of the sustainability definition in the specific area of research.

Environmental deterioration has become a significant problem in recent decades and we need to move towards sustainable development in order to save the planet from our own selves. There are different issues which are making things ever worse. Climate change and global warming risks are rising significantly (Hall et al. 2017: Starik, and Kanashiro, 2013). Bui and de Villiers (2017: p. 5) referred to climate change risk as all risks associated with "*changing fuel prices and the related changing valuation of generation equipment, the direct cost of carbon emissions, windfall gains for renewable generation capacity, societal pressures and customer reactions, competitive risks, and opportunities to invest in new renewable generation*".

The petroleum industry has been criticised as one of the largest contributors to the world’s carbon emissions and the main hurdle in the way of attaining sustainability. For example, despite the petroleum industry’s significant economic contributions to the UK’s GDP and its use for the supply of 75% of the UK’s primary energy source (Total Energy, 2014), it contributes to about 133.9 million tonnes of carbon emissions representing around 28.8% UK’s CO_2 emissions.

In Libya, the petroleum industry is the most significant sector in the country and represents over 90% of government revenues. It contributes 61.69 million tonnes of carbon emission, which is higher than for any other source. The petroleum industry is economically driven and originated for economic benefits. Practitioners and researchers in the field of sustainability are studying ways to attain sustainability in other sectors to reduce the reliance on petroleum products for energy generation. They have concentrated on renewable energy sources and technologies, yet a large amount of environmental emissions are incurred by oil and gas operations which cannot be easily ignored.

Although it is known that renewable energy sources are increasing, the petroleum industry is still a significant energy provider and is not likely to be replaced by other industries in the near future (SESR, 2006 and Mohamed et al., 2012). There are energy replacement developments in the market like solar, air etc. but still the main emphasis of our energy consumption is petroleum. Therefore, any industrial endeavours and management measures are essential to address and achieve sustainability for petroleum operations, which might help save our planet.

2.2. Background of Sustainability

Wittgenstein (1953) stated that "*meaning*" is defined by the way language is used. He stated that the meaning of the word depends on how it is used and how the receiver will interpret it. A word may have full meaning, some meaning or be empty of meaning, consequently, to explain a word it is sensible to appreciate its history and background, since the definition of a word is vital to its understanding. In order to understand the real meaning of the word sustainability and find the perfect definition of this word, we need to discuss the history and context of the word first (Pennington, et al. 2014).

The term "sustainability" has various definitions in the existing literature, which makes it difficult to define a common clear definition. Many researchers and scholars have approached the meaning of sustainability differently depending on the subject it is related to. According to Van Zon (2002), it was only during the second half of the 20th century when the terms "sustainability" and "sustainable" appeared for the first time in the Oxford English Dictionary. Van Zon reported that other equivalent terms were used in other language such as 'durabilite' and 'durable' in French, 'Nachhaltigkeit' which literally means "lastingness" in German as well as "duurzaamheid and duurzaam" which are in the Dutch language.

Sustainability means the ability to sustain and practitioners as well as academics in the field define and interpret sustainability into many different ways. In its early use, sustainability was always linked with the term “eco” which means “environmentally friendly” or “sensitive” that is abbreviated from the term “ecology. According to the Oxford Dictionaries (2014), ecology is defined as “*the branch of biology that deals with the relations of organisms to one another and to their physical surroundings in a given time*”. Hodge, (1997: p. 9) defined sustainability more specifically as the "*persistence over an apparently indefinite future of certain necessary and desired characteristics of both the ecosystem and the human subsystem within*". The Latin word “sustinere” which means to sustain is the root word of sustainability. It has many other synonyms such as to keep, to maintain and to preserve. According to Mensah et al (2012), “sustinere-eco” is the term that is receiving much debate in which it means to hold or to maintain the environment.

Adams (2006) states that the term sustainability is new and can be traced back to a conference held 3 decades ago. It is claimed that sustainability began from the United Nations conference on human environment when the poverty was the key issue at the time (UNEP, 1972). A thoughtful statement that changed our understanding of sustainability was given by the Indian prime Minster, Indira Gandhi which is “Poverty is the worst pollution” (Dresner, 2008; Adams, 2006). The use of the word pollution was the main cause of all the happenings and it caused the foundation of the United Nations Environment Programme (UNEP) in Kenya (Dresner, 2008). The term eco-development was first formulated at the first meeting as an intention to develop the environmental protection.

The term 'sustainable development' was first established in the conference of Science and Technology for human development in early 1970s (World Council of Churches, 1974). It was a reaction to the objections of developing countries about the environment who felt there should be more focus on humans in some parts of the world suffering from deprivation and poverty (Dresner, 2008, p. 1). Poverty was the main theme of both conferences. It is in the 1980s, through the world conservation strategy that the term Sustainable development was progressively adopted (Adams, 2006).

The concept of sustainability came to the surface in 1987 when the United Nations issued the Brundtland report. It defines sustainability as the "*development that meets the needs of the present without compromising the ability of future generations to meet their needs*" (World Commission on Environment and Development, 1987, p. 8). Although the Brundtland definition of sustainable development is popular, there is no one generally recognised and accepted definition. Pearce et al, (1989) in their book "blueprint for a green economy" mention 23 definitions, and Murcott (1997) revised the list and combined 57 different definitions of sustainable development, which make it very confusing even for people working in the same subject area. Pezzey (1992) archives sixty definitions! In 1992, sustainability was increasingly acknowledged by business leaders and government institutions through the United Nations conference on Environment and Development. Table (2.1) shows the key historical milestone of sustainability as offered by (Yusuf et al., 2013.p502)

Table 2.1 Key significant stages of sustainability (Yusuf et al., 2013: p. 502)

Year	***Event and description***
1946	Introduction of Sustainable agriculture
1949	First UN Scientific Conference: The issue of social and economic development through proper management of natural resources in order to avoid their depletion was first mentioned.
1968	Inclusion of environmental issues in the global consciousness and agenda: UN Economic and Social Council added environmental issues to its major agenda.
1972	First Earth Summit: The UN Conference on the Human Environment took place in Stockholm and came up with a declaration that first mentioned the issue of climate change.
1983	Establishment of Brundtland Commission: The resolutions titled ''The Environmental Perspective to the Year 2000 and Beyond'' was passed by the UN Assembly
1987	Brundtland Report was published: The report first brought the issues of sustainable development to the spotlight
1990	World Climate Conference: Indicated an urgent need for international action on the environment.
1992	UN Conference on Environment and Development: Requests for various countries to consent to the UNFCCC framework.
1997	Kyoto Protocol came into existence: The agenda was to reduce carbon emission to at least 5% of 1990 levels from 2008–2012.
2009	UN Climate Summit: Recognised the need to keep rising temperatures at r2 1C but failed to provide the protocols to do so.
2010	UN Climate Change Conference, Cancun: Latin American countries threatened withdrawal if developed countries were not mandated to show more commitment to the Kyoto protocol.

2011	UN Climate Conference, Durban, South Africa, 28 November to 11 December 2011, was meant to establish a new treaty to limit carbon emissions. All the countries at the conference agreed to a legally binding deal that will be prepared in 2015 and to take effect in 2020. Progress was also made concerning the creation of a Green Climate Fund (GCF).

Research in the field of sustainability aims to enhance the appreciation and understanding of organisations, societies and individuals in relation to the influence of economic activities on the nearby environments and society as a whole (Daily, et al. 1994). Yet, the meaning of sustainability and sustainable development is perceived differently by practitioners and researchers in this field. Some scholars view sustainable development as an oxymoron, since development appears to involve environment degradation. Some say that sustainable development, as a concept, is used to cover up the continuity of destroying the natural world (O'Riordan 1988). Others like Missimer et al. (2017: p. 44) argue that "*sustainability is thus about the elimination of mechanisms of systematic degradation of essential aspects of both the ecological and the social system*".

The perspective of Serageldin and Grootaert (2000) and Porritt, (2007) is that the economy itself is a subsystem of human society, which is a subsystem of the biosphere (the totality of life on earth) and that no subsystem is able to expand beyond the capacity of the total system. Others from an economic perspective state that sustainable development is too cautious and affects the economic growth for the sake of extreme anxiety about depletion of natural resources (Dresner, 2008). This initiated a debate among researchers from various fields. Some economists see consumption of the Earth's capital as if it were revenue.

Sustainability is also defined as "non-declining capital" by David Pearce where earth is discussed as a natural capital (Dresner, 2008: p. 76). Sustainable development is also defined as "*a development that improves the quality of human life, while living within the carrying capacity of supporting eco-systems*" (Hill and Bowen, 1997) defined by Caring doe the Earth. Regardless of the fact that Adams (2006, p. 2) sees the definition of the Brundtland report as imprecise, he thought that it ingeniously captured two vital issues: environmental degradation and economic growth. He disputed that the definition of sustainability is general and vague, which is backed by many other researchers and scholars. This concept gets individuals together, but does not essentially aid them to decide on purposes, therefore sustainable development debatably ends up meaning nothing. According to Dresner, (2008, p. 66) Michael Jacobs likewise states that sustainable development is a “contestable concept”.

The UK Government’s definition of sustainable is captured with this quote: "*our strategy for sustainable development aims to enable all people throughout the world to satisfy their basic needs and enjoy a better quality of life without compromising the quality of life of future generations*” (HM Government, 2005: p. 6). Debate of sustainability definitions argue that disagreement does not mean it is meaningless. There is sensible agreement that sustainable development should address ethical authoritative and moral necessities to provide for the wants of those alive at present without hindering future generations' probabilities of the same. The deviation of opinions debated above demonstrates the complexity of the concept and evidences that sustainability is vaguely defined. Thus, this study reaches a conclusion that there is no clear and common understanding of the concept of sustainability, however there is a separate and overlapping theme of enhancing the economy, and upholding the biosphere and human race.

Nevertheless, explanations and meaning such as those conveyed by the Brundtland report and the UK government provoke as many questions as they answer. For instant, whose life do we mean? How are we to differentiate between desires and needs? Is it just for us living in the developed world? Regrettably the answers are not clear-cut. Besides, despite sustainability as a subject matter being complex and treacherously subjective, the overwhelming question is `how is sustainability to be achieved in practice?’ This question requires some elaboration of the conditions that must be satisfied and it is this qualified definition that is developed here. The following section will discuss the definition of sustainability and produce a context-specific definition - a definition that is consistent with the needs of this study.

2.3. What Is Sustainability?

In order to move forward with the study, it was important to agree on one definition from the literature. Thiele, (2013), argues that sustainability is one of the least meaningful and most overused words in the English language. She suggests that it might be clearer if the practice of sustainability was more measurable and impactful. A common understanding of the term sustainability is hard to attain due to the limited discussion of the definition in the current literature.

Whenever we hear or read about sustainability, our attention diverts towards environmental issues, because sustainability is always referred to in the context of the environment, but this is not actually the case. To be truly sustainable, an organisation, or a project must do more than just safeguard nature and protect natural resources. In fact, it must meet and support economic needs as well. In parallel, it must address social needs and equitable relationships. Sénéchal et al. (2017: p. 331) explained that sustainability is "*hinged on three dimensions: the social dimension that consists of looking after the welfare of people, the environmental (or ecological) dimension that deals with the planet's health, and the financial dimension aimed at reducing costs and boosting benefits*".

The term "*sustainable development" was used to support the sustainability phenomena, in which economic aspects were added to the former ecological and social aspects that were presented and introduced by the Brundtland Report in 1987. Furthermore, the Agenda 21 with "sustainable development*" as a global object was a declaration signed in the United Nation's Conference on Environment and Development in 1992, in which more than 170 nations participated. The declaration was considered by many as another milestone in the sustainability arena. However, Agenda 21 was not followed by great cooperation from member states of the UN, so an opportunity was lost to further ensure that sustainability was a key priority of governments' policies.

Another issue with the understanding of the subject of sustainability is because the terms \`sustainability' and \`sustainable development' are being used interchangeably. The problem is seen by the ambiguity of the phrase \`sustainable development (O'Riordan 1988). Some might think that the term \`development' means \`economic growth' but it has a much wider emphasis than just economics and is intended to embrace \`quality of life' and the fulfilment of wellbeing necessities (Pearce et al, 1989). Selmes (2005) agrees with Thiele, (2013) and argues that there is a significant need for more clarity about sustainability within the field of environmental management and other disciplines. The need for clarity is due to the risk of confusion, but more seriously the failure to effectively communicate and understand sustainability issues which in return damages the ability to act decisively (Boron and Murray, 2004). So, in order to work properly in the field, we really need to understand the difference between the two terms.

The UN definition of sustainability has been criticised by Taylor (2002) in which he argued that determining the future needs of the next generations is a difficult task because of the differences in perceptions and values that they could have from the people of today. Moreover, Taylor indicated that needs are perceived differently between developed and developing countries. However, it can be argued that the UN definition provides better understanding of two important areas associated with sustainability which are: the need to raise awareness about environmental impacts that exist as a result of economic growth, and combating poverty in society.

A conceptual model to describe the three interconnected sectors associated with sustainability was proposed by Barton (2000) and Du Pressis (2000) in which the model presents how the economy, the society and the environment interconnect as shown in Figure 2.1. They argue that a reasonable level of balance should be kept amongst these three areas so that sustainable development can be achieved. According to Boron & Murray, (2004) sustainable development is defined as "*a system for the meeting of needs in a way that could continue forever, and the state of sustainability is the result of sustainable development achieved globally*". The definitions explains that the term sustainability is the general outcome and sustainable development describes this outcome functional and is implemented at a more local and specific scale (such as an organisation or a country). It is similar to the Brundtland's definition which defined sustainable development as the "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (UN, 1987).

The rate of environmental degradation as a result of economic growth and development is increasing at a fast rate as reported in the literature. Developing countries are also witnessing some degree of development associated with the transformation of the earth as there is growing industrialisation in these countries. This is highlighted by Wackernagel and Rees, (1996) who argued that consumption of resources as raw materials is high and growing which imposes significant risks to the environment. Lang et al (2012) affirmed that a balance should be maintained between the economy, the environment and mankind in which many organisations, governments and the world at large is finding hard to maintain. This could imply that the world efforts communicated through the UN and other leading organisations of both developed and developed countries are coordinated to ensure sustainable development is incorporated at policy level.

There have been various sustainability initiatives developed and implemented to enhance organisations' sustainable development (Whiteman and Cooper, 2000; Savitz and Weber, 2006). Theoretically, the concept of sustainability includes three overlapping pillars: the environment, the economy, and the society. This means that for an organisation to be truly sustainable, it has to exhibit exceptional environmental, economic, and social performances. A “triple bottom line” theory has been developed by Elkington (1997, 2004) which recommends that the only way to become truly sustainable is to concurrently and continuously balance social, environmental and economic objectives in a way that improves competitiveness and safeguards long-term survivability. In addition, sustainability is not only about the minimisation of environmental impacts, but also about smarter management of an enterprise's strategic, operational and organisational affairs (Savitz and Weber, 2006).

The reasons for not having a clear definition of sustainability as claimed by Goodland and Daly, (1996) are because *“Detractors are terrified of defining Environmental Sustainability precisely since they know to do so would change their behaviour*” (Goodland and Daly, 1996: p. 1002). They argue that for a clear definition of sustainability, it is important to separate and distinguish the environment, society and economy for sustainability. In other words, it is the challenge of social scientists to define social sustainability, and the same goes to economists to define economic sustainability and environmentalists “environmental sustainability”.

Three distinguished concepts are given. Social Sustainability (SS) is attained by systematic community participation and strong civil society. Almahmoud and Doloi (2012) described social sustainability as a "*positive condition within communities and a process that can achieve it*". Goodland and Daly, (1996, p.

1003) state that social sustainability emphasises “moral capital” such as diversity, sodality, sense of community, humanity, love, patience honesty etc. Ahmad and Thaheem (2017: p. 3) identified eight social issues that are commonly addressed by nations as part of their social sustainability efforts, namely: "*health, participation, safety, security, accessibility, education, identity and job opportunity*".

Economic Sustainability (EcS) refers to “maintenance of capital”. Economic sustainability includes using the various assets of the enterprise efficiently to let it continue functioning profitably over time (Business Dictionary).

Environmental Sustainability (ES) seeks to improve human welfare and social sustainability by protecting the sources of raw materials used for human needs and ensuring that sinks for human wastes are not exceeded, to prevent harm to humans (Serageldin et al, 1994; Soflaei et a. 2017). In other words, environmental sustainability means “maintaining natural capital” (Cook et al. 2017).

In the 20th century, we were able to see our planet from space for the first time. It did not look as if it was dominated by a pattern of human’s activities, but more like a pattern of small balls surrounded by clouds, and dominated by oceans, soil and woods. Humans failed to fit their activities into that pattern, which affects and changes our ecosystems. Several of these activities and changes risk life-threatening dangers. This new reality must be realised and managed effectively since there is no escape from it (Morelli, 2011).

In regard to the concept of environmental sustainability (ES), Goodland, (1995) discussed the history of sustainability and pointed out its significance. He attempted to define ES by distinguishing it from social and economic sustainability. He stated that sustainable development (SD) should integrate environmental, economic and social sustainability and use them to make development sustainable. Goodland (1995: p. 10) defines environmental sustainability as “Maintenance of Natural capital”. By this definition, he confirms that ES is a natural science concept which follows biophysical laws. He also defines ES and SS, as being all related and connected to ES. Morelli, (2011) agrees with Goodland’s definitions and confirms their validity. In this research, these definitions are not repeated, but also are accepted as valid and will be used to proceed for further developing the concept.

The discussions above indicate that the term “environmental” is what is largely associated with and describes the relationship between humans and the ecosystem. It is shown that the terms sustainability and sustainable development have been revolutionised over the past three decades. Several definitions have been proposed by many scholars and organisations to clearly define and interpret sustainability and societies can achieve sustainable development. This research is focused on enhancing environmental sustainability of the Libyan petroleum sector. In other words, it addresses how Libyan petroleum companies could be more efficient, environmentally friendly, resources efficient, produce lower emissions and apply effective waste management. Furthermore, humans’ influence is still considered in this research due to the fact that it represents a major part of the problem and the solution at the same time. This research considers the definition of sustainability by Brundtland to be valid.

2.4 Models of Sustainability

Sustainability as a concept is wide-ranging, covering far more than environmental issues. To make the matter more manageable, as discussed by Goodland (1995), the subject is often differentiated between economic, social, and environmental domains. All the three domains are so well connected that it is difficult to contemplate significant progress in any one domain of sustainability to the exclusion of others (Selmes, 2005). Indeed, the requirement that all three domains are properly accounted for is central to the `triple bottom line' (TBL) approach, which is the core theory of this concept.

2.4.1. Three-overlapping Circle Model of Sustainability:

The sustainability concept is often portrayed pictorially as three intersecting circles of social, economic and environmental objectives (Mebratu, 1998) (see Figure 2.1). The intersecting circle model looks like a Venn diagram (This is a mathematical concept which shows the common things in two sets within overlapping circles) and imply that the delivery of social, economic, and environmental goals will deliver `true' sustainability at the point where these three features (circles) overlap (we can see this in Figure 2.1 as **S**).

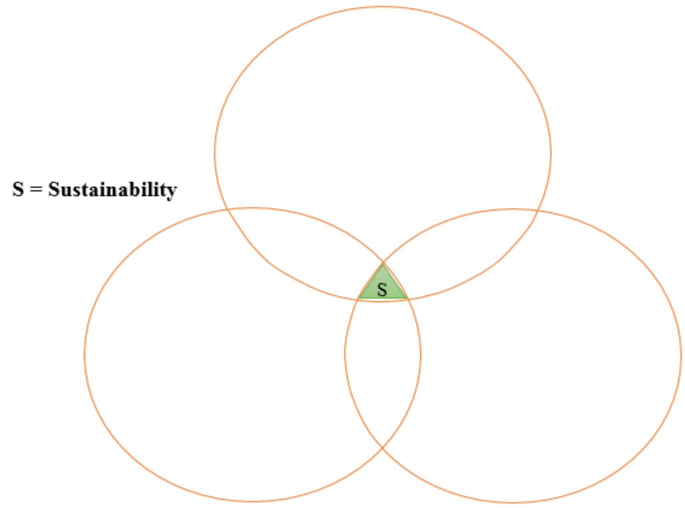

Figure 2.1: Three-overlapping Circle Model of Sustainability (Source: Mebratu, 1998)

The overlapping region correctly suggests that all three domains have to be ultimately satisfied, but this does not mean that all efforts towards sustainability are required to be balanced between these three domains. This model does not replicate the fact that the economic sphere is exclusively reliant on the other two and is therefore somewhat vague. Of the economic, social and environmental aspects of sustainability, it is the environmental issue that is the most fundamental and it is sensible that be reflected in such a diagram (Brockhaus et al. 2017).

It is the natural environment that supports societies and economies (Mitchell, 2000). In other words, the environment can survive without human societies and economies, yet economies and societies cannot survive without the environment's resources, which surely makes the environment domain the most important one in this theory (Wagner, 2015). Economic advantage has to be based on sustainable activities which function within the constraints of society and nature. Furthermore, economic mechanisms must promote sustainable activities which then deliver a sustainable economy. In fact, the integration of environmental sustainability into organisations' strategic management functions is believed to contribute positively to their economic sustainability. Wagner (2015: p. 1310) argued that the "*integration of environmental issues relates positively to economic performance and thus also support the notion of organisational idiosyncrasies in the case of integration. Therefore, firms that increase integration can realise competitive advantages and improved performance in a variety of* *economic performance dimensions, such as risk, image, efficiency or market performance*".

In today's world, humans tend to see themselves as somehow emancipated from, or in control of, the natural environment. The humans believe that they can control nature, but this is not the case as they are actually under the control of the Mother Nature. This perception is unhelpful as it makes it harder to see problems, yet this kind of thinking is perhaps encouraged by the intersecting circles model. What is more, interpreting the three domains as requiring equal attention encourages thinking about the continued practicality of trade-offs which arises directly out of the business dilemma. Unfortunately, this model implies that the economy can exist independently of society and the environment—that the part of the economy circle that does not overlap with the society and environment circles has an existence of its own. This large incongruity leads us to the next, more accurate model.

2.4.2. Three-Nested Dependencies Model of Sustainability:

Also referred to as concentric circle model of sustainability, it is believed to be more accurate than the previous model.

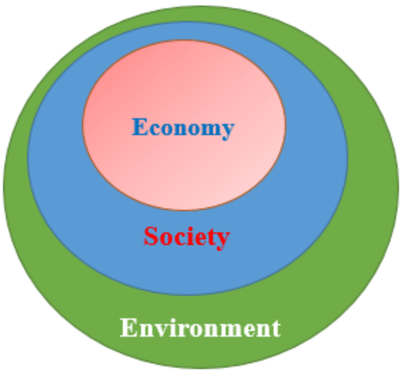

Figure 2.2: Three-Nested Dependencies Model of Sustainability ((source: Mensah et al. 2012)

This model tells us that everything is dependent on each other, i.e. all the three factors are dependent. As far as this model is concerned, the economy is dependent on the society, which means that money can be taken out of the society and there is no other place to get the money. The society is dependent on the environment, which means that the money is also dependent on the environment.

2.4.3. Three-Legged Sustainability Stool:

The 3-legged stool model considers three dimensions which are essential to enjoy a high quality of life by mankind. It also affirms that high quality of life cannot be achieved if one of the three is weak. However, this metaphor separates the economic, environmental and social legs which are the core of the sustainability concept.

Figure 2.3: Three-Legged Sustainability Tool

From Figure 2.3, it can be seen that the stool is not a strong metaphor, which explains why the model is not much used in defining and explaining sustainability.

2.4.4. Levett's Model of Sustainability:

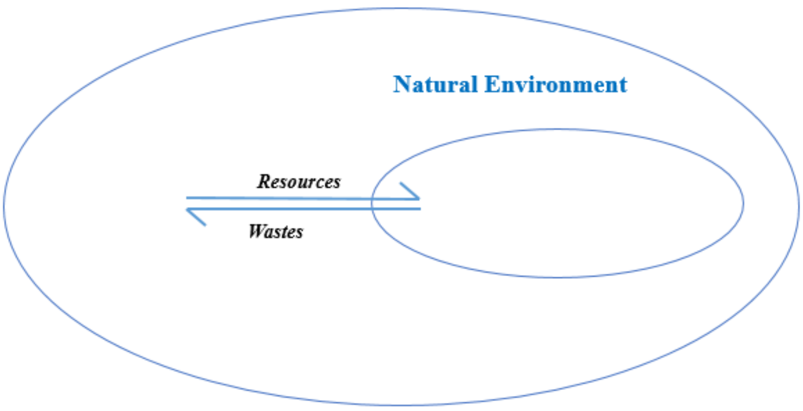

Figure 2.4: Levett's Model of Sustainability (Levett, 1998)

A model such as Figure 2.4 is consistent with that presented by Reid (1995: p. 34) during a discussion of 'The Limits to Growth'. The diagram Reid uses actually goes further in that it represents the environment as a thermodynamically closed system. Since `economy' is a construct of society it is possible to go further still. Levett makes this very point and re-defines the 3 intersecting circles model as concentric circles or `Russian dolls' (Levett, 1998) (see Figure 2.1): "`The economy' is not an end in itself or a force of nature. It is a social construct. *It only works as it does because human societies have created the institutions, and inculcated the assumptions, expectations and behaviours which make it so*".

Levett's model is fundamentally different to the intersecting circles model (Figure 2.4). Whether or not the intersecting circles model is intended to imply a balance of social, economic and environmental goals - or something else entirely - the concentric circles model helps illustrate unequivocally that the economy is `within' society, and that society must live within the limits of the environment.

2.5. Categorization of Sustainability Models:

Todorov and Marinova, (2009) classifies sustainability models into five categories:

- Pictorial visualization models
- Quantitative models
- Physical models
- Conceptual models
- Standardizing models

2.5.1. Pictorial Visualization models:

The three overlapping circles model (economic, social and environmental) dimensions represented as pillars, Venn diagram or embedded circles are classified as pictorial visualisation models. Todorov and Marinova, (2009) criticised them as they are limited in information but complemented them in regard to reaching a broad audience.

2.5.2. Quantitative Models:

Boulanger and Bréchet, (2005: p. 340-341) state that the quantitative models include, "*macro-economic models, optimization models, system dynamic models and computable general equilibrium models*". This area of models has been extensively researched and as a result, a wide range of models have been developed, with the most common being economic models (Faucheux et al., 1996). These models are criticised in that they lack the holistic approach to address local-global perspective and fail to acknowledge the need for stakeholders' participation.

2.5.3. Physical Models:

Sustainability physical models are limited to its environmental component. For example, they have been applied for urban design and energy efficiency (Levings, 2004) and toxicity (e.g. Karlsson, 2008) and in realising engineering ecology (Todorov and Marinova, 2009). These models are very specific and measurable; however, their time period is limited. They apply a participating methodology which covers only a disjointed part of the sustainability system and therefore serves a limited purpose.

2.5.4. Conceptual Models:

The conceptual Models are more general and theoretical. The models belonging to this category are very broad and relate to societies. They alert global environmental issues such as global warming and weather changes. Some of these models date back to 1981, with the work of the Club of Rome (Meadows et al., 1971) to the effects of using nuclear power (Turco et al., 1983) and Ozone depletion (Litfin, 1994) on global warming and climate change. These models seem to be more politically centred and similar to other categories, have their pros and cons. The models have succeeded in alerting the general public / raising awareness of environmental issues and have trigged a number of political and environmental policies. Nevertheless, they lack tangible concrete solutions to the sustainability crisis. The theoretical models make it difficult to manage uncertainty and as a result, give rise to a variety of opinions on their effectiveness. An example of that is the so-called climate change rejection (Nuccitelli, 2014).

2.5.5. Standardized Models:

The last category of sustainability models are the "Standardised Models". One of these examples includes: sustainability indicators. The United Nations provided 96 sustainability indicators (United Nations, 2007). The standardised models normally cover specific activities for example sustainable consumption or tools to measure sustainability (Hamilton, et al., 1997). Other models include ecological footprint (Rees, 1992) and National happiness (Brooks, 2008).

These models and indicators allow measurement of the performance of the system (Bell & Morse, 2008), they can accommodate a very specific local–global perception and the process of their development can be participating. Todorov & Marinova, (2009) argue that although these models attempt to measure sustainability or unsustainability, we have many other signs available to us which flawlessly resembles the present situation. Meadows et al., (1972) said and quoted from Meadows, (2000) "*We can learn at least as much about sustainability by turning our eyes away from numbers and noticing the soil washing down the streams, the clear-cuts where forests once stood, the changing climate, the smell of city air, the places on earth too contaminated to live in or too desperate to be safe in, and the hectic emptiness of our lives. Some day we may have numbers to measure these blatant signals of unsustainability. In the meantime we can admit that we already know*".

This acceptance of the problem needs a new way of thinking about sustainability as argued by Todorov & Marinova, (2009); they stated that we need to focus on the actual process itself rather than the external component and outcomes. With regards to this, the author agrees with Todorov and Marinova, (2009) however, this does not mean that the author considers all the above models as unimportant; they are useful tools and provide guidelines to improve sustainability at various levels and situations. Ultimately, however, we need a system which looks at processes and activities to offer a better stewardship role of sustainability; a model which can be used in all kind of environment and industries.

2.6. Triple Bottom Line: An Important Phenomena

As explained in the previous sections, the three overlapping circle model of sustainability is also referred to as the Triple Bottom Line. The Triple bottom line is stated to as "a brilliant and far-reaching metaphor" (Henriques, 2007, p. 26), the concept was coined by Elkington (1997). The term was not coined before the 1990s but is now well-known in environment quarters. TBL has been widely researched over the past decade as discussed by (Norman & MacDonal, 2004).

Elkington (1997) points out that TBL has integrated the economic and social aspects with the environmental agenda. The sustainability issue is very well explained by TBL because it not only connects with the environment but also with the economic and social parts of the society. Using economic, social and environmental lines, TBL offers organisations the opportunity to measure their performance as reported by (Geol, 2010). It is argued that TBL is a practical framework or system of sustainability (Rogers & Hudson, 2011). Many researchers believe that if any organisation wants to develop a sustainability system, they should follow the TBL. Hence, it could be argued that a consistent and balanced focus on the social, economic and environmental aspects is provided by the TBL agenda in which value will be created for organisations.

The three lines are explained below:

2.6.1. The Economic/Money Line

The impact of the organisation's business practices on the economic system is what is referred to by the economic line of the Triple Bottom Line framework. i.e. Profit and Loss system (Elkington, 1997). Economy is taken as one of the subsystems of Sustainability which will help the organisation survive, support future generations and do better in the future as a business (Spangenberg, 2005). In other words, there is a relationship between the growth of organisations, the overall economic growth of countries and the TBL framework. This relationship is affirmed by focusing on the organisation's economic value in the wider system (Sarkis and Dhavale, 2015). It is essential to keep a track of the profit and loss system from an economic point of view in order to ensure sustainability in the organisation.

2.6.2. Social Line:

Conducting beneficial and fair business practices to the human resources of the organisation is what the social line of the TBL is referring to. Elkington (1997) believes that social benefits should not just reach the direct human resources associated with the organisation but also to the wider community. For example, organisations should ensure that their employees and workers are receiving fair wages and working in healthy and safe environments. Organisations need to focus on giving back to their communities as part of their social responsibilities. Moulay et al. (2017: p. 59) stated that social sustainability denotes "*the development and growth suitable for the harmonious evolution of civil society.*

These foster a supportive environment for greater cohabitation of culturally and socially diverse groups by preserving the capacity of current and future generations to create healthy and livable communities".

Over history, many companies have witnessed several issues with integrating their social responsibilities within the wider goals of the organisation. For example, as reported by Dhiman (2008) the public voted against the establishment of a Home Depot in the Bay area of California during the civic elections in 2002 as it was perceived to have negative impact on the residents. Thus, as outlined by Geol (2010), the social element is very important in relation to addressing community involvement, employee relations and human resources.

2.6.3. Environmental Line:

Preserving the environmental resources for future generations is the core aspect of the environmental line of the TBL. In other words, it focuses on the need of protecting the environment by the efficient use of energy resources. It also puts much emphasis on the need to reduce greenhouse gas emissions and the ecological footprint (Geol, 2010). This is because environmental initiatives influence the sustainability of organisations as is the case of the social line.

A study by Kearney (2009) examined 99 sustainability-focused organisations across 18 industries in terms of their environmental impacts and how this associated with the organisational performance. Several industries were analysed which included retail, tourism, automotive, chemical, food and technology. The main question was whether companies can withstand an economic downturn if they are adopting sustainable practices. The selected organisations were all part of the Dow Jones Index. A three-month and six-month phase analysis was carried out. The study concluded that organisations which had practices that are geared towards protecting the environment and improving social well-being of the stakeholders were more capable of outperforming their peers financially. As explained by Kearney (2009), the financial performance was associated with reduced operational costs as well as increased level of revenues from innovative green products.

A study by Hidayati (2011) aimed to understand the extent to which the TBL approach is being adopted in the execution of corporate social responsibility programmes. Ho and Taylor (2007) used a quantitative approach on TBL reporting in which it evaluated how economic, social and environmental issues are reported within organisations.

2.7. Sustainability Efforts Made By Different Countries:

Different environmental agencies and governments put pressure on countries and organisations to work on sustainability development following worldwide focus. All developing and developed countries started working on systems which enabled a decrease in carbon emission, and they also started working on the economic and social side of sustainability (Galal and Abdul Moneim, 2016).

Developed countries such as Finland, Sweden, Denmark and Switzerland have had more than fifty years of industrialized activities and cutting down of rain forests and a huge number of trees all over their countries, which have caused the high accretion of greenhouse gases. However, developing countries such as Brazil, India, Pakistan and China are just emerging in the industrialized world and are regarded as not having contributed much to the accumulated greenhouse gases. Through industrial growth, these countries have now started to pile up the gases in the environment, which is a cause for concern. (Daioglou, et al. 2012). The UNFCC therefore placed a restriction on the emission of greenhouse gases of the developed countries while the developing countries were not placed under any mandatory obligation but were encouraged to access better technology in order to curb their emissions. Following the industrial revolution in developing countries, the obligations and rules have been forced on them also. (Liu et al., 2012).

2.7.1. Efforts made by Switzerland:

After being accused by International agencies of doing too little to prevent the erosion of rain forests and the environmental damage this causes, Switzerland was the first country to officially start work on sustainability. It worked on all the three fronts previously defined i.e. environmental, social and economy. Almost all the standards and policies, which are in effect right now were first introduced in Switzerland. All the industries operating inside Switzerland are obliged to work under the defined set of rules regarding environmental, economic and social sustainability, in order that the country follows UN agencies and partner rules (Theurillat and Crevoisier, 2014).

2.7.2. Efforts made by United States of America:

The responsibility on the shoulders of United States of America regarding sustainability is highest because of their stature in the world. They not only have to put effort into ensuring sustainability in their own country but also to make sure that other countries are doing so too (Lynch and Mosbah, 2017). According to Huang and Wang, (2013), the USA has done a very good job with this responsibility. They have not only made efforts in their own country but have also made huge investments in other countries to ensure sustainability in their countries. Their support has been technical as well as financial.

2.7.3. Efforts made by other European Nations:

Countries like Germany, UK, France, Spain and Portugal are also working on all the three parts of sustainability. They have contributed towards many sustainability systems and standards which are currently in use around the world (Antonova, 2016). Countries like the UK and France have also helped developing countries financially so they can accelerate the adoption of good practices.

2.8. Environmental Sustainability

Goodland, (1995) claims that environmental sustainability definitions should be left to environmentalists, economic sustainability to economists and social scholars to define social sustainability. He described environmental sustainability as the protection of raw materials and sources required to satisfy people needs. He implies that people must not make more waste than the environment can handle and that people's consumption should contemplate and give emphasis to sustainability. Bracho (2000) stated that the numerous concerns that occur with global warming have intensified the type of attention offered to environmental sustainability. These severe consequences include various weather changes, floods, increased heat, drought and famine, amongst others, which will cause disturbance for economic activities and lead to food shortages.

Another significant issue is the depletion of oil reserves. According to forecasts from the International Energy Agency (IEA, 2012), the growth of the world economy will increase by 60% in the next 20 years. In parallel, geological studies estimate that global oil product will reach its peak around the year 2020 and from then on, it declines to the point of depletion (Bracho, 2000). According to Bracho, (2000) one way to avoid this is by the development of renewable alternative sources of energy. Consequently, the public claim in the conventional oil world is that the problem in the future will not be a lack of demand but shortage of oil supply. Oil companies around the world use this declaration to defend investment and favourable treatment. But this conservative understanding should be confronted and challenged. Others such as Skjærseth & Skodvin, (2003) recognise the concerns and add that petroleum companies should do something towards both the depletion of oil and the reduction of environmental impacts. This opinion is shared by George et al. (2016: p. 197) who believe that the "*social and environmental impacts of the petroleum industry have serious consequences and call for sustainable solutions and practices. Embedding sustainability into organisations is vital to address these issues, and requires the integration of sustainability into performance management systems*".

Parry (2007) highlights that the climate change issue has become highly visible and the goals and agreements offered by the Kyoto Protocol are seen by many, especially by the developing countries as insufficient. Thus, there is a crucial need to develop more rigorous principles to limit the exploitation of the environment by humans. In reality, the means of doing this has challenged people. It appears that no country is ready to abandon its economic well-being for the environment (Yahaya et al, 2012). Countries such as Libya and Venezuela are heavily dependent on their petroleum industries and any reductions of the demand will negatively impact their economies. Therefore, one way to reduce the environmental sustainability issues and improve performance is by ensuring companies are responsible for their own environmental degradation and must apply effective sustainability systems.

Yahya et al, (2013) stated that social sustainability is a means of achieving economic and environmental sustainability. Goodland and Daly, (1996) argue that social sustainability can only be achieved by the systematic community participation and strong civil society. They add that social sustainability puts an emphasis on “moral capital” which is concerned with diversity, sodality, a sense of community, humanity, love, patience and honesty. It is also concerned with the political and economic rights of people, socially conscious, corporate governance structures, human development and labour rights (Meyer, 2000). Economic sustainability, in contrast, is concerned with the “maintenance of capital”. Economic sustainability focuses on using the various assets of the enterprise efficiently to let it to continue functioning profitably over time. This is clearly different from environmental sustainability, which is concerned with the protection of the ecosystem and the preservation of natural resources (Serageldin et al, 1994). In other words, environmental sustainability focuses on "maintaining natural capital". This research mainly focuses on the environmental pillar of sustainability in the Libyan petroleum sector, however economic and social dimensions are also considered to some extent.

Morelli, (2011: p. 23) defined environmental sustainability as "*a condition of balance, resilience, and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity*".

2.9. Sustainability in the Context of Petroleum Industry

Words and phrases like green, sustainable, ecological, renewable, conservable and environmentally conscious may have clear meanings in different contexts and situations, but in others, their meanings and implications are complex like in the oil industry. Oil companies realise the importance of adopting sustainability practices due to pressures from various groups and as reported by USGS (2000). However, there is limited understanding of how sustainability can be incorporated into these organisations' policies and strategies.

Sustainability as understood in the above sections means that it is a "forever" term. However, in the context of petroleum industry knowing that oil and natural gas are non-renewable resources which are set to run out some point in the near future, sustainability is more of an abstract term; it is hard to imagine the petroleum industry can ever be fully sustainable. However, for many scholars (i.e. Bartlett, 2012) the term sustainability in the context of petroleum industry does not mean "forever". Rather, sustainability means more correctly as "an approach of doing business" or "an approach of doing business in the best possible way". Bartlett, (2012) provided a business definition of sustainability which conceptualises it as a means of "*linking business decision-making to ethical value, legal compliance and respect for people, communities and the environment and at the same time, meet shareholders expectations*".

Bartlett's definition appeals to the author as it is more practical and achievable in the context of the petroleum industry. However, there is a vagueness of how to balance the expectations of shareholders and the business goals with environmental protection, legal compliance and social welfare. This seems to be the key challenge of incorporating sustainability principles in this industry. Therefore, the author considers this definition as valid and the basis of this research, however, the research will investigate ways to address the gaps this definition leaves.

The World Commission on Environment and Development, (1987) defined sustainable development as "*meeting the needs of the present without compromising the ability of the future generations to meet their needs*". It could be argued as noted in the literature review, that oil companies find it difficult to differentiate between the concept of being "sustainable", "green" or "environmentally conscious" (Silvestre et al. 2017). Oil companies can use the above definition of sustainability to evaluate their current business strategies as it encourages them to preserve the resources for future generations as well as reducing their environmental impacts.

It is commonly argued in the literature that oil companies should focus on the need of integrating sustainability within their corporate strategy as well as developing and promoting sustainable policies across the different levels of their operations. This will help oil companies achieve sustainable growth and development especially when it comes to minimising the environmental impacts of their operations. However, Silvestre et al. (2017) complained about the excessive emphasis put on the environmental pillar of sustainability, while neglecting the other two pillars. Silvestre et al. (2017: p. 361) argued that the oil industry "*tends to see sustainability largely through the lens of environmental concerns and initiatives. This tendency limits the sustainability discourse and the perception of what sustainability truly is, creating confusion and misleading impressions that an operation, organisation, or supply chain is sustainable, while in reality the social dimension has not been seriously considered*". This suggests that industries have other responsibilities towards nature and society, which they need to fulfil in order to be successful and sustainable.

Corporate social responsibility (CSR) is considered to be synonymous with sustainability as it includes balancing economic, environmental and social considerations into decision-making processes.

"CSR is defined as the continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society" (Crane, et al. 2013).

CSR and sustainability have developed to be significant universal notions in global discussions and have been well debated and at times followed up through numerous initiatives by shareholders in the developed world (Szczuka, 2015). In the developing economies, despite the increasing concerns of the issues, the level of debate varies from one region to another and one country to another. Hence CSR has extended to contain not only traits of business conduct that impose on environmental, social and economic issues, but also the role of the corporate in regard to poverty reduction in the developing world (Prieto-Carron et al. 2006). It is clear that for various reasons, such as environmental scandals, globalisation, environmental issues, human rights issues, global warming and climate change, petroleum companies are 'top of the list' for upsetting public confidence in sustainability and CSR discussions. Thus, companies are "*under intense pressure to rebuild public trust and stay competitive in a global economy*" (Jamali, 2007: p. 1).

Sustainability and CSR are no doubt growing in the developing world, however, these concepts vary from country to country and region to region (Eweje, 2011). In Libya, Libyan petroleum corporations lack sustainability and CSR in their agenda (Attah, 2010). This research considers that the sustainability concept includes a business approach to optimise and improve environmental, social and economic aspects in a balanced way. The sustainability goal is not about unrealistic and unachievable goals such a zero emissions, but it is about the process of making sustainability improvements continuously and wherever possible improve the welfare of local communities.

Despite the different understandings of the term sustainability and sustainable development and the debate concerning the ambiguousness of the term, it is generally agreed that in order for businesses to be sustainable, they need to optimise their activities and processes in respect of the economy, society and the environment (Rodger and George, 2017). This research focuses on the latter namely “environmental sustainability”. However, it will still consider economic and social pillars to some extent.

The definitions of environmental sustainability as provided by the Brundtland report, Goodland, (1995) and Morelli, (2011) are all considered valid for this research. In other words, to be environmentally sustainable and safeguard the environment, businesses and in particular, petroleum companies need to minimise environmental impacts and wastes, seek zero air emissions, increase energy efficiencies, promote sustainable power generation.

2.10 The Challenges of Sustainability

The petroleum industry is debatably the most vital industry to the world’s economy (Hatler 2011). Oil and gas products are no doubt the main energy supply of the world and this is expected to last for several decades (Longwell, 2012). Petroleum companies must go through various economic risks as they participate in investments of new exploration agreements and run large and complex plant (Junior et al. 2017). This means that petroleum corporations have to consider how their environmental performance relates to their financial and strategic performances. Stead and Stead (2008, p. 6) defined strategic management in the context of sustainability as the "*processes that are economically competitive, socially responsible, and in balance with the cycles of nature. Whereas in traditional strategic management, the term, sustainable, is typically used in reference to a firm’s ability to continuously renew itself in order to survive over the long-term, we’re taking a more comprehensive global view of the term, referring not only to the survival and renewal of the firm itself, but also to the survival and renewal of the greater economic system, social system, and ecosystem in which the firm is embedded*".

Moreover, sustainability and corporate social responsibility related issues such as climate change, energy policy, ecosystem protection, emissions, social welfare and human rights are becoming the key debated and discussed challenges (Hatler, 2011; Goldemberg, 2000). This is due to recent rises in consumer awareness of sustainability issues, as well as intervention from governments, NGOs and other stakeholders. They refer to these concerns under general terms of “sustainability” or “CSR” and are requesting that corporations display and report their activities and progress towards dealing with these critical challenges (du Plessis & Grobler, 2014).

There is no doubt that the petroleum industry around the world faces major sustainability challenges (Jafarinejad, 2017). However, they have been widely criticised that they are not doing enough to enhance their practices. For example, Schweitzer (2011) has conducted a review study into three large petroleum companies namely BP, ExxonMobil and the Royal Dutch Shell. These three are considered the largest oil and gas corporations in the world. The author has carried out an intensive review into the companies’ sustainability reports to investigate whether the companies support the sustainability agenda and the increasingly “green” rhetoric. The author used word count analysis for the companies’ annual reports, operational data, expenditure statements, and corporate reports to clarify what each corporation is declaring and actually doing.

The findings of her study suggest that although there are slight differences in what each corporation does and declares, each corporation seemed oddly similar. She states that the similarity of their practices was due to external pressures including press coverage, government legislation, advocacy campaigns, participation in trade associations and the use of new technology. Interestingly, just one single disaster in one of these companies could have a significant impact on the whole industry.

It is important to understand that the statements of an organisation does not necessarily reflect their action, this goes well with the petroleum giant companies as discussed by (Pulver, 2007). Petroleum companies especially the ones originated in the developed world might have initiated programs to minimise their emissions and waste, but this does not mean that their products and corporate decisions are sustainable as they assert. This is considered to be “green-washing”. According to a New York environmentalists, Jay Westeveland, “greenwashing” is a term created to refer to the deceptive use of marketing where companies dishonestly claim that their policies, products and operations are sustainable and environmental friendly (Sullivan, 2009). Oil companies such Exxon mobile, Shell and BP are accused of green-washing (Schweitzer, 2011).

On the other hand, these companies have been praised for their growing interest and focus onto environmentally and socially conscious aspects of their strategies. One of these aspects is oil companies' investment in renewable energy sources. In regard to BP, Shell and Exxon Mobile, part of their strategy is to transform their companies to be sustainable. Renewable energy investments have already been made by several oil and gas companies. Renewable energy sources include wind, solar, tidal and geothermal heat. These types of energy sources are considered clean to the environment and sustainable in that they do not deplete and are able to be regenerated (Hussain et al. 2017). Unlike non-renewable energy such as oil, natural gas and coal.

Despite the fact that renewable sources are excellent options from an environmental impact and emission point of view, there are major barriers associated with their utilisation which stands as an obstacle for petroleum companies to become a key player in renewables investment. One of these barriers is the fact that renewable energy at its current capacity cannot offer sufficient energy supply for even a small percentage of the global energy demand (Lucas et al. 2017).

Another obstacle is the economic feasibility of renewable energy programs and projects. According to Schweitzer (2011), renewable energy investment is deemed not profitable in the short or medium term. For a greedy petroleum corporation, profitability is the ultimate goal for the business and this therefore conflicts with their business goals. Therefore, this identifies other corporate social responsibility issues and business culture which requires change. To be fair, the three giant petroleum companies mentioned above have been making reasonable growing investments into renewable energy sources, but the implications of these investments remain unclear.

Petroleum companies in the developing world and in particular the Libyan petroleum companies, have made minimal investments in renewable energy. In fact, they are not even making sustainability reports of their activities and operations. Thus, it could be assumed that it is the time for the Libyan National Corporation and its associated companies to show serious intent in enhancing their sustainability performance and apply sustainability systems.

Business culture and history is believed to be an influential factor on the business activities as discussed by Leung et al (2005). In order to understand the petroleum companies' statements and actions, it is important to consider the historical root of each company individually and we should not generalise the statements and actions of one specific corporation to the whole industry. Although the structure and the business of each company is similar, the historical background of each could influence the perspectives on sustainability matters of each company. For example, the big petroleum corporation ExxonMobile, has experienced numerous changes in the previous decades, most recently a union between Mobil and Exxon in 1999 (Yergin, 2008). Similarly, BP has gone through various changes in the past years; it originates in the United Kingdom and according to Yergin, (2008) BP today is a result of a 2000 merger of Arco, Amoco and British Petroleum.

2.11 Petroleum Industry Sustainability Impacts

Petroleum operations (upstream, midstream and downstream) have various environmental impacts (Ahmad et al. 2016). These impacts are dependent on factors such as the size of the project, the process, the sensitivity and nature of the project and most importantly, the effectiveness of planning, control techniques, pollution prevention and mitigation measures considered before the project (Ahmad et al. 2016). Oil and gas activities have impacts on huge areas of the land and sea. This applies to all stages from exploration activities, oil and gas field development to well drilling, production and decommissioning. The Petroleum industry requires a huge expansion, large infrastructure and operations onshore and offshore, in addition to a great amount of drill cuttings being discharged to sea and land.

This section will review the potential impacts associated with the petroleum industry according to the United Nations Environmental Program (UNEP, 1997). It is important to note that these impacts with proper attention and care, could be minimised or even avoided. These impacts are classified by their type and namely are: 1) human, socio-economic and cultural impact; atmospheric impacts; aquatic; terrestrial and biosphere impacts.

2.11.1. Human, Socio-Economic and Cultural Impacts

Oil and gas operations are likely to encourage cultural, economic and social changes. These changes mainly impact the local people in which the projects occur. It may affect their traditional lifestyle. The crucial impacts include:

- Impacts on land, agricultural, fishing and hunting (for example land-take and exclusion) or by affecting access routes and changes to physical land.
- Population level change, the petroleum operations will lead to labour immigration and other immigration from remote areas due to enhanced resources and opportunities
- Socio-economic changes due to new jobs.
- Socio-cultural impacts such as practices, beliefs.
- Access to services and goods, and the availability of these resources such as healthcare, housing, fuel, electricity etc.
- Transportation due to increased movement (i.e. roads, sea and air).

There are also some positive changes that will occur due to these projects. These might include infrastructure improvements, waste treatment, water supply, education, health care and sewerage. There might be issues that arise due to the uneven distribution of such improvements leading to random consequences.

2.11.2. Atmospheric Impacts

Air emissions are one of major impacts gaining wider attention and publicity globally. This is due to the direct influence of emissions to increase global heat, global warming and climate change. International community, governments and industries are all trying to find methods of minimizing atmospheric impacts. Petroleum companies are expected to minimize their emissions. It is important to understand the key sources of these impacts, which are:

- Flaring and venting
- Exhausts from combustion processes (heavy duty diesel engines, gas and steam turbines etc.)
- Fleeting gases from process equipment, loading and tankage activities.

The main content of these emissions include carbon dioxide, carbon monoxide, organic carbon, methane and nitrous oxides. There is a possibility of emissions of sulphur dioxides and hydrogen sulphide depending on the sulphur content of the crude oil, especially when used as a diesel fuel. Furthermore, ozone depleting substances are used in some fire protection systems, principally halon and as refrigerants. Flaring produces the highest emitted gases especially in the areas where there is no infrastructure.

2.11.3. Aquatic Impacts

Aquatic impacts vary throughout the oil and gas operation streams but generally they include:

- Chemicals, well treatment substances, drilling fluids and muds.
- Leakages and spills,
- Cooling and produced water
- Drainage water, wash and process water.

Similarly to emission, the scale of these impacts is dependent on the amounts of waste created at each phase of the project. It might be high at the initial stages of the project, mainly the upstream operations and will decline at the mid and downstream activities.

2.11.4. Terrestrial Impacts

These are soil and land related impacts which according to UNEP (1997) occur from three major sources:

1. Physical disturbance as caused by construction;
2. Contamination caused by leaks, solid waste and spills.
3. Other impacts due social change.
4. Poor design and planning could lead to soil contamination.

These impacts negatively affect the environment especially plants, agriculture and land farming.

2.11.5. Potential Emergencies

Petroleum operations by their nature are accompanied by high risk from the early stages of upstream operations to the last stages of downstream activities of sales and distribution. Therefore, there are potential emergencies along the way which must be risk assessed, prepared for and key measures of mitigation taken. Some of these potential emergencies include:

- Spills of crude oil, fuel, gas, chemicals and other dangerous materials.
- Oil/gas well expulsions
- Blowouts
- Fires for facilities and near by
- Un predicted plants upset and shutdown
- Natural disasters (i.e. floods, hurricane, earthquakes, lightening, wars etc)

The environmental impacts shown above are just a snap shot of the categories and classifications associated with oil and gas operations. These impacts are harming the environment, adding more risk to global warming and climate change.

Governments and organisations are starting to integrate sustainability issues into the business management framework under a variety of terminologies such as Sustainability strategy, environmental management strategy and corporate Social responsibility (CSR) strategies (D'Amato et al., 2009). Furthermore, industrial sectors including petroleum companies have responded differently. One of these major reactions is that companies initiate or implement sustainability management system in an attempt to improve their sustainability practices. The following section will review the major sustainability related systems that are used to deal with sustainability issues and environmental impacts.

2.12 Sustainability Approaches and Technologies

In response to the sustainability issues and challenges, and with the pressures from United Nations, governments, legislations, NGOs and most importantly the consumer, organisations are starting to develop and implement methodologies, system and approaches in order to enhance their sustainability practices. These approaches vary in the methodology, effectiveness and validity according to Singh et al., (2009). This section aims to review the relevant sustainability approaches and system to the petroleum industry. The goal is to establish an understanding of these approaches, their merits and limitations according to the literature. It is important to note that throughout this thesis the author refers to sustainability, environment interchangeably. However as clarified, sustainability includes three pillars (the environment, economy, and society). Therefore, in order to be sustainable, an improvement and balance among the three must be created. It was also clarified that the main focus of this research is towards the environment pillar of sustainability, so whenever the term sustainability is used, it basically refers to the "environmental sustainability".

There are many different sustainability and environmental management systems which are commonly implemented by organisations, but the most popular are: the Environmental Management system (ISO 4001); the Eco-Management and Audit Scheme; and the British Standards BS 8555. Other technological and practical sustainability approaches such as the Environment Impact Assessment (EIA) and Life Cycle Assessment (LCA) are also popular.

2.12.1 Environment Management System

Environmental Management System is a structured framework for managing organisations' environmental impacts. Granly and Welo, (2014: p. 196) explained that EMS is the "*part of an organisation's management system that is used to develop and implement its environmental policy and manage its environmental practices. Through a formal EMS, companies are guided in their efforts to systematically identify and manage environmental practices while communicating their environmental commitment to corporate stakeholders*". It is a structured tool which, once implemented, helps a firm to identify the environmental impacts resulting from its business activities and to improve its environmental performance (Australian Government 2004). It offers a methodical approach to planning, implementing and reviewing firms' environmental management (Pun et al., 2002).

It is believed that aligning EMS with existing organisational systems is more effective (McDonald et al., 2003). The environmental aspects of any firm are all of its products, services and activities that have an environmental impact. EMSs enable firms to identify, control and minimise these impacts (Melnyk et al., 2003).

It is argued by Melnyk et al. (2003) that the key purpose of an EMS is to develop, implement, manage, coordinate and monitor corporate environmental activities to achieve two goals: legal compliance and waste minimisation (Sayre, 1996). For an organisation, compliance merely means attaining the essential legal requirements for suitable environmental impact levels which is driven by the desire to evade legal issues and penalties. For instance, the inability to fulfil the legal standards could lead to amplified costs (fines), bigger outside interference in daily operations, and, in risky situations, issuance of cease orders.

Undoubtedly, environmental impact reduction goes beyond legal compliance and focuses on organisation's activities to dramatically decrease negative environmental impact. Though the idea of EMS pre-dates the acceptance of the ISO 14001 EMS standard, scholars paid slight consideration to the study of these systems. It was not until 1996, that the International Organisation for Standards (ISO) published the standard and related guidance books (Melnyk et al., 2003).

There are two key orientation standards that set requirements for an EMS; the ISO 14001 established by the International Organisation for Standardization (Rino and Salvador, 2017); and the Eco Management and Audit Scheme (EMAS) controlled by the European Regulation EC 1221/2009 (Testa et al. 2014). The two approaches have been very successful due to their flexibility which eases the process to set up and adapt an EMS based on the internal features and to recognise the best solutions to enhance their performance. The two EMS standards are investigated in more detail.

2.12.1.1 ISO 4001

The International Organisation for Standardization designed the Environmental Management System ISO 4001 in 1996 with the intent to reduce environmental business impacts, facilitate trade and reduce trade issues as well as raising expectations for environmental practices worldwide (Melnyk et al. 2003). ISO believes that organisations can meet these expectations if they properly implement ISO 14001 (Ferrón-Vílchez, 2016).

Since its introduction, ISO 14001 has been adopted by organisations all over the world. The areas which are encompassed include auditing, performance evaluation, life cycle assessment, product standards and labelling (Tibor and Feldman, 1996). Two general categories were proposed by Tibor and Feldman when it comes to environmental management as shown in figure 2.5. Figure 2.5 illustrates the categories which shape the standards. The first category deals with the organisation evaluation. This category deals with evaluating the environmental performance of the firm and the auditing practice. The continuous evaluation and auditing helps ensure that the EMS implementation is successful. The second category deals with the product and process evaluation. It includes the life cycle assessments and environmental labelling. The key focus is on the product and process characteristics.

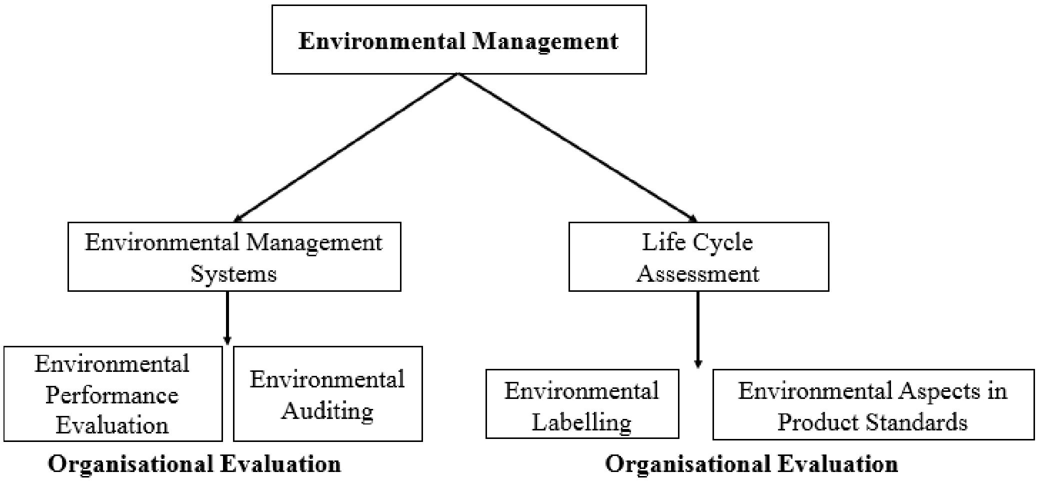

Figure 2.5: ISO 14001 and environment management systems (Source: Tibor and Feldman, 1996)

Melnyk et al. (2003) state that EMS includes a set of practices and procedures whose aim is to enhance the environmental performance of the firm. These involve the training of employees, monitoring, evaluating, summarising and reporting the performance information to the internal and external holders of the firm. The EMS requires detailed documentation of environmental information which is used to minimise and reduce environmental impacts and enhance the environmental performance. The focus internally is on the design, pollution and emissions control and minimisation, waste reduction reporting to top management and setting goals. EMS is also used to communicate the environmental data of the firm in a form of annual reports to demonstrate transparent responsibility which therefore enhances corporate image.

It is argued by Brandli et al (2009) that EMS and in particular the ISO 4001 is an essential business function in order for the business to attain competitive advantage and comply with international environmental legislations and standards. This is due to the fact that ISO 4001 has been proved effective in allowing the firms to reach goals of enhanced environmental and corporate performance. ISO 4001 certification is seen as an essential means of gaining and sustaining a competitive advantage (Tibor and Feldman, 1996) and (Sayre, 1996). The standards are set for basic and structural elements of an EMS and enable management to:

- Establish an environmental policy suitable for the firm

- Aid the planning, implementing, regulating and controlling to ensure the policy is followed and appropriate for the firm
- Identify the regulation and law requirements that need to be met.
- Create a program for implementing the policy and the environmental goals.
- Develop management and employee commitment to the stewardship of the environment.
- Support the environmental planning throughout the firm's departments and activities
- Offer training and resources to achieve the required performance levels on a continuous basis.
- Create a management procedure to review and audit the EMS and to recognise opportunities for enhancement of the system and subsequent environmental performance.
- Start and keep suitable communications with relevant internal and external parties (Bernardo et al. 2015)

The ISO 4001 Environmental management standards focus on minimising impacts to the environment, pollution prevention. It also focuses on incorporating continuous improvement culture and uses the PDCA cycle. EMS can allow savings in input and energy consumption and increase demand among environmentally sensitive consumers (Miles and Covin, 2000). The number of ISO 14001 certificates has risen to 285,844 (see ISO, 2013). Research shows that the implementation of the standards is very beneficial and has a significant positive impact on the business performance (Braun, 2005; Mendel, 2006).

Despite the fact that ISO 4001 is totally voluntary, the increasing awareness of consumer of environmentally friendly products, make it a compulsory measure. There are many benefits of the standards as analysed by many scholars such as (Link and Naveh, 2006; Zaramdini, 2007; Gavronski et al., 2008; Singh, 2008). Table 2.2 shows the benefits arising from ISO 4001. Scholars have used various proposed classification of benefits such as operation and financial performance (Naveh and Marcus, 2004; Briscoe et al., 2005), internal and external benefits (Casadesús et al., 2001) and many other classifications.

Table 2.2: ISO 4001 benefits according to Bernardo et al. (2015: p. 262)

Benefits	**ISO 14001 studies**
Efficiency (productivity, cost savings, reduction in mistakes and rework, shorter lead times, improved management control)	Singels et al. (2001), Gotzamani and Tsiotras (2002), Pan (2003), Arauz and Suzuki (2004), Lo and Chang (2007), Martínez-Costa et al. (2008), Singh (2008).
Improved customer satisfaction (reduction in complaints, etc.)	McAdam and McKeown (1999), Singels et al. (2001), Gotzamani and Tsiotras (2002), Pan (2003), Arauz and Suzuki (2004), Casadesús and Karapetrovic (2005), Lo and Chang (2007), Zaramdini (2007), Martínez-Costa et al. (2008), Singh (2008)
Improvements in employee results (motivation, satisfaction, teams, communication, knowledge)	Arauz and Suzuki (2004), Casadesús and Karapetrovic (2005), Rodríguez-Escobar et al. (2006), Lo and Chang (2007), Zaramdini (2007), Martínez-Costa et al. (2008).
Profitability	Corbett et al. (2005), Lo and Chang (2007), Zaramdini (2007), Benner and Veloso (2008), Martínez-Costa et al. (2008).
Improvement in systematization (improved documentation, work procedures, clarity of work, improvement in responsibilities)	Gotzamani and Tsiotras (2002), Rodríguez-Escobar et al. (2006), Lo and Chang (2007), Singh (2008).
Market share	Rodríguez-Escobar et al. (2006), Lo and Chang (2007), Zaramdini (2007), Singh (2008).
Sales and sales growth	Arauz and Suzuki (2004), Casadesús and Karapetrovic (2005), Corbett et al. (2005), Singh et al. (2006).
Improved image	Terziovski et al. (1997), Lee (1998), Magd and Curry (2003), Lo and Chang (2007), Zaramdini (2007).
Exports	Magd and Curry (2003), Arauz and Suzuki (2004), Singh et al. (2006)
Improvement in competitive position/competitive advantage	Abraham et al. (2000), Rodríguez-Escobar et al. (2006), Singh et al. (2006), Lo and Chang (2007), Zaramdini (2007).
Improved relationships with suppliers	Gotzamani and Tsiotras (2002), Casadesús and Karapetrovic (2005), Rodríguez-Escobar et al. (2006), Zaramdini (2007).
Improved quality in product/service	Gotzamani and Tsiotras (2002), Magd and Curry (2003), Zaramdini (2007), Singh (2008).
Improved relationships with authorities and other stakeholders	Pan (2003), Magd and Curry (2003).
Environmental performance	Yin and Schmeidler (2009), Russo (2009), Gavronski et al. (2008), Barla (2007), Zeng et al. (2005), Tan (2005), Potoski and Prakash (2005).

In summary, according to the study conducted by Bernardo et al. (2015) which reviewed 59 research studies on the ISO 4001, the key benefits are classified into internal and external benefits.

INTERNAL BENEFITS

Internal benefits are the outcomes of the ISO 4001 implementation and include:

1. **Global organisation**

The benefits of the ISO 4001 implementation has been proved to increase the efficiency of the organization as well as enhancing organisational culture and continuous improvement. It provides a more efficient and easy communication system in addition to reductions to resource costs (time, human and financial). These benefits lead to improved risk management and competitive market management.

2. **Human resources**

The benefits to employees includes increased and enhanced training, increased awareness of the significance of employee contributions to the organisation and consequently enhanced staff empowerment. This also leads to increases in employees' motivation and productivity.

3. **Performance**

The EMS system enhances the environmental performance of the organisation in addition to other external improvement such as higher quality products, efficient use of resources and improvement productivity.

4. **Management systems**

ISO 4001 frameworks improve the management system for an organisation making the system more systematic and integral with good planning phases which incorporates environmental goals. This leads in the avoidance of duplication in policies and procedures. Efficient documentation and recordings also lead to generating sufficient data which could be used to improve the business further.

5. **Audits**

The ISO 4001 frame work enhances the audits as ISO 4001 is a flexible standard providing better definitions of management responsibilities.

EXTERNAL BENEFITS

There are external benefits confirmed by (Bernardo et al. 2015: p. 262) which include (1) enhance corporate image and reputation; (2) satisfied related stakeholders and partners; and (3) integrated external audits.

On the other hand, EMSs in general and ISO 4001 has received criticism from various scholars concerning their effectiveness in improving the environmental performance (Yin and Schmeidler, 2007; Morrow and Rondinelli, 2002; Link and Naveh, 2006). For instant, Maier and Vanstone (2005) state that ISO 4001 is an efficient framework for organisation to apply as it has various managerial and operation benefits; yet, in regard to the environmental performance it is an inadequate system due to the fact it gives organisations the flexibility of establishing realistic environmental objectives.

Potoski and Prakash (2005) claim that ISO 4001 certified companies aren't necessarily environmentally friendly as the certification procedure is general and easy to justify. There is no doubt that ISO 4001 is a useful framework for organisation to improve their management procedures and activities, yet in order to attain environmental sustainability goals, there is a need for a specific and inclusive sustainability system which integrates and deals with each business industry and focuses mainly on environmental sustainability impacts.

In the context of the Libyan petroleum sector, it is noted that the Libyan petroleum companies lack the implementation of ISO 4001. In fact, according to the International Organisation of Standards (ISO, 2013) only a total of 15 Libyan companies have successfully gained ISO 4001 certification (see Figures 2.6 and 2.7) and most of these are food and other industrial companies.

Figure 2.6: World Distribution of ISO 14001 certifications in 2013 (Source: ISO, 2013)

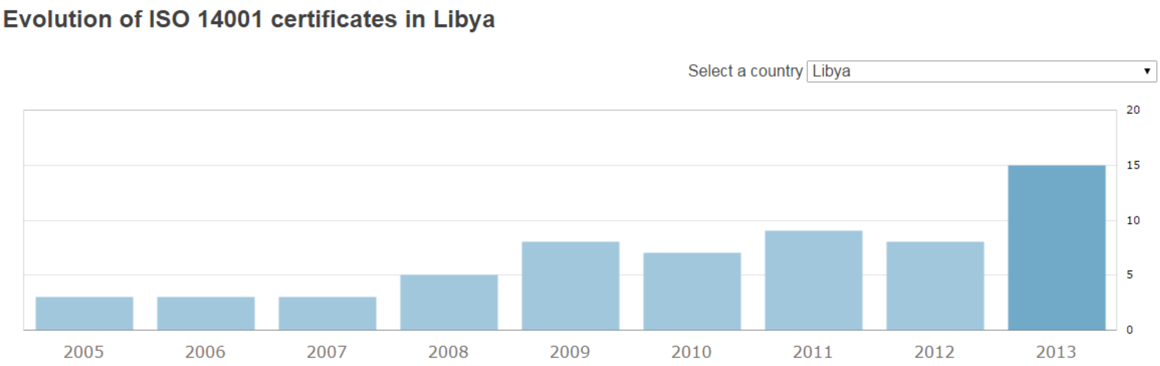

Figure 2.7: Evolution of ISO 14001 certificates in Libya (Source: ISO, 2013)

To & Lee, (2014) show that the number of ISO 4001 certifications increases gradually every year in the rest of the world, with Europe and the Far East having the highest percentage of ISO 14001 implementation. In 2007, the Far East exceeded Europe and since then has been the leading operator of ISO 14001 certification.

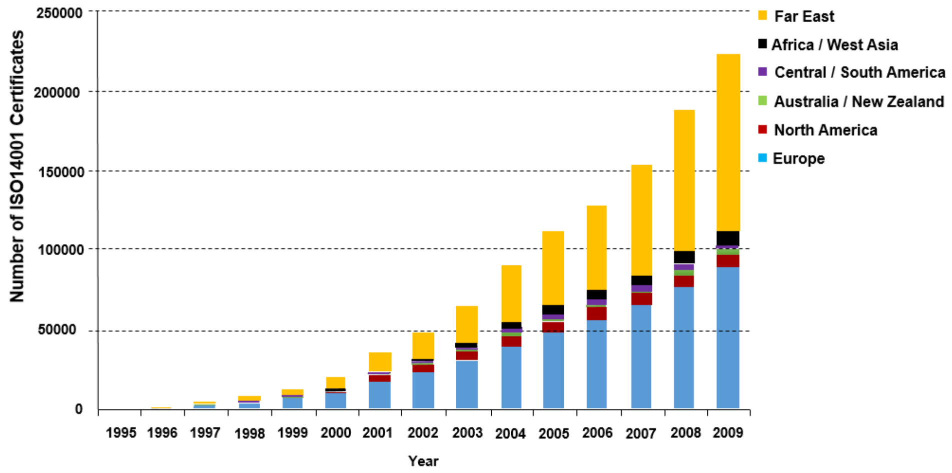

Figure 2.8: The number of ISO 14001 certificates issued from 1996 to 2009 (To & Lee 2014)

There is a clear difference between the implementation and certification of ISO 4001 in the developed world compared to the developing world and Libya in particularly. Libyan companies in general and petroleum companies specifically need to start implementing environmental management systems as the benefits it offers to organisations is significant. However, it is known that the lack of implementation has many explanations. Some studies, such as González, (2004) investigated this and concluded a number of reason which include the bureaucratic work and the costs associated to the certification, the lack of time, and the difficulty of dealing with environmental aspects and with EMSs. In addition, resistance to change, lack of information and technical knowledge in the implementation were also demotivating factors. Libya lacks the investigative research to identify the key causes of extreme lack of implementation; which is partly addressed by the author in this study.

2.12.2. Life Cycle Assessment (LCA)

Increasing environmental awareness has led many industries and organisation to use assessment and management tools for their environmental activities (Mazzi et al. 2017). Consumers are increasingly aware of sustainability issues such as global warming, weather changes and resources depletion partly due to increased press attention. Many well informed organisations have responded by attempting to provide cleaner and greener products and processes. Environmental sustainability became a chief issue which led organisations to look for systems and tools to measure their impacts. Businesses have found that it is effective to look for techniques to move beyond compliance and environmental management systems to enhance qualitatively their environmental sustainability performance.

One of the tools for assessing quantitatively environmental sustainability impact is Life Cycle Assessment method (LCA). Life Cycle Assessment (LCA) is a method used to evaluate the potential impacts on the environment of a product, process, or activity throughout its life cycle (Gillani et al, 2010). The LCA analysis considers all of the life cycle stages of the product from raw material extraction, materials processing, manufacture, distribution, use, maintenance through to disposal or recycling. In other words, it embraces the "cradle to grave" approach to analysis (Mazzi et al. 2017). The tool allows estimation of the environmental impacts resulting from all life cycle stages such as transportation, raw material extraction, and the end of life disposal. The evaluation of the impacts is carried out throughout all stages which enables a realistic comprehensive view of environmental aspects of a "process" or "product" to enable efficient and well informed decisions and product trade-offs.

The most accepted and repeated definitions of LCA are:

1. The Society of Environmental Toxicology and Chemistry defines Life Cycle Assessment as follows*: "The life cycle assessment is an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and material usage and environmental releases, to assess the impacts of those energy and material uses and releases to the environment, and to evaluate and implement opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process, or activity, encompassing extracting and processing raw materials; manufacturing transportation and distribution; use/re-use/maintenance; recycling, and final disposal." (Consoli et al, 1993)*
2. ISO 14040 defines Life Cycle Assessment as follows*: "LCA is a technique for assessing the environmental aspects and potential impacts associated with a product by:*
    - A. *Compiling an inventory of relevant inputs and outputs of a product system;*
    - B. *Evaluating the potential environmental impacts associated with those inputs and outputs;*

C. *Interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.*

LCA studies the environmental aspects and potential impacts throughout the product's life (i.e. cradle to grave) from raw materials acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences" (ISO 14040; 2006). The International Standards Organisation (ISO 14040, 2006) provides a four phase methodology for LCA (See Figure 2.9). The specific standards are; (ISO 14040: Principles and framework); (ISO 14041: Goal and scope definition and inventory analysis); (ISO 14042: Life cycle impact assessment) and (ISO 14043: Interpretation). The four phases of LCA are explained below.

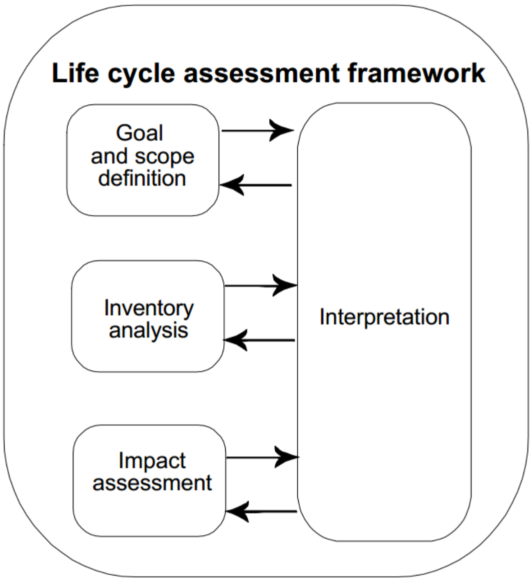

Figure 2.9: LCA framework (ISO 14044:2006)

- **Goal and scope definition Phase**

The goal and scope phase of LCA focuses on establishing the purpose of the LCA and determine the system boundaries and functional unit. It is very important to define the LCA study requirements in this phase including all of the relevant information such as how accurate the results must be to add value, what analysis method will be used and how information is interpreted. This phase will also define time and resource requirements as well as providing details about the functional unit and system boundaries. The functional unit is the vital beginning that allows alternative goods or services to be examined and analysed. The functional unit is a measure of the performance of the functional outputs of the product system (Arvanitoyannis 2008). All the impacts identified along with the energy and materials from these flows are linked to the functional unit. The functional unit is the base for all comparisons between sensitivity analysis and the different things under examination within the same functional unit. Connecting the data makes the findings of various studies comparable; therefore the functional unit must be clearly defined relative to the inputs and outputs and be measurable as advised by the ISO 14040 (Gillani et al. 2010).

Another significant aspect in the first phase of the LCA is the System boundary. Defining the system boundaries aims to identify and state which modules have to be part of the LCA in a study. Numerous influences, such as time, cost and the access of data affect the system boundaries and the study in general. Preferably, the system under study is determined in such a way that input and output flows are elementary flows at the point of the system boundaries. The system boundaries need to be designed to count all processes, contingent on the quantity and type of products which could lead to huge and complex life cycle inventories that cannot be dealt with (Gillani et al. 2010).

- **Life Cycle Inventory analysis (LCI) Phase**

This phase is concerned with quantifying energy and raw material needs, air emissions, wastes (solid and waterborne) and other pollutants and impacts from the whole life cycle. Typically, in the LCI phase, all relevant data is collected and structured. The data is used as a basis to evaluate and compare environmental impacts for potential improvements (Luz et al. 2015). LCI is very important in the sense that the accuracy and detail of the LCA results is mainly based on the accuracy and detail of the data collected for the LCI phase. The main uses of ICI include assisting in decision-making process for policymaking. LCI provides understanding which could help developed legislation regarding resource use and emission (Luz et al. 2015). LCI quantifies the impacts emitted to the environment and the amount of energy and materials used.

- **Life Cycle Impact Assessment (LCIA) Phase**

The LCIA is the evaluation and assessment phase (Callesen, 2016). It uses the impacts identified from the inventory phase and applies impact assessment tools. The results address the human health and ecological effect and resource depletions. Impacts categories include climate change; toxicological stress, noise; land use, air emissions etc. and, in some cases, in an aggregated way such as years of human life lost due to climate change, carcinogenic effects, noise, etc. One of the common issues of this phase is the subjectivity of modelling and the choice of evaluation of the impact categories, therefore assumptions need to be clearly described and reported to ensure transparency (ISO 14040, 2006).

- **Life Cycle interpretation Phase**

According to ISO 14040, (2006) the interpretation of LCA is a "*a systematic technique to identify, quantify, check, and evaluate information from the results of the life cycle inventory (LCI) and the life cycle impact assessment (LCIA), and communicate them effectively*". This phase requires an analysis and evaluation of the results of the LCIA to synthesise conclusions. This phase should clarify understanding the study's limitations and enable the extraction of useful, well informed recommendations based on the finding of the previous phase.

2.12.2.1. LCA TOOLS

LCA assessments methodically analyses and quantifies the environmental impacts, energy and resources consumption with a process, product or activity. The analysis of the entire product/process life identifies opportunities to enhance the environmental performance. In order to ease the LCA analysis, a number of LCA specific software has been developed in the last two decades as stated by Mutel and Hellweg, (2009). The most common and leading software packages are Gabi life cycle assessment tool, Umberto and SimaPro. GaBi package has been developed by more than 60 developers, which has provided over 4000 LCI profiles for professionals and engineers over the years.

It compiles all of the ISO 14044, 14064 and 14025 standards together. The Ecoinvent database is also integrated into GaBi software, which offers wide access to inventories and industrial fields. One of market leading LCA tools is Umberto. It is widely used by companies and researchers. It is commonly used for modelling, calculating and visualising energy and material flow systems. The assessment feature in Umberto uses economic and environmental performance indicators. This package is useful not just for environmental performance but also for sound economic decision making as Umberto addresses organisations with cost concentrated production that wish to enhance their processes and improve competitiveness (Mutel and Hellweg, 2009).

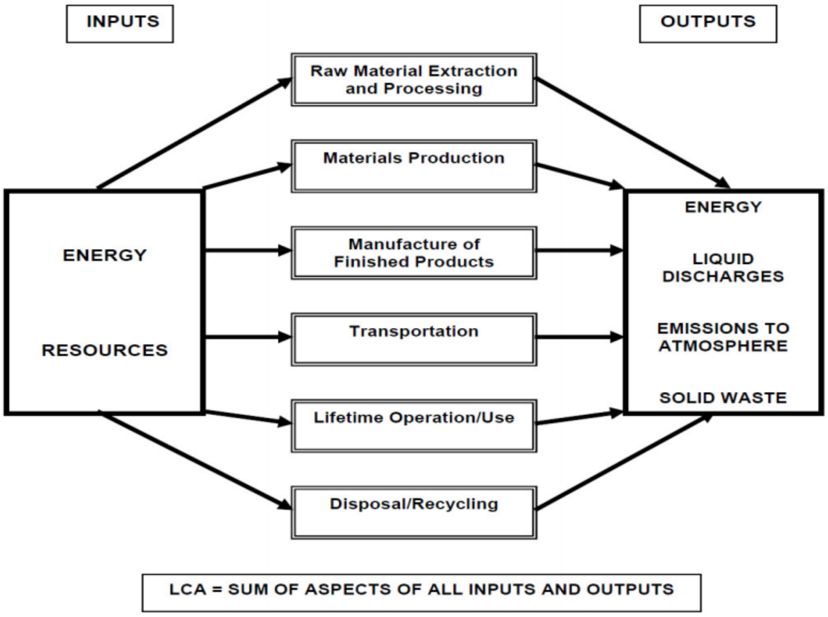

Figure 2.10: Summary of Life Cycle Assessment procedure for a typical industry (RSC EHSC 2005)

SimaPro is also one of the leading LCA assessment tools. SimaPro LCA tool is compliant with the ISO 14040 standards and includes most common databases such as US, Dutch, and Danish Input Output databases, ETH-ESU 96, Ecoinvent, IDEMAT 2001, LCA food, EuP database for Energy using products etc. (Goedkoop and Schryver et al, 2008). This research study used SimaPro 7 PhD version to analyse the Libyan crude oil life cycle in fulfilment of this study's objectives. The preference of using SimaPro software is due to the availability of PhD version at the Univerisity Labs and the previous experience of the research on using this particular software.

2.12.2.2. Limitations of LCA

LCA is tool, which could provide key information about the environmental performance of a specific product, process or activity. Guldbrandsson and Bergmark, (2012) consider LCA as one of the most important methodological platform for environmental prioritization and understanding. On the other hand, they have stated that LCA is associated with a set of limitations. It is argued that the results of the LCA are only valid under the assumptions of the study and are still allied with considerable uncertainty, which require to be taken into consideration to understand the study findings.

Uncertainty

It is known that there is a clear difference between uncertainties and errors (i.e. mathematical errors). Uncertainty can be certainly minimised, but never fully removed or avoided whereas errors in principle can be eliminated and/or corrected. Therefore, it essential to fully understand the uncertainty associated in understanding LCA results. The literature indicates that there are three distinguished groupings of uncertainties connected to LCA (Lloyd and Ries, 2007; Finnveden, et al. 2009; and European Commission, 2010). These are:

- **Parameter uncertainty**: this type of uncertainty is statistical in nature and can be evaluated with the use of simulation.
- **Scenario uncertainty:** this uncertainty is dependent on the selection of choices which could cause big variations in the results such as cut-off and allocation.
- **Model uncertainty:** Recounts to uncertainty from inadequate information of the mechanism of the calculated system and is problematic to measure.

It is widely argued in the literature that uncertainty assessments for LCA in general are never accurate due to the fact that it relies to some extent on estimates and assumptions, and therefore parameter and statistical uncertainty is beyond reach for LCAs. This is more evident especially for the complex LCA studies related to petroleum products and crude oil. It is very difficult to conduct a study on a complex process or a product such as a crude oil which is associated with many different raw materials and production processes. The input variables will rely on estimates even if supplied by petroleum companies. The study data comprises many sources of uncertainty that will influence the accuracy of the results and their interpretation.

Another limitation of LCA techniques is the need for subjective judgement especially in the evaluation and decision making process. It is vital to consider all of the specific study parameters and the uncertainties associated to ensure a sound and viable decision-making process. This indicates that transparency and effective communication of results is essential. This justifies why many scholars have criticized the use of LCA studies.

Crude oil is the main fossil fuel used around world contributing to around 33% of the world consumption of energy according to Morales et al. (2015). The world is highly dependent on crude oil products for various uses such as energy generation and transportation. This extraordinary reliance on oil and its products comprises major environmental issues, largely related to the emission of greenhouse gases (GHG). Around 11 Gt CO_2 were emitted worldwide in 2010 as of the International Agency report (IEA, 2014). In order to minimise these impacts, LCA studies were used as a quantitative tool. The literature show a number of LCA studies concerned with crude oil and its products such as (Keesom et al., 2012;; Singh et al., 2010; Spatari et al., 2010; and Furuholt 1995). These studies take into account fuel production in addition to the final use of the crude oil products and address different regions and countries. Studies include Rahman et al. (2014), UK (Borrion et al. 2012), Spain (Bredeson et al. 2010), Indonesia (Restianti & Gheewala 2012),Greece (Nanaki & Koroneos 2012), India (Garg et al. 2013) and Brazil (Cavalett et al. 2013).

There is a clear gap in LCA studies in developing world regions (Middle East and North Africa and Libya in particular). Despite the fact that the majority of oil reserves are based on this region, no LCA studies have been utilised in Libya to investigate the environmental profile of Libyan oil products. Therefore, the author has conducted his own study TO offer tangible recommendations. The LCA study is original and novel in the context of the Libyan petroleum industry (See Chapter 8).

2.12.3 Environmental Impact Assessment (EIA)

Another environmental sustainability approach widely used is the Environmental Impact Assessment (EIA). EIA is one of the major tools used to assist environmental analysis of a project of this nature (Cesari et al. 2017). It was first established from the National Environmental Policy Act 1970 (NEPA) in the USA. This legislation has received high recognition in the US. The NEPA law has spread to over 40 countries by 1990s (Robinson, 1992). Some countries have established their own EIA requirements and modifications which explains the huge variations in the quality of EIA among countries. EIA is internationally recognised by various international protocols, conventions and agreements Morgan (2012) such as:

- The Convention on Transboundary Environmental Impact Assessment;
- The Convention on Wetlands of International Importance;
- The Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters;
- The United Nations Framework Convention on Climate Change;
- The United Nations Convention on the Law of the Sea;
- The Protocol on Environmental Protection to the Antarctic Treaty.

The widespread use of EIA has been examined by Morgan, (2012: p. 6). Morgan, (2012) conducted a detailed search in Nov, 2011 on the ECOLEX database (an environmental law information service jointly operated by UNEP, FAO and IUCN: http://www.ecolex.org for legislation and treaties comprising text references to 'environmental impact assessment' and their interpretations in French and Spanish). Results show that 191 out of 193 member nations have national legislation or a signed form of legal instrument that refers to EIA. EIA is a 'planning tool' used to forecast and evaluate the impacts of a proposed project and its alternatives.

Ortolano & Shepherd (1995) argues that EIA from a "technocratic paradigm" perspective is a planning tool used for decision making. Projects are evaluated based on criteria and objectives by engineers and planners who choose, or design alternative projects and conduct studies (EIAs and cost benefit analysis) to estimate and predict impacts. The results gained are used to choose one project from the rest. EIA ensures environmental problems are considered and eliminated.

There are various procedures that have emerged under the umbrella of EIA since the 1970s. These include strategic environmental assessment (SEA), health environmental assessment (HIA) and social environmental assessment (SEA). Morgan (2012) argues that these forms result from the dissatisfaction of EIA practice. For example, the SEA has gained major developments in the late 1980s especially in USA. EIA was criticised with neglecting social impact and focusing only on the ecological impacts (Taylor et al. 2004).

Furthermore, the National Academy of Sciences (2011) adds that recently HIA has emerged due to the lack of emphasis of EIA on community and individual health. A linked methodology, sustainability assessment (SA), has arisen which focuses on sustainability criteria in the assessment of policies. Conversely, sustainability has numerous definitions and meanings and therefore the process of SA is viewed differently (Bond and Morrison-Saunders, 2011). SEA is valid on the basis that it promotes sustainable outcomes which gain access to the boundaries of SA (Sadler, 2011). Similar issues occur in the environmental impact assessment, as a greater differentiation of EIA model into a named mixture provides terminological and conceptual complexity.

Morgan (2012: p. 9) reviews a set of a significant contributions of EIA stages which are outlined below. Over the last two decades, there have been significant contributions to the literature on each of the main steps in the classic EIA model:

- Screening: e.g. Enserink (2000), Wood and Becker (2005), Pinho et al. (2010), Rajaram and Das (2011) and Weston (2011).
- Scoping: e.g. Mandelik (2005) and Snell and Cowell (2006).
- Impact prediction: there are many papers dealing with specific techniques, across the various environmental sectors and different forms of human activity, plus broader contributions, such as Duinker and Greig (2007) on scenario approaches to prediction.
- Significance: from a conceptual standpoint: e.g. Lawrence (2007a, 2007b); more technical approaches: e.g. Ijas et al. (2010), Cloquell-Ballester (2007) and Mustow et al. (2005).
- Monitoring and other aspects of follow-up: e.g. Marshall et al. (2005), Morrison-Saunders and Arts (2004).

EIA works as an impetus for administrative change. EIA in some countries as described by Ortolano & Shepherd (1995) has transformed the public decision making by engaging and informing the public, agencies and NGOs with the impact of the intended projects. EIA opens the projects to public scrutiny. In the past, EIA has led many NGOs and communities to sue government agencies to provide full disclose of impacts in the US. Another benefit of EIA studies is the administrative and managerial processes to companies. The EIA program requires the environmental assessment related documents to be reviewed by government bodies (i.e. ministry or environmental agency). The reviews lead to management and administrative improvements as it spreads information about proposed actions and their impacts.

2.13. Barriers and Success Factors

2.13.1. Implementation Barriers

Schneider, et al. (2011) assert that oil and gas companies play a significant role in the world but their efforts towards sustainability require improvement. It was highlighted by Salzmann et al (2005) that organisations fail to integrate sustainability and environmental management practices into their policies for many reasons including their lack of expertise and provision of required resources. Hence, it is vital to discuss the implementation barriers that hinder the adoption of sustainability approaches within organisations.

There is very limited published research about sustainability practices in the oil and gas industry; however, many organisations have developed environmental management systems based on international standards in an attempt to improve their environmental performance. Such systems do not usually add efficiency to the organisation as indicated by Melnyk et al (2003), however. One of the key barriers associated with poor implementation of sustainability and environmental management practices is the lack of a strategic approach towards sustainability at the organisation and corporate level (Lozano, 2013). In other words, organisations need to ensure that sustainability is embedded within the corporate strategy of the organisation to ensure that it bring benefits at all levels.

Figge et al (2002) highlight that due to the lack of links between environmental and social management and economic success, organisations fail to achieve and accomplish their long-term objectives and improve their performance. In other words, organisations need to ensure that their economic, environmental and social performance is linked together as these are strong contributors to sustainability. Moreover, embedding sustainability within the corporate strategy will direct the management’s commitment towards adopting sustainability practices and approaches. Hence, the key implementation barrier as discussed is failing to integrate sustainability with the overall corporate strategy.

Some scholars believe that organisations fail to implement environmental and sustainability practice due to the belief that such systems will incur huge costs (Steger, 2000). It must be noted that additional costs will be witnessed in the short term from the process of developing such systems which require resources, physical environmental changes, expertise, training and other technological advancements that are required to capture the environmental impact of the operations and activities of these organisations. It could also be assumed that costs will arise from the development of internal and external strategies to deal with any rising problems (Darnall and Edwards, 2006).

However, such investments will bring a lot of benefits to an organisation by ensuring its resources are being utilised efficiently and will also improve its growth and development as well as its reputation among other organisations. Bromley (2007) believes that the absence of a regulatory framework which organises and regulates the process of developing sustainability and environmental management systems in some sectors is why some organisations fail to integrate and implement such systems. Issues include the lack of available support, guidance and monitoring from regulatory agencies. This could also be partly responsible for the lack of implementation in developing countries such as Libya where there are no regulatory agencies to monitor and issue improvement notices to companies

Some scholars believe that failures in the implementation of such systems could be linked to the level of training, support and development that is provided to employees and stakeholders (Sammalisto and Brorson, 2008; Babakri et al., 2003: Campos et al., 2014). Training and development is vital in organisations as they enhance the skills and knowledge of the staff at all levels to ensure their actions are in accordance with the procedures and rules. Lack of awareness amongst the public and companies in some countries has led to poor or ineffective implementation of sustainability and environmental management systems (Gadenne et al., 2009). Some also argue that such low levels of awareness will create resistance to change within organisations and these organisations will find it difficult to impose changes that are long lasting (Jones et al., 2005). Finally, lack of rigid auditing and monitoring systems contribute significantly to the poor implementation of sustainability and environmental management systems (Chavan, 2005).

Based on the above discussion, it can be concluded that several factors hinder the adopting of sustainability and environmental management systems which can be classified into the following categories:

- Lack of public awareness about the importance and value of sustainable development
- Lack of regulatory frameworks and regulatory agencies that monitor the work of oil and gas companies
- Lack of the provision of required resources either physical or human
- Lack of direction in the corporate strategy of organisations in which sustainability and environmental management are not embedded within the corporate strategy
- Lack of the provision of training and development programmes to all stakeholders
- Lack of commitment from the leadership and management

Such factors will surely influence the adoption and implementation of sustainability and environmental management systems and will have significant impact upon the effectiveness of such programmes. Thus, an integrated approach to sustainability management in the oil and gas industry in developing countries is badly needed.

2.13.2. Success Factors

Several scholars have examined the factors that lead to the successful implementation of management systems including, environmental and sustainability management systems, and point out that one of the key factors is organisational integration of business functions, objectives and long-term goals within the overall corporate strategy. In other words, the scholars argue that sustainability needs to be integrated into management control and strategy (Johnson, 2007; Ahrens and Chapman, 2007; Whittinghton, 2007). They argue that organisations need to involve all participants and stakeholders so that everyone can become a champion for sustainability management and sustainability reporting. This involves the need to have a systematic technical, organisational, managerial and individual integration of all functions. This is referred to by Brown and Duguid (1991) as ‘community of practice’ in which common practices are shared by different departments. Zutshi and Sohal (2004) assert that high levels of communication that is based on two-way channels in which the organisation communicates its messages and lessons to all stakeholders is highly effective.

Daily and Huang (2001) point out that human resources management practices may also contribute to the success of implementing environmental management systems. They argue that top management support directly affects the success of implementing such systems as they have the ability to create a culture of employee involvement and employee empowerment which will consequently impact upon their practices and behaviours towards the newly adopted system.

Jayashree et al (2015) argues that top management support is vital as they will be able to provide the required resources in terms of training and incentive programs as well as reward systems which will reflect positively on the implementation of environmental management systems. It was argued by Janson and Gunderson (1994) cited in Daily and Huang (2001) that bureaucratic structures of management that have rigid, top heavy structures find it more difficult to implement changes than those companies that have lean organisational structures. This commitment from top management plays a significant role in the process of ensuring that such systems are implemented successfully. It was indicated by Kitazawa and Sarkis (2000) that culture change is vital to support the implementation of environmental management systems, which also needs strong direction and support from top management.

Figge et al (2002) has explored the importance of embedding sustainability with the corporate strategy and highlighted that among the success factors that are important, is the need to motivate employees, having strong information systems as well as qualifications and goal orientation. In other words, organisations need to have competent people in place to ensure that such systems are being developed in accordance with the required standards.

Figge et al (2002) also indicates that having the financial capabilities helps organisations to successfully implement sustainability practices. Moreover, Rebelo et al (2016) point out that human resources are vital to gain a sustained success when implementing EMS. Therefore, it could be summarised that embedding sustainability into the corporate strategy makes it more likely for companies to adopt sustainability management systems. Top management commitment and availability of resources are also key success factors along with the creation of culture within the organisation and employee empowerment and motivation.

2.14. Chapter Summary

This chapter encompassed the definitions, history and explanation of the most important part of this study (i.e. sustainability). The chapter also highlights the models which are being used while working on sustainability and the categories in which the models are divided. Further, details are provided about efforts being made by different countries to ensure sustainability in their region.

As highlighted above, the oil and gas industry is one of the today's fundamental contributors to growth and development as it provides essential raw materials and energy for global development. The industry also invests in infrastructure, social initiatives, technology and environmental preservation efforts as well as mitigating adverse impacts of their operations.

Moreover, the oil and gas industry has significant impacts upon the environment which means that such companies need to be fully aware of the concept of sustainability and how it can be incorporated within their strategies so that they can create value for their shareholders and all relevant stakeholders. Sustainability has become one of the pillars in which organisations should develop their strategies due to its vital importance to human and environmental aspects. It is shown that sustainability requires the integration of different business functions to ensure it provides the results and outcomes that are desired.

Furthermore, this chapter discussed the broader concept of sustainability and the different approaches that are used as well as discussing the challenges that face organisations from adopting sustainability practices. The chapter provides clarity to the barriers that face companies as well as the success factors which could help organisations in adopting sustainability practices. It was found that sustainability thinking needs to be embedded within the organisation's strategy and that top management needs to show high levels of commitment towards sustainability and its adaptation at all levels.

Success requires the need to have a regulatory framework in which organisations are provided with clear guidelines that enable them to reduce their environmental impacts. There are several approaches and methodologies which can be used by companies to enhance their sustainability such as the adhering to international standards and the use of product and service evaluation tools such as EIA and LCA. The following chapter presents an overview of the Libyan petroleum industry along with discussion of the sustainability challenges in the oil and gas sector.

Chapter 3
Libya's Oil & Gas Industry

3.1. Introduction

This part of the literature review provides information about Libya in general and the Libyan petroleum industry in particular. It will explore the historic and current economic, political and environmental characteristics within Libya in order to gain a better appreciation of the context of the study and build a basis to interpret the current sustainability picture of Libya.

3.2. Libya

3.2.1 Location, Religion, Language and History

Libya is a developing Arab country located in North Africa (See Figure 3.1). It is the fourth largest country in Africa with an area of around 1,775,500 square kilometres (Shibani, 2012). It is surrounded in the north by the Mediterranean Sea, Chad and Niger from the south, Egypt and Sudan from the East, Algeria and Tunisia from the west. There are three major climate regions in Libya: Costal Mediterranean climate; semi-desert region; and the Sahara region (General Information Authority). According to Otman and Karlberg (2007) Libyan land is mostly vacant, 94.7% is a desert, 3.9% is agricultural and 0.29% is forests. Libya is a dry country, the rainfall at the coastal areas is between 100 to 350 mm, this lessens as one moves south away from the sea. The rainiest areas are mainly at the green mountain (Al Jabal Alakdar) areas which average 600 mm (Otman and Karberg, 2007). Due to the colonization of the Italians and the Ottomans rule, there have been no official records made of the Libyan populations. The first census was in 1954, three years after the independence. That census gave a Libyan population of 1,088,889. Libyan population nowadays is 6,244,174 according to CIA fact book (CIA 2014).

Figure 3.1: Map of Libya (source: Infoplease 2000)

The dominant religion of the country is Islam representing 98% of the population. The rest are mainly Christians formed by foreigners working in Libya mostly African and European immigrant workers. Arabic is the official language of the State. Historically, Libya has been colonised through history until it enjoyed independence in 24th Dec, 1951. For the past thousands of year, the country witnessed wave after wave of military invasion. According to Wright, (1981), the Greeks had colonised Libyan eastern side in the 600 B.C. “Cyrene”, the city of Shahat today. Following that period, four more important cities were also established in the Libyan cost: Appolonia (Susah); Teuchira (Tukrah); Eursperides or Berenice (Benghazi); and Barce (Almari) (Vandewalle 2012). Later on, the Romans invaded Libya around 100 B.C. They stayed there until the Vandals beat them in the 5th century all over the whole of North Africa. The Byzantines controlled Libya around 534 A.D. for about a century (Vandewalle 1998).

In the 7th century, Libya moved away from the European identity after it was conquered by Arabs and Islamic empire in the 643 A.D. It established a new culture along with the rest of North Africa (Otman and Karlberg 2007). Islamic influence on Libya and the region was significant, it shaped the whole region. By the 16th century, the northern coast of Africa had become alive with sailors and trade. It attracted the imperialistic designs of Christian Spain and the crusading Ferdinand, the Catholic, took Tripoli in 1551 (Drysdale and Blake, 1985). Subsequently, the Turks took the whole of Libya in the 1551, the whole of Libya became a part of the Turkish Empire, also under the doctrine of Islam, up until the invasion of the Italians led by Mussolini in 1911. Italy was in war continuously for a bout twenty years due to a tough Libyan resistance. Both suffered heavy losses (Wright 1981). Italy colonised Libya for over thirty years until the World War II.

By the commencement of the World War II, Libya was a battleground between the Axis (Germany and Italy) and Allies. With the assistance and contribution of Libyans under Sanussi leadership, the Axis were defeated at Al-Elamien battle on the 23rd of October 1942 (Barker et al. 1996). The Italians were thoroughly conquered by the French and the British in late 1942. Britain controlled the northern part of Libya and the east part (Tripolitania and Cyrenaica), while the French controlled the southern part of Libya (Fezzan). The control of the British and the French continued up to the declaration of Libyan independence by the United Nations on the 24th of December 1951 (Shareia 2006). On that day, Libya was acknowledged as an independent united kingdom, with a federal constitution according to the constitution promulgated in October 1951. Libya was a federal monarchy governed by King Al-Sanussi and the country was established by the three provinces of Tripolitania, Cyrenaica and Fezzan. In April 1963, the federal government announced a new legislation that transformed Libya from a federal into a unitary state.

In 1969, the monarchy was dethroned by a group of army officers led by Colonel Gaddafi who planned for the 1st of September Revolution. The bloodless revolution announced the Libyan Arab Republic. Gaddafi rule lasted for 42 years until he was overthrown by the 17th February, 2011 uprising led by the National Transitional Council (NTC). NTC declared Libya to be officially “liberated” in October 2011 and promised to turn Libya into a pluralist, democratic state. The power was handed to a newly elected parliament in August 2012 “General National Congress”. In August 2012, the NTC handed over power to Libya's newly elected parliament, the General National Congress. The General National Congress of 200 members lasted for one year and seven months until it was replaced with a new elected Council of Deputies based in Tobruk.

Libya is supposedly governed by a parliament known as the Council of Deputies elected in the June 2014 elections. However the parliament lost its control of the country. There is an armed conflict and civil war between Islamist supporters of the former General National Congress and their opponents led by General Khalifa Haftar. In the current conflict, government services are functional to a very limited degree with no police influence.

3.2.2. The Economic Context

Libya was in an extreme poverty before the discovery of oil in 1959. Most of Libyans earned a per capita income of lower than $50 per year. The main sector was agriculture. An economic advisor to Libya in the 1956, Benjamin Higgins stated that Libya is a poor country, there is no sources of power and no mineral resources. Agriculture expansion is harshly limited by climate condition. The country also lacked skilled labour and native entrepreneurship (Higgins, 1959, p. 26).

The evident deficit in the Libyan economy is understood due to the fact Libya witnessed many wars in the past including the Italian invasion and colonisation. Technical abilities, skills and education were neglected and the Libyans were barred from the administration and duties which might enhance their abilities and skills. The deficit economy was caused by the fact that Libya experienced so many wars and colonial administrations. At that time, the Libyan economy was mainly based on the agriculture and animal provision and other few industries. The agriculture being the biggest was hindered by the scarcity of water supply, lack of suitable land as most of the Libyan land is a desert.

In general, prior to oil discovery, Libya was classified as poor country with low levels of domestic products and consumption counterbalanced by foreign aid (Wright 1981). Libya relied on the foreign aid until the discovery of oil in the 1955 which have created astonishing changes to the country in all means of Libya. Foreign aid stopped and was replaced by foreign oil companies mostly from the West (Bait-Elmal et al., 1973). Libyan economy has grown significantly since the discovery of oil. Table (3.1) shows the GDP by sector for the period 1970-2008 according to Central Bank of Libya and African Statistical Yearbook, (2014).

Table 3.0-1: Libyan GDP by sector (in millions LYDs)

Economic Sector	1980	1986	1991	1995	1999	2002	2003	2004	2005	2006	2007	2008
Agriculture & Fishing	183	320	678.2	947	1449.9	1348.8	13039.3	1328.6	1447.5	1643.1	1905.3	2020.7
Petroleum & Gas11	6571	1784	3054	2468	3995.9	13164	20217.9	29227.4	43946	55649.0	58963.8	70691
Mining and Quarrying	48.8	49	72.5	148.6	223.3	364.0	1333	1328.6	1447.5	1643.1	1905.3	2020.7
Manufacturing	192.2	401.8	706	799.7	863.1	813.5	3865.5	3996.9	4324.2	4643.5	5218.9	5723.8
Electricity & Power	49.7	112	177	216.7	270.4	293.7	755.0	734.3	876.6	972.7	1019.1	1255.6
Construction	935.7	895	1319.5	483.9	803.6	1262.7	1787.0	2159.2	2683.5	3129.3	4198.4	5994.5
Trade, Restaurants & Hotels	489.8	485.9	1041.5	1254	1693.3	2089.5	1875.9	2194.9	2657.5	2863.6	3396.3	3949.5
Transport/Communication	356.1	395.5	812	892.6	1211.7	1429.2	1812.0	1944.0	2412.6	2724.2	3299.5	3884.2
Banking & Insurance	246.4	285.4	370.5	286.2	323.5	414.2	590.7	627.7	717.1	816.5	980.8	1081.3
Ownership of housing	210.4	252.4	315.3	391	452.7	515.0	1991.9	2448.7	3131.7	3606.9	4032.1	4746.6
General services	946.6	1521	1894.5	1853	2429.2	2859.5	3279.2	3658.6	4481.9	4935.1	6507.3	6670.7
Other services	47.4	75	172	307.7	358.6	427.5	217.6	226	241.4	279.2	321.4	363.7
Total GDP	10277	6577	10612.5	10048.7	14075.2	24981.2	50765.0	49847.9	68368.2	82906.2	91748.2	108402.3
Petroleum & Gas	63.9 %	27.1 %	28.8 %	24.6%	28.4 %	53 %	39.8 %	58.6 %	64.2 %	67.1 %	64.2 %	65.2 %
Other Sectors	36.1 %	72.9 %	71.2 %	75.4 %	71.6 %	47 %	60.1 %	41.3 %	35.7 %	32.8 %	35.7 %	34.7 %

Sources: [(Central Bank of Libya, CBL, 2011 & African Statistical Yearbook, 2014)

It is clear that Libya is financially sound especially with the discoveries of more new oil and gas reserves. The following section will provide detailed overview of the Libyan petroleum sector.

3.3. Libyan Petroleum Industry

Petroleum products have been used for many years for lighting. Historically, it was not until 1859 that "Colonel" Edwin Drake constructed the first successful oil well, with the only drive of producing oil. The Drake Well was situated in the centre of discreet farm country in north-western Pennsylvania. Since then, the spark of international search for an industrial use for petroleum started. The picture (Figure 3.2) shows Drake well in the Tarr farm, oil Creek Valley. On the right, Phillips well produced around 4 thousand barrels per day and the Woodford well on the left 1500 barrels per day, 1862 (Devold 2013).

Libya has discovered and produced oil around one century after Drake wells in the 1950s. Libya petroleum industry is the main economic sector in Libya. It is run by the state-owned National Oil Corporation (NOC). NOC was first established in the 1970, under Libyan law No: 24/1970 to take responsibility of the Libyan petroleum sector (NOC, 2014). Libya post-1969 has seen considerable industrial and urban development. The Libyan petroleum sector, run by the National Oil Corporations (NOC), has created a substantial amount of this development.

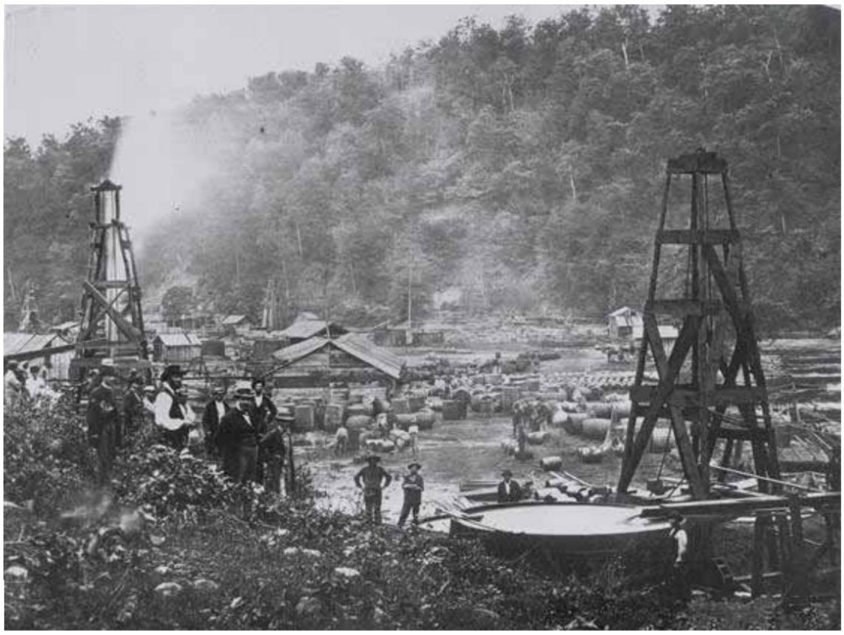

Figure 3.2: Drake Well Museum Collection, Titusville, PA Source: (Devold, 2013)

Libya is an active member of the Organisation of the Petroleum Exporting Countries (OPEC) since 1962, it holds Africa's largest proved crude oil reserves and fourth largest natural gas, and a significant supplier to the global supply of light, sweet crude oil (OPEC, 2015). Libya's petroleum production and exports have been noticeably affected by civil war over the past few years. In Feb, 2011, Libya witnessed unrest and revolution which lasted for 8 months which caused a near-total disruption. The minimal production was fully consumed internally. Libyan petroleum production has recovered in 2012, but it keep on lower levels prior to the revolution.

In the years 2013 and 2014, Libya witnessed major changes in its oil production, dropping to its lowermost level since the revolution of 0.2 million barrels per day (bbl/d) at the end of 2013. For almost a year, Libya's major eastern oil ports (Es Sidra, Ras Lanuf, Zueitina, and Marsa Al-Hariga) were shut by the blockade led by Ibrahim Jidran, a branch leader of the Petroleum Facilities Guard (PFG), which was hired to protect the facilities. The exportation blockade stated in July 2013 and finished after arrangements were made to revive the ports in April 2014 (Zueitina and Marsa al-Hariga) and June 2014 (Es Sidra and Ras Lanuf). In the western part of Libya, production at the 340,000-bbl/d El Sharara oil field and, to a smaller degree, the 100,000-bbl/d El Feel oil field has also been frequently shut down (EIA, 2014).

Libyan economy is profoundly reliant on petroleum industry. According to the International Monetary Fund (IMF, 2008), oil and natural gas accounted for approximately 96% of total government revenue and 98% of export income in 2012. Roughly 79% of Libya's export income originates from crude oil exports, which brought in about 4 billion US dollars per month of net revenues in 2012 (IMF, 2008).

Libyan crude oil production is not stable due to the unrest taking place in Libya and the political conflicts. However, during 2016, the Libyan National Army has taken control of the oil crescent when they pushed out the militias that were controlling the oil ports and the production of oil started to improve but such improvements may not continue as the country remains to be in a chaos.

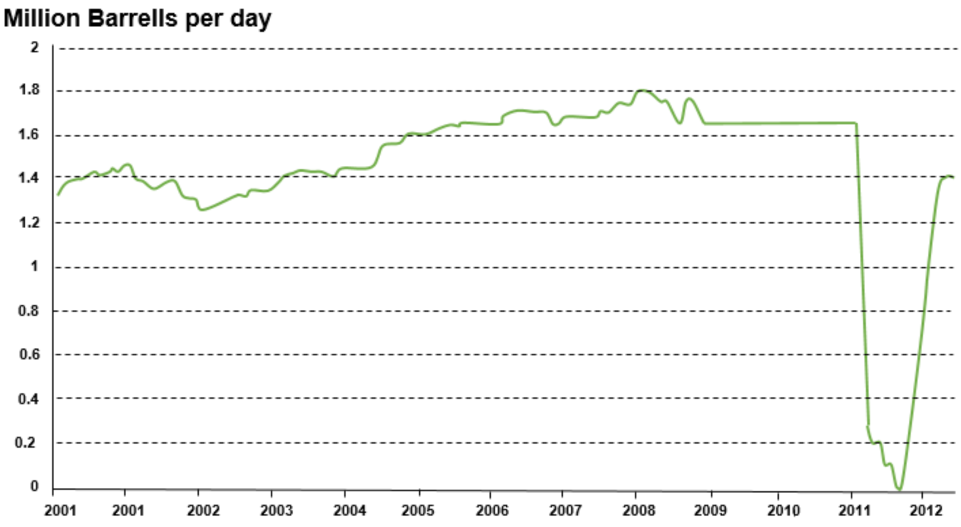

Figure 3.3: Libyan crude oil production, Jan 2000 – May 2012 (Source: EIA, 2013)

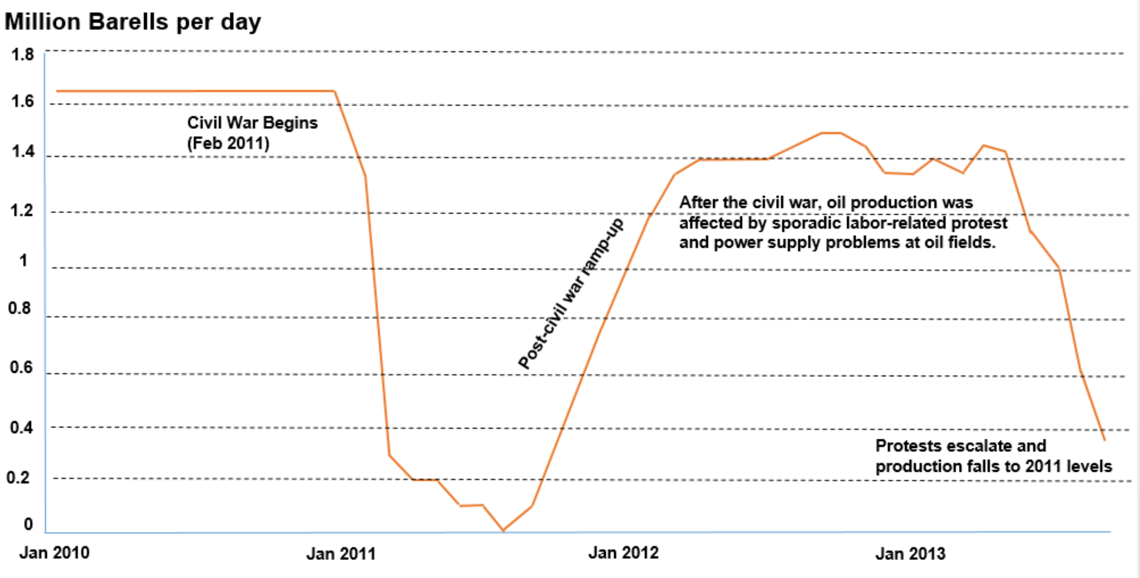

Figure 3.4: Libyan crude oil production, Jan 2010 – Sep 2013 (Source: EIA, 2013)

According to the Oil & Gas Journal (OGJ, 2014), Libya had proved crude oil reserves of 48 billion barrels as of January 2014—the largest in Africa, making 38% for the continent's total, and the 9th largest quantity globally. In Libya, there are six large sedimentary basins—Sirte, Murzuk, Ghadames, Cyrenaica, Kufra, and the offshore, which the National Oil Corporation believe has significant undiscovered potential. Around 80% of Libya's reserves are situated in the Sirte basin, which also contributes for most of the country's crude output (Arab Oil & Gas Directory, 2013). Libya mostly remains unexplored and due to the continuous civil unrest, it disrupted a large-scale exploration program.

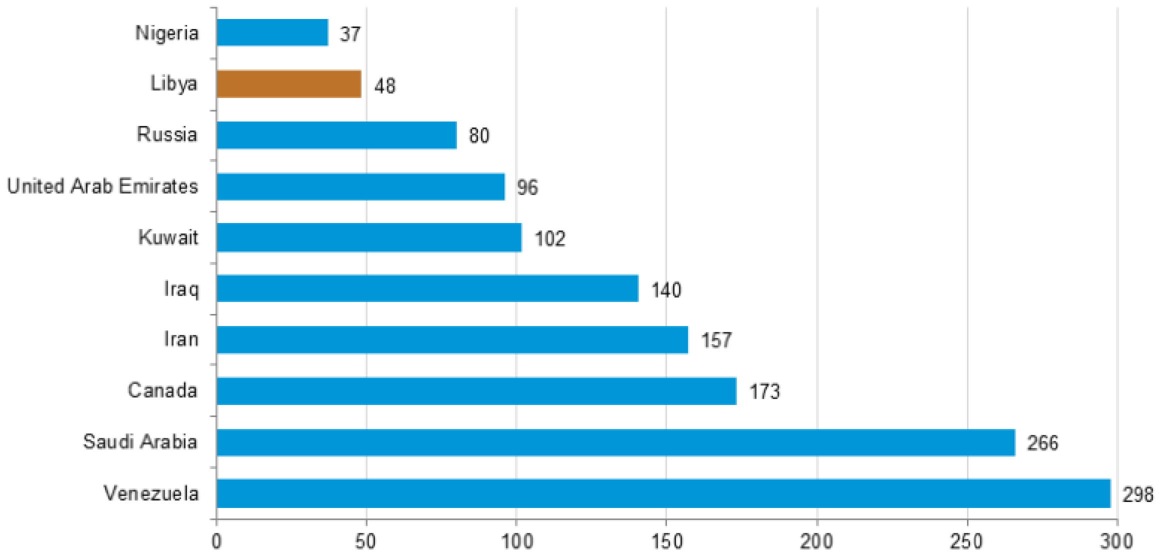

Figure 3.5: World's top 10 holders of proved crude oil reserve (Source: EIA, 2013)

The NOC is the state owned administrator of the Libyan petroleum sector. It is responsible for employing Exploration and Production Sharing Agreements (EPSA) with international oil companies (IOCs), along with its own field development and downstream activities. NOC subsidiaries include various medium and large national and international companies. NOC carries out exploration and production operations through its own affiliated companies. NOC also contributes with other companies under service contracts or any other kind of petroleum investment agreements.

The sector includes the fully owned national Libyan companies, joint venture companies, other international companies holding exploration and production sharing agreements (EPSA) and educational and training institutions. Table (3.2) illustrates the major institutions which comprise the Libyan petroleum sector.

Table 3.2. Libyan petroleum industry companies (Source: NOC, 2015)

NOC Fully Owned	EPSA
▪ **Sirte Oil Company** ▪ **Arabian Gulf Oil Company (AGOCO)** ▪ **Ras Lanuf Oil and Gas Processing Company** ▪ **Zawia Oil Refining Company** ▪ **Brega Petroleum Marketing Company** ▪ **National Oil Wells Drilling Company** ▪ **Jowfe Oil Technology Company** ▪ **National Oil Fields and catering Company** ▪ **North Africa Geophysical Exploration Company** ▪ **Taknia Libya Engineering Company** ▪ **Petro Air Company**	▪ Eni North Africa Company ▪ Amerada Hess Company ▪ India oil Company ▪ Total E&P Company ▪ Petro Canada Company ▪ Polish Oil & Gas Company ▪ OMV Company ▪ OXY Company ▪ BP Exploration Libya Limited Company ▪ STATOIL Company ▪ Gazprom Company ▪ Repsol Murzuq Company ▪ Petrobras Company ▪ Chevron Libya LTD Company ▪ Shell Company ▪ RWE Company ▪ Sonatrach Company ▪ Turkish Petroleum Corporation ▪ Medco Energy Company ▪ Exxon Mobil Company
Joint Ventures	
▪ **Zueitina Oil Company** ▪ **Mellita Oil & Gas Company** ▪ **WAHA Oil Company** ▪ **Mabruk Oil Operation Company** ▪ **Harouge Oil Operation Company** ▪ **Akakus Oil Operation Company** ▪ **Nafusah Oil Operation Company**	
Centers & Institutes	
▪ **Oil Clinic** ▪ **Petroleum Training and Qualifying Institute** ▪ **The Specific Training Center of Petroleum Industrial (Zawia)** ▪ **Libyan Petroleum Institute**	

The largest NOC subsidiaries and crude oil producers are the Arabian Gulf Oil Company (AGOCO) and Waha Oil Company (WOC). The production of AGOCO is around 400,000 bbl/y before the Libyan petroleum crisis and civil war (EIA, 2014). AGOCO produces oil from Messla, Nafoora and Sarir oil fields. Waha Oil Company (WOC) was initiated in 1986 to replace Oasis Oil Company a joint venture company with another three foreigner companies (Conoco, Marathon and Amerada Hess). WOC claims the production of 350,000 bbl/d (EIA, 2014).

Zueitina Oil Company (ZOC) and Sirte Oil Company are also two other large NOC subsidiaries which function in five Intisar oil fields in the Sirte Basin. SOC runs the Raguba oil field and Attahadi and Assumud gas fields in addition to Marsa el-Brega liquefied natural gas (LNG) plant. NOC runs a total of five oil refineries such as Zawia and Ras Lanuf refineries, and also ammonia, urea, methanol, Ras Lanuf petrochemical complex and the gas processing plants.

3.3.1 Joint Ventures in the Oil Industry

Joint venture is defined by Lee and Carter (2005, p. 173) as "*an arrangement where a firm is required to share equity and control of a venture with a partner from the host country*". Joint ventures in the oil industry are always required in the Libyan oil sector. The NOC seeks to form joint ventures with foreign oil partners to operate the country's oilfields as well as to gain considerable knowledge, know-how, and technology. The joint venture agreements in Libya usually require the international oil company to fund all exploration operations. However, the NOC has the right to contribute to funding the development cost and bearing its share of the operating cost, in proportion to its share of joint venture, in the case of discovery of commercial quantities. The international company will also be entitled to repayment of part of the exploration cost (Townsend 2001).

The NOC encourages foreign companies to invest in Libya via joint ventures. This method can bring to the country the much-needed technology, knowledge, and other advantages, which can help in modernizing the country's oil and gas infrastructure. The essential condition for companies interested in forming a joint venture with the NOC is that the majority of the company's board of directors, as well as its director, must be Libyan citizens (U. S. & Foreign Commercial Service and U. S. Department of State, 2008). Certain joint venture agreements may be termed `negotiated nationalization': the NOC became a 50% partner of the existing concession and concluded joint venture agreements on new areas whereby it shared both financial burdens and benefits equally. The NOC would participate in the management via equal numbers of members on the management committee (Townsend, 2001).

There are several responsibilities under Libyan petroleum law for sharing the benefits of doing business in the oil industry between the NOC and the foreign oil companies. These responsibilities obligate mainly the international companies to adhere to certain rules, such as to perform all petroleum operations in conformity with the rules set out in Regulation No. 8 of the Libyan Petroleum Law regarding safety measures and conservation of petroleum resources and in compliance with sound and reasonable standards; to fulfill the requirements of Regulation No. 9, dealing with the financial, administrative and technical control for the preservation of oil wealth; to take all practical precautions in order to avoid danger to human life, property, natural resources, archaeological sites, beaches, religious or tourist sites, cemeteries, and public installations, as a result of petroleum operations, and, finally, to ensure that the machinery, equipment, and materials used in petroleum operations are in conformity with the safety and efficiency standards existing in the oil industry (Oleynik et al., 2005).

3.3.2. Exploration and Production Sharing Agreement (EPSA)

NOC uses international agreements with international foreign companies to invest and explore crude oil in Libya. It is called the Exploration and Production Sharing Agreements (EPSAs). EPSA is the first vital commitment in oil exploration contracts which shares the management, financing of discovering oil. It is used by the NOC to leave the exploration risks on the foreign partner (Townsend, 2001).

Licensing of oil and gas in Libya started from the 1959, followed by joint venture agreements in the late 1960. NOC is the key body responsible for all EPSA activities and agreements based on a General Secretariat of General People’s Congress legislation (decision No. 10, article 5 (1979) in regard to the re-structure of the NOC (Elgobbi, 2008).

3.3.3. Natural Gas

Natural gas was first discovered at El-Atshan field in 1950s. the field is located in the south west of Libya. According to CIA, (2013) Libya has significant natural gas reserves around 1.5 trillion cubic feet which made it 22nd largest in the world. It is believed that Libya unproven natural gas could be as much as double the proven reserves according to Townsend, (2001) and Otman, (2005). Some of the existing natural gas fields located in Ghadames, Murzuq, and Cyrenaica include Defa-Waha, Hatiba, Zelten, Sahl, and Attahadi. Table 3.3 indicates the production of gas from the years 2004 and 2011.

Table 3.3 Libya gas production rate 2004 and 2011 (Source: Libyan Central bank Annual report, 2011).

Years	Production rate (1 million cubic feet)	
	Daily Average	Annual Average
2004	1.444	527.1
2005	2.097	765.4
2006	2.598	948.1
2007	2.807	1024.4
2008	2.932	1070.1
2009	2.837	1035.5
2010	2.956	1078.8
2011	2.025	738.9

The Libyan gas sector considerable development, due to the sanctions imposed in Libya in 1992 by the United Nations, many Libyan oil and gas facilities has development issues. Many operating facilities have been in operation for many years and was not maintained nor upgraded. For example, the LPG plant which was built by Esso has been operating for many years at half-capacity, due to mechanical complications.

After the lifting on the UN sanction in 2003, international oil companies were invited to modernize the sector and consequently, various foreign companies started operating in Libya. According to the EIA, (2008) many companies won contracts with NOC to upgrade oil and gas facilities including the Royal Dutch/ Shell, which signed a contract with the NOC to upgrade liquefied petroleum gas export facilities, and build a new liquefied petroleum gas export facility. Similarly, Repsol has been working on upgrading the country's liquefied petroleum gas export potential.

BP signed a partnership agreement with the NOC to invest at least US$ 900 million in exploration in one deep-water offshore area in the Gulf of Sirte, and in two onshore areas in Ghadames. BP will also develop the Libyan manpower and spend about US$ 50 million on training and education projects during the exploration and appraisal phase, which aims at upgrading the training process and utilizing international expertise regarding data transfer technology in the fields of exploration and production in order to develop local individuals' expertise and skills in these fields (EIU, 2007).

3.3.4 Western Libya Gas Project (WLGP)

The Western Libya Gas Project (WLGP) is the first significant initiative of integrating upstream, downstream and exportation facilities to export Libyan natural gas to Europe. It was established in 2004. Libya now exports compressed gas to Italy and the broader European market, in addition to supplying the domestic Libyan market with gas for feedstock or power generation.

WLGP is the Mediterranean's most ambitious project, the country favoured gas exports to Europe through a sub-sea pipeline. The NOC and its partner, Italy's Eni Gas, have been investing over US$ 6 billion in upgrading the Bahr Essalam field, 110 kilometres offshore from the capital (Tripoli) and the Wafa field, south-west of Tripoli (Beckman, 2005). The two fields, hold recoverable reserves of roughly 1,750 million boe, and will have a target production of about 240,000 boe/day, around 10 billion cubic metres/ year of natural gas, 8 billion of them reaching European markets via the underwater Green stream gasoline, 520 kilometers long and linking Mellitah on the Libyan coast to Gela in Sicily, Italy (Annual Report of Eni, 2004).

Furthermore, 50:50 joint venture between the NCO and the Enterprise Tunisienne d'Activites Petrolieres "ETAP" (Tunisian State Oil Company) was set up. The main activity of this venture is to link Mellitah in Libya to Gabes in Tunisia by a gas pipeline about 285 kilometres in length. The budget of this project was estimated at US$ 250 million (US$ 100 million for the procurement of pipeline; US$ 80 million for gas turbines & compressors, and US$ 70 million for pipe construction). The UK's Penspen International is responsible for project management, while the design and engineering was carried out by France's Sofregaz).

3.4. Upstream and Downstream Petroleum Operations

The petroleum industry is a high capital (asset) intensive industry. According to Varma et al., (2008), from the exploration, production and engineering management standpoint, the industry has numerous unique features that differentiate it from other industries (Varma et al., 2008) such as: (1) suppliers: the quantity of suppliers in this industry is limited; (2) raw Material: in other industries, raw material costs are fairly stable however the prices of crude oil swings considerably; and (3) high transport costs. The petroleum industry which comprises oil and gas industries in divided into two major sectors: upstream and downstream (An et al. 2011).

The upstream petroleum operations are associated with the explorations and production of the hydrocarbons. Downstream petroleum operations include all the refining and processing of crude oil and gas into various products and all the activities which follow the refining and processing activities such as the sales and delivery of petroleum products(Nooman and Curtis 2003; Bayagbon, 2011). The following sections will review the typical petroleum streams in details.

3.4.1. Upstream Petroleum Operations

The upstream petroleum operations typically comprise the searching and exploration of possible underground or underwater hydrocarbons and natural gas reserves. It consists of the drilling of exploratory wells, and later on drilling and operational of the wells that recover and produce the crude oil and/or raw natural gas to the surface. Upstream activities are concerned with early stages of oil operations (exploration and production) as shown in Figure 3.6.

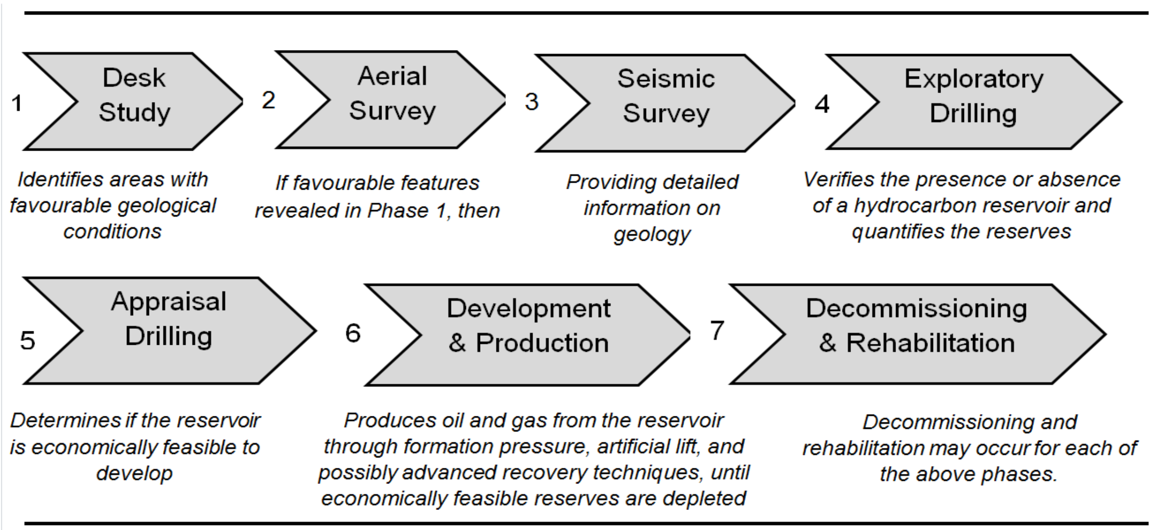

Figure 3.6. Petroleum upstream exploration and production activities

Exploration (Seismic Survey)

The exploration activities include mainly the seismic survey. Desk study and aerial surveys are activities conducted before the seismic survey to initially identify favorable geological conditions and hydrocarbons. Seismic survey involves the search for hydrocarbon bearing rocks and water bodies in which geological maps are reviewed to identify major sedimentary basins. Ikein (1990) states that aerial photographs are arranged to recognize promising earth establishment such as vaults and anticlines which mainly indicates the existence of oil.

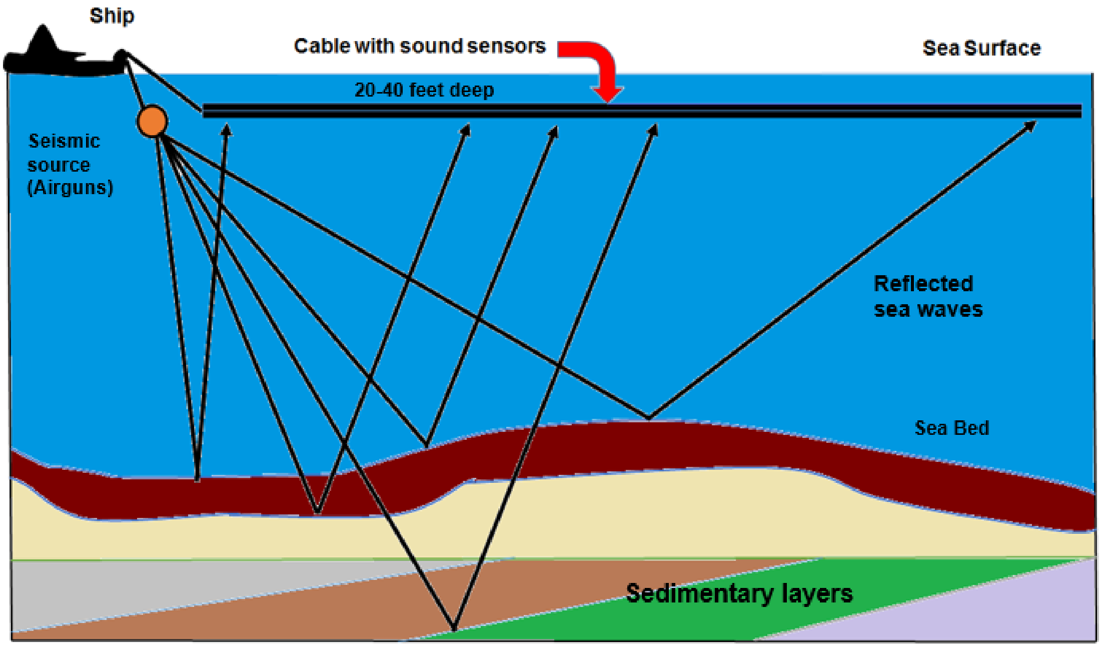

Figure 3.7 seismic survey (Source: Energy Tomorrow, 2015)

According to Nooman and Curtis (2003) there are numerous approaches used to conduct seismic survey operations, some of the common approaches include:

I. The use of acoustic wastes at specific locations along a moderately straight survey line which signified variations in the subsurface geological strata. Sensors installed along the survey lines register the sensed changes.

II. The method of using short holes with small explosive charges installed in a small diameter holes with depths of one to thirty meters.

Computer processing techniques are used to deal with the data generated to map the underlying strata, which are understood to determine the shape and size of the geological structures, which are then used as feed data for taking engineering decision for additional investigation.

The exploration activities are associated with various sustainability issues. Some of the general sustainability issues according to Ikein (1990) in Ghazi et al. (2011) include the loss of biodiversity of the natural resources inherent in the area of the exploration activities, and therefore have an overwhelming impact on the eco system. Major environmental pollution at this stage include: (1) explosive waste; (2) non-biodegradable flammable waste; and (3) non-flammable waste.

Exploratory Drilling

The following activity is the exploratory drilling. The seismic survey informs the exploration activity. This activity confirms the existence of hydrocarbons and estimates the internal pressure of the reservoir. It is considered most expensive part of the exploration sequence. Drilling indicates the presence of minerals by providing samples of the soil which also help quantify the presence of hydrocarbons (Ghazi et al. 2011).

Drilling relies on the geographical formation of the area. In offshore, it typically requires drilling rig, drilling barge or drilling ship in the case of onshore to provide all requirements for drilling activities. Drilling mud is used to continuously lubricate, cool and flush out the rock cuttings from underground up to the surface. The purpose of these activities is estimating the hydrocarbons reserves quantities.

Exploratory drilling is then followed with the appraisal drilling which assesses the economic feasibility of the reservoir. Darling, (2005) adds that major environmental impacts are created at this phase mainly through wastes such as oil spills, drilling mud, cuttings, cement waste, chemical wastes, construction materials, and non-burnable waste scrap metals.

Development and Production

The final stage of the upstream phase is development and production. This occurs if feasible amount of hydrocarbon is confirmed in the prior stages and it includes the drilling of additional wells to optimize production and the construction of other facilities to form the oil field. Bayagbon, (2011) argues that with all the previous environmental issues, emissions are continuously emitted in the atmosphere from flaring, venting, and exhausts from engines and machines. It is clear that each barrel of oil is pumped along with several barrels of environmental issues.

The development and production phase is concerned with the extraction of oil and gas from the wells. It also includes the drilling of more wells to optimize production and the construction of production facilities which deals with production, storing and transport the produced fluids. The size and type of these facilities depend on many factors such as the discovered reservoir type, size, location and the amount of work required for running and managing the wells and all associated activities.

Furthermore, these activities require the establishment of employee’s accommodation, communication equipment, waste treatment and disposal facility and service and maintenance stations (Akeredolu & Sonibare 2004). Common environmental impacts at this phase include all impacts at the exploration, drilling stages and construction. In addition to large amount of emissions emitted to the atmosphere mainly through gas flaring and the venting of gases and exhausts of heavy-duty machines.

The NOC's main subsidiaries responsible of upstream operations (exploration and production) are:

- **Arabian Gulf Oil Company (AGOCO):** it is the largest oil producer, it is fully owned NOC Company which was established earlier by the British Petroleum Company (BP). AGOCO deals with crude oil production from Sarir, Nafoora and Messla oil fields. It produces around 430,000 b/d (Biltayib. B 2006). The company runs two oil refineries and oil exporting port; Tobruk refinery, Sarir refinery and Marsa El-Hariga exporting terminal(AGOCO 2014).
- **Waha Oil Company (WOC):** WOC is a joint venture shares company NOC (59.16%), Conoco (16.33%), Marathon (16.33%), and Amerada Hess (8.16%). It is the second largest oil producer and operates in 4 oil fields. WOC runs 800 productive oil well from a total of 1100 wells.
- **Zueitina Oil Company (ZOC) :** it is also a fully NOC owned company specialises in oil E&P operations. Zueitina Oil Company runs eleven joint venture oil fields and other four EPSA oil fields. It produces around 62,000 b/d for the period 2001-2006 (NOC, 2015). It runs Zueitina exporting Terminal. The company is handling up to 20% of the country's crude oil via Zueitina Terminal (ZOC, 2015).
- **Harouge Oil Operations Company:** it is formerly Veba oil operations. It was first established by Exxon Mobil Oil in agreement with the German Company Gelsenbrg AG which later was renamed to 'Veba Oil Libya' to share its exploration and production rights and obligations. Veba is a joint venture with the NOC (51%) and Veba Oil Libya (49%), to explore, develop and exploit eight concessions in central Libya’s Sirte basin. Veba Oil Libya was retitled to 'Petro-Canada Oil Libya' and in 2008 to 'Harouge Oil Operations'.

- **Akakus Oil Operations Company:** The Company was established by virtue of an exploration and production sharing agreement between the National Oil Corporation (65%) and the European companies union (Repsol, OMV, Total) with a 35% stake. This consortium was approved by the General People's Committee (Ministerial Cabinet) resolution No. 802 issued on 06 December 1994. The Company activities are limited to exploration and production of oil for the benefit of shareholders. The crude oil pipeline project from El-Shararah field to the storage tanks in Zawia on the coast was executed with a total length of 723 km and a diameter of 30 inches (Akakus, 2009).
- **Mellitah Oil & Gas Company:** this enterprise is made up of three partnerships; NOC, Eni oi and Eni gas. The is based mainly on the western region of Libya and responsible the West Libyan Gas Project (WLGP). It also the Mellitah complex facility.
- **National Well Drilling Company (NWD):** it is a fully owned NOC company specialises in well drilling onshore and offshore. It was established in 1987 (NWD, 2015).

Midstream petroleum operations

The midstream operations typically include the storing, transporting of oil and natural gas, it comprises the transport (by pipeline, rail, oil tanker or truck), storage of crude or refined petroleum products (UNEP, 1997). The midstream operations are regularly taken to embrace some elements of the upstream and downstream sectors. For instant, sometimes the midstream natural gas processing plants that decontaminate the raw natural gas and eliminating and producing elemental sulphur and natural gas liquids (NGL) as finished end-products (Devold 2013).

3.4.2. Downstream Petroleum Operations

Downstream petroleum operations involve all the activities carried out after the production of crude oil and gas. It includes distillation and separation processes, conversion and final product treatment, petrochemical plants, processing, distribution, storage and retailing (Ehinomen and Adeleke, 2012). The downstream operations include crude oil refineries, Natural gas processing complex, petrochemical plants, storage stations and exporting terminals.

3.4.2.1. Petroleum Refineries

The oil refineries have a total capacity of about 380,000 barrels per day. Two of the refineries are large, these are located at Ras Lanuf (in the Sirte Gulf), and Zawia (45 kilometers west of Tripoli). The other three, which are relatively small refineries, are located at Sarir, Marsa El-Brega and Tobruk. Table 3.4 shows these refineries, including their capacity, as well as their start-up date.

Table 3.4: Libyan petroleum refineries (Wallace and Wilkinson, 2004: p. 135).

Refinery	Capacity (barrels per day)	Starting up year
Ras Lanuf	220,000	1965
Azzawiya	120,000	1974
Tobruk	20,000	1986
Sarir	10,000	1965
Marsa El-Brega	10,000	1965
Total	380,000	

It was highlighted by Gurney (1996) that the Libyan crude oil has different properties when compared with other crude oil. High wax content, light and easier to handle is how Gurney (1996) described the Libyan crude oil. It is also very well convenient for internal combustion engines as it has a low Sulphur content when compared with other crude oils. It is also less polluting. For this reason, the Libyan crude oil is considered one of the best crude oils especially in Europe which is also very close to the Libyan shores (OPEC, 1999). Since 1961, Libya has become one of the leading exporters of oil in the world.

3.4.2.2. Petrochemical plant

According to Libyan Oil Almanac, (2010) Libyan downstream sector has around eight petrochemical manufacturing facilities. The three main plants are:

- ✓ **Ras Lanuf:** his plant is the biggest petrochemical facility in Libya situated on the Mediterranean Coast and run by the NOC. It was established in 1987.
- ✓ **Brega:** This plant is located at Marsa AL-Brega terminal. It was established in the 1978.
- ✓ **Abu Kammash:** In addition to that, the downstream sector runs six major oil terminals and storage facilities along the Mediterranean coast. Five in the east

of Libya Marsa AL-Brega, Zueitina, Es Sidra, Ras Lanuf, Brega and Alzawyia in the west.

Downstream petroleum operations and upstream activities are potentially associated human health, safety, and sustainability risks. The key challenge for the NOC and the petroleum companies which operate in Libya is balancing these concerns with their economic development goals. This is normally achieved by establishment of a regulatory frame work which is made of legislation creating obligations, rights and procedures (Otman 2005; Elgobbi 2008). The following section will explore the existing legislations related to petroleum industry.

3.5. Libyan Petroleum Laws

Libya has a petroleum Law (25/55) which was established in 1955. The law is considered outdated and does not cover the new aspects and considerations of sustainability practices and natural gas development (Petroluem Law, 1955). The new Libyan government and ministry of energy are considering to propose a new law which aims to tackle the limitations of the existing petroleum law and establish united national law which covers all aspects of the hydrocarbons sector (EIA, 2014). In respect to the protection of the environment, Libya has established a number of legislations concerning the environment which is listed below:

3.5.1. The Environmental Law No. 7 of 1982

The legislative Act No. 7 in of the 1982 is concerned with the protection of the environment. The act was established by the Libyan authorities. This legislation is considered to be the first significant act concerning the environment stewardship. It offers a comprehensive environmental definitions and meanings. The legislation consists of 11 Chapters split into 75 articles. The first chapter consists of general provisions. Chapter 2 deals with the protection of air. Chapter 3 focuses on the protection of seas and marine. Chapter 4 is about the protection of water resources. Chapter 5 deals with food security and protection, chapter 6 deals general environmental protection and social improvement. Chapter 7 focuses on the protection of diseases. Chapter 8 is concerned with the protection of soil and plants. Protection of wildlife is specified in Chapter 9. Transitional provisions are addressed in Chapter 10, where chapter 11 deals with the offences and penalties.

The legislation considers the protection of the environmental in all aspects, air, water, soil and food. It urges all authorities to implement the legislation in all sectors and industries according to Article (6) of the act. Article (7) requires the establishment of independent monitoring center to enforce regulatory compliance.

3.5.2. The Environmental Law No. 15 of 2003

The environmental law No. 15 of 2003 on the protection and improvement of the environment is basically a renewing of the Environmental Act No. 7 in 1982. It is considered the main environmental legislation in the country which is current. The legislation is made of 12 Chapters split into 79 articles. The law is an expansion of the previous act with additional details on the protection of the biodiversity. In addition, the act requires the authorities to propose plans for environment protection; contamination control; collaboration with the International Authorities on contamination control; education in environment protection; control and protection of water resources; issuance of licenses; recording of all chemicals that may cause pollution; environmental disasters; preparation of necessary legislation for the protection of the environment and research and inspection (article. 6). The Law also requires the establishment of the Environment police under article 9.

Article 9 provides for the establishment of the Environmental Police with the competence to inspect on the environment. All factories, laboratories, etc. must register amounts, potentials and components of air contaminants created by their activities. It is forbidden to burn hazardous materials in populated zones (Article 14). Hazardous materials' transportation must be authorised according to specifications in Article 15. Article 16 deals with the control of vehicles' emission.

General People’s Committee have established a Decision No. 263 (1998) to establish an environmental advisory and watch dog body called Environment General Authority (EGA). EGA was established in 2000 under the General People's Committee for Health and Environment (ESA 2011). Conservation of biological resources, sustainable development, environmental pollution and integrated planning of the community are some of the responsibilities of the regulatory, scientific and advisory body, EGA (ESA 2011). In addition to the above legislation, Libya authorities have established a number of laws related to sustainability and environmental protection which include:

- Law on the Protection of Agricultural Lands (No. 33 of 1970).
- Labour Law (No. 58 of 1970).
- General Peoples Council Decision No. 8 of 1974 – Protection and Security of Employees.
- Law on Industrial Security and Labour Safety (No. 93 of 1976).
- Decision no (81) for 1976: Model regulation to Regulate the Water and Drainage Utility at the Municipalities (28 April 1976).
- Decision no (94) for 1976: Model Regulation Related to Public Cleanliness (16 May 1976).
- Decision no (142) for 1976: Rules for Disposal of Waste Materials at the Municipalities (19 May 1976).
- Decision No. 69 0f 1980: Creation of the Planning Authority for Water.
- Law on Water Use (Law No. 3 of 1982).
- Law No. 3 of 1425 (1995) Protection of Antiquities, Museums, Old Cities and Historic Buildings.
- Law on Range and Forest Protection (No. 5 of 1982).
- General Peoples Council Decision No 790 of 1982 – Provisions of Water Use, and No 791 – Definition of Water Zones.
- Law on Public Cleanliness (Law No. 13 of 1984).
- Law on Protecting Animals and Trees (No. 15 of 1989).
- General Peoples Council Decision No. 249 of 1989 – Creation of the PA for Water.
- General People's Committee Decision No. 263 (1998) – Establishing the Environment General Authority.
- General People's Committee Decision No. 101 (1999) – Nominating the Secretary of the EGA People's Committee.
- General People's Committee instruction (22 January 2002) - Implementation of Environmental Protection Principles.
- Law on Environmental Protection (Law No. 15 1371, 2003).
- Health Law No. 106 (1973) – Details aspects of environmental protection including water pollution and sampling

3.6. Petroleum Sector Sustainability Issues and Challenges

It is clear that one of the most prominent issues facing the globe nowadays in the sustainability challenges. The environmental risks and problems have been extensively featured in the literature and media. The risks to the world require urgent actions, and Libya is not isolated from the rest of the world. This section aims to briefly introduce the key sustainability challenges facing Libya.

In Libya, it is apparent that the major sustainability issues are fundamentally associated with the petroleum industry, a contaminator by nature. Selim (2009) stated that in a legal context it is vital for the role of judiciary in the enforcement of the environmental legislation to be appreciated. Its key role has not perhaps yet been fully understood from the point of view of long-term environmental protection. Despite the existence of comprehensive Environmental Laws with their own critics, Libyan petroleum sector yet suffers various infrastructure and sustainability issues. The issue is more of compliance to the laws.

Libya, as a developing country and petroleum sector in particular suffers mainly from the lack of compliance of legislation and laws (Otman 2005; Irhoma et al. 2013). In a review of the legislations, it is evident that Libya have current and to some extent comprehensive environmental legislation, however the compliance and obedience of these articles is generally very limited and in some cases, there is no compliance at all. This issue is evident not in the petroleum sector, but rather in other sectors. Mohamed et al. (2012) stated that, detailed consideration and inspection are implemented on the aspects which have direct harm to human health such as dangerous chemical substances, food hygiene, health and safety. These aspects seems to gain sufficient attention, but on the other hand, air quality, emissions, pollutions to soil and sea seems to gain less focus (Ali & Harvie 2013). Irhoma et al. (2013) argues that the lack of focus towards these aspects of the environment are due to various factors; mainly lack of awareness towards environmental issues, lack of training and know-how on dealing with these issues.

Sustainability considerations are insufficiently incorporated in national development plans and policies, resulting in unsustainable use of natural resources for development programs. Although Libya is endowed with unique and rich natural resources, there is insufficient awareness, management, technology, and resources of environmental sustainability in fuelling and sustaining economic growth and human welfare (Tolba & Saab 2008; Irhoma et al, 2013). Selim (2004) also stated that in future years Libya will face serious sustainability challenges and the most significant challenges are those linked with the petroleum sector include: gas flaring; marine and groundwater pollution; and wastes. Chapter 4 of this thesis will review sustainability issues associated with petroleum industries and what measures have been carried out in order to control it.

Sustainability reporting is one of the challenges petroleum corporations face. Companies are asked to manage, and report the key sustainability indicators for each environmental issue. These indicators reflect significant economic, environmental and social impacts, and would essentially impact the assessments and decisions of stakeholders. There are different methods of reporting sustainability indicators in the literature (Bell and Morse, 2008; Bossel, 1999; Singh et al., 2009) however this represents a major challenge especially for those companies which lack the sustainability management infrastructure in their business management.

Another major sustainability challenge is the **lack of good governance**. There is a significant relationship between national governments and petroleum companies in which they operate in. Many countries such as Libya, Nigeria and other Middle Eastern countries relay almost comprehensively on the revenues from the petroleum industry. According to Mehlum et al., (2006) and Humphreys et al., (2011) this has led to the formation of a system which relies on “rent-seeking” and “elite capture”, and has established a governing elite in control of the country key industries, thus powering deprived governance and lack of political motivation to efficiently control the industry. This disturbs the compliance of legislations and standards in various operations of the sector due to impediment and manipulation of the leadership by parties who are beneficiaries of the dysfunctional scheme which allows and encourages of corruption, weakening of regulatory and monitoring bodies (Amundsen, 2010).

In Libya, this issue is evident and one of the major corruption drivers which has affected the whole industry sectors of the country and not only the petroleum sector. This is inherited from the previous Kaddafi regime, yet it is still followed today. Successive governments failed to curb this culture and elite control. Corrupted governance also led to the inability of civil society the petroleum sector leadership from being held responsible for not developing frameworks to enhance sustainability practices. It is important to declare that numerous efforts have been made by various individuals and groups to improve the practices of sustainability and corporate social responsibility but they did not succeed due to other challenges such as inadequate funding, and lack of leadership commitments.

However, confusion is there regarding the attentions of the Libyan government and the NOC. Although, there is a huge lack of research studies concerning the Libyan petroleum industry in general and in particular sustainability related studies, it has been highlighted that the Libyan petroleum sectors suffers serious environmental and safety issues in both the upstream and downstream operations. Despite the fact that there is a strict environmental legislation established, the compliance with these legislations is minimal.

Arguably, many aspects of upstream and downstream environmental issues are attributable more to issues of the production, processing and safe handling of petroleum products (Dare et al., 2009) and could be easily avoided or minimised by existing law enforcements. This could also suggest that another sustainability challenge for petroleum corporations is the lack of funding. In fact, this challenge affects all other business sustainability challenges. It creates poor enforcement as it can be attributed to low funding for the regulatory bodies by minimising the resources required such financial incentives, sufficient number of qualified employees and families and equipment's. It could be argued that despite that fact that Libyan petroleum sector is a wealthy sector, budgets concerning sustainability related aspects is very low and neglect able.

Increasing customer awareness about sustainability and green products is increasingly contributing to the business improving their sustainability performance especially in the developed world. It could also be assumed that that the Libyan consumer awareness of sustainability is very low as a result of the country's political system and structures in the past which prevent the creation of free NGOs that can report on rising issues in different sectors. Furthermore, due to the political regime in Libya, the country has a massive gap of civil society organisations and NGOs establishments. These are all factors contributing to the lack of petroleum companies' attention towards sustainability.

Advancement is technology is considered to be one of the key solutions in minimising sustainability issues. Petroleum industry relies significantly in technology advancements and it seems that technology improvements generally focus on reducing cost and increasing operational efficiency. Recently, various petroleum giants such as BP, ExxonMobile Shell initiated various programs to improve environmental performance. Again, and not surprisingly, Libyan petroleum companies do not have any technological advancement in their agenda to enhance sustainability practice which makes technological advancements another challenge for Libyan petroleum industry. It is argued that large petroleum corporations which specialise in the petroleum operations for many years such as Shell, BP and

ExxonMobile have been largely criticised of their sustainability practices and their stewardship towards the environment (Escobar and Vredenburg, 2011).

The argument here is that if the massive global petroleum giants such as BP, Shell and ExxonMobile are widely criticised for their stewardship towards the environment, this means it should not be surprising that Libyan national petroleum companies who lack the infrastructure, technology, the know-how and the experience compared to the big corporations do not have sustainability in their agenda. Petroleum companies certainly have a lot to do in order to improve their environmental sustainability practices. Attah (2010) argued that sustainable growth can only be attained through the integration of policies that connect the economy, environment and the society.

Thus, it could be argued that there are various factors which affect any organisation in which it reacts to sustainability. These factors include: political aspects in which the organisation operates; the organisation culture; the management and leadership of the organisation; the technological infrastructure; and the organisation's financial capabilities. It is no doubt that the political situation of the country has major influence on the strategies of any particular organisation. For instance, petroleum companies operate in the UK will have to obey the governing legislations of the UK and align their business policies and strategies with the UK strategies.

In Libya, it seems that companies are also influenced by the political system in Libya as the ex-political system does not directly seem to enforce or encourage petroleum companies to minimise their environmental impact and enhance their sustainability practices. Furthermore, the business leadership and management is a significant factor in which the business operate. If sustainability is integrated as a business goal in the business strategy, tangible sustainability improvement will be gained. Also business culture, employee awareness and technological and financial resources are also major factors. These factors have not been studied in the Libyan petroleum industry, and there is a clear gap.

3.7. Chapter Summary

This chapter provides information about Libya in general and the Libyan petroleum industry in particular. It will explore the historic and current economic, political and environmental characteristics within Libya in order to gain a better appreciation of the context of the study and build a basis to interpret the current sustainability picture of Libya. The chapter was divided into two section, the first section introduced Libya as the operating environment where the petroleum industry plays a significant role in the development of Libya. The second section explored the Libyan petroleum sector and its upstream and downstream operations.

Libya is a rich country with various natural resources. It has many advantages including its strategic location near European markets, availability of high crude oil and gas reserves. This chapter provided an overview of Libya and the petroleum industry. It gave a glance of the Libyan petroleum companies and its stakeholders to provide the basis of the following chapter to investigate sustainability issues and challenges and the measures to be taken in order to tackle these issues. The next chapter presents the research methodology that was adopted for this thesis.

Chapter 4
Research Methodology

4.1 Introduction

This chapter offers a detailed overview of the philosophical assumptions made for this project and the research methodology followed to achieve the research goals. It clarifies the suitability of the realism paradigm employed in the study.

The chapter starts with an overview of various philosophical assumptions and follows up with the research methodology selected for this project. It also critically evaluates the factors used in selecting the methodology and highlights the relationship between the methodology and research goals. The discussion and critical evaluation included in the chapter are to ensure a valid, suitable and strong research methodology is applied throughout the project. It will justify the use of the methods of this research and the validity and reliability of the interviews, case studies, EIA, LCA and the questionnaire are also addressed.

The whole research process is explained detailing the design, strategy and the research methods backed with justification for the selection.

4.2 Sustainability Management as the Field of this Study

It is important to select the correct methodology when undertaking a research project. It is vital to use a set of methods to ensure the research project questions, aims and objectives are attained, leading to valid and reliable conclusions (Yin, 1994). The knowledge gained has various types, descriptive or exploratory (Yin 1994). It is highlighted by Goodland (1995) that environmental sustainability management is a fairly new concept in research in which this study is situated. Fahy and Rau (2013) indicate that methodological pluralism based on numerous methodological and philosophical paradigms is used in sustainability management research. Hence, it was noted that general strategies have progressed from social and natural sciences that are used in the environmental management research. In other words, quantitative and qualitative data collection methods are being used.

Plenty of acknowledged research methods which can contribute to knowledge were developed. Thus, it is important to understand the philosophies on which these methodologies are based and founded upon. However, philosophical grounds cannot be used alone to test the suitability and practicality of a certain research design but aspects of applied research are important to select which method is suitable for certain studies.

4.3 Research Paradigms and Theoretical Assumptions

A research paradigm as described by Bryman and Bell (2011) is what guides the research design as well as the presentation of the study results. Bryman and Bell (2011) pointed out that several paradigms have been developed in the social and natural sciences. It is argued by Knight and Ruddock (2009) that environmental sustainability management draws from both the social and natural sciences. Goodland, (1995) points out that environmental sustainability can be considered as a discipline which is based on natural sciences, thus positivism.

The definition of positivism as reported by Bryman and Bell (2011) is “a discipline is hinged on natural science, thus positivism. Positivism is defined as “an epistemological position that advocates the application of the methods of the natural science to the study of social reality and beyond” (Bryman and Bell, 2011 p. 15). Positivism favours all knowledge according to Knight and Turnbull (2008) as tied to observational forms of verification and methodologically founded on scientific experiment. However, human element is associated with environmental sustainability research as it incorporates both nature and humans.

Before looking where this research is situated within the research paradigms, it is important to understand ontological and epistemological assumptions of this research, and a comparison between positivism and interpretivism. Research theory is influenced by the ontology and epistemology of the study. Ontology is the nature of reality where epistemology is the relationship between the researcher and the reality (Carson et al. 2001). Dainty (2008) points out that objectivism and constructivism are the extremes of ontological positions of research. Objectivism research is about the independence of the social phenomena of the social actors whereas constructivism is when the social phenomena is being investigated by social actors (Bryman and Bell, 2011). This implies that a social phenomenon is in a constant state of revision. Hence, it is vital to understand the difference and the impact these paradigms have on the research process.

Epistemology is associated with the knowledge of a specific discipline. Epistemology of research is also classified into positivism and interpretivism similar to the ontological paradigm. Fellows and Lui (2008) believe that researchers need to base their research studies on a clear ontological and epistemological stand so that contribution to knowledge can be claimed. Positivism believes that there is a single, objective and external reality to a research question regardless of the opinion of the research (Hudson and Ozanne, 1988). The positivists use a structured and controlled approach in conducting research, in this context the researcher is detached from the participants of the research. Positivists use quantitative research as a central method as they adhere to specifically structured research techniques (Harwell, 2011).

Creswell, (1994) discusses two types of paradigms namely, quantitative and qualitative. Another attitude distinguishes between two types of paradigms: positivism and interpretivism (Collis and Hussy, 2003; Knight and Ruddock, 2009). Others, (Burrell and Morgan, 1979) however, categorise four paradigms, namely: radical humanist, radical, structuralism, interpretive, and functionalist.

The major two paradigms are:

- The quantitative paradigm which also known as the positivist, traditional, empiricist paradigm. The quantitative paradigm aims to develop understandings that contribute to the theory and that allow one to better predict, forecast, explain and comprehend some phenomenon.
- The qualitative paradigm which also known as the naturalistic and the constructivist. This paradigm relies on information gained from human attitudes and opinions.

Though these differences are heuristic devices, rarely do actual studies demonstrate all of the ideal characteristics of either paradigm (Creswell, 1994). Therefore, Sustainability Management subject matter necessitates multi-paradigms. This is because Sustainability Management is not only limited to facts (product and process technical issues and environmental indicators and impacts) but also comprises the participants' perceptions (i.e. management commitments, organisational policy and culture).

In the context of this research study, the multi-paradigm utilisation is essential due to the fact that environmental sustainability management, (the field of study) is viewed as both a natural science (i.e. positivism and quantitative strategy) but also highly influenced by participants' opinions, behaviours, management and attitudes (social science). The contrasting epistemology to positivism is the Interpretivism.

Interpretivists believe that the reality is relative and multiple. In particular, the human action is what is being understood by this paradigm rather than the forces that influence it. It uses qualitative methods such as interviews and observational research to understand human activities. The following table presents the differences between the two epistemological positions according to Easterby-Smith et al. (2008).

Table 4.1: Opposite suggestions of positivism and Interpretivism (Easterby-Smith et al. 2008)

	Positivism	**Interpretivism**
The observer	Independent	Is part of what is being observed
Interest of humans	Should be relevant	The main drivers of science
Explanations	Need to show causality	Intends to improve general understanding of the situation
Research progresses through	Hypotheses and deduction	Colleting rich data from ideas
Concepts	Need to be operational so that they can be measured	Should include stakeholders perspectives
Units of analysis	Should be reduced to its simplest terms	May include the complexity of 'whole' situation
Generalisation through	Statistical probability	Theoretical abstraction
Sampling requires	Large numbers selected randomly	Small numbers of cases selected for specific reasons

The assumptions of quantitative and qualitative paradigms are founded on diverse ontological and epistemological tactics. This argument has directed limited debate toward the interaction of ontological (denoting to the metaphysical nature of being) and epistemological (denoting to the theory of method or bases of knowledge) concepts. Ontology refers to the conceptions of reality (Bryman and Bell, 2011). Bryman and Bell (2011) divide ontology into two main streams:

- Objectivist Ontology: Realises social phenomena and their meanings as standing independently from the researcher;
- Constructivist Ontology: Concludes that social phenomena are created through social interaction and are in a constant state of revision.

There is another ontological type which is the multiple realities which stands in any given situation (Creswell, 1994). The author proposes taking this multiple reality stance as a suitable approach for encompassing the scope of Sustainability Management. Subsequently, the ontological issue is about what is real, the quantitative scholars view reality as objective, which can be realised and measured quantitatively and objectively by using one or more of the available method such as, questionnaire, interviews, or case studies. Hence, for sustainability management, the participants' rational (i.e. participants' opinions) produces issues that have no counterpart in natural science.

In this regard, reality is partially personal, subjective and numerous as viewed by participants in study. For example, an essential issue concerning sustainability management integration in the petroleum industry is about foreseeing human behaviour and tactics to ecological values which may be not exclusively clarified scientifically. Epistemology denotes to what should be viewed as satisfactory knowledge (Knight and Ruddock, 2009). According to Knight and Ruddock (2009), contemporary epistemology is divided into:

- Empiricism, where any belief can count as knowledge if, and only if, it is grounded in sets of actual or possible experience.
- Rationalism, as opposite to empirical knowledge, often originates subsequent to experience.

Sustainability management as the subject under study does not represent all of the ideal characteristics of either paradigm (positivist 'quantitative', and interpretivist ‘qualitative’). This is due to the fact that Sustainability Management as a field is underpinned from ecological natural science and at the same time, is highly influenced by social science. In other words, SM is not only limited to facts (quantified environmental indicators and impacts, product and process technical issues) but also comprises the participants’ perceptions (i.e. management commitments, organisational policy and culture). Therefore it is deemed appropriate to the author to take multiple reality stances as a suitable ontological approach for extending the scope of Sustainability Management. In regard to the epistemological considerations, the author is independent from what is being studied, and he has to be in control of bias, choosing samples, and be objective in evaluating a situation.

It is important to note that the ontological and epistemological issues are not limited in the research approaches but also founded on the type of the method(s) to collect the data. Philosophical assumptions also influence the methods selected. Recker and Niehaves (2008), for example, claim that interview research method (semi-structured) can be utilised in both positivism and interpretivism approaches. Case studies are claimed to have similar validity in both approaches.

Despite the fact that positivism and interpretivism are opposing sets of philosophies about the nature and understanding of knowledge, in both, epistemologies interviews and case study methods could be used. This is due to the flexibility of these methods. For example, from an interpretivist stand, in order to understand the complex nature of a topic, semi-structured interviews are used so that the social context and natural settings are taken into consideration.

In contrast, positivism uses interviews to measure a participant’s perception about pre-defined factors as well as exploring the association between paradigms (Recker and Niehaves, 2008). The qualitative approach (Interpretivism) is also used when conducting an exploratory approach (especially in the identification and exploration of human related issues such as employee perception, opinions, attitudes and factors in the use of sustainability approaches in petroleum industry). For the purpose of this thesis, interpretivism will be used to guide this study.

Developing a conceptual sustainability management system for petroleum companies to enhance the environmental sustainability performance is at the very core of this research. In order to develop the system, a detailed understanding of the existing environmental sustainability related issues (management and organisation culture) are investigated and understood. Furthermore, there is a need to investigate and understand the management and employee perception and attitudes regarding sustainability in general and sustainability approaches in particular. Thus, it is to "understand human behaviour", qualitative research approach (interpretivist) is deemed suitable for this kind of research.

On the other hand, the development of the sustainability management system require an understanding of all sustainability related issues, and a major part of these issues is related to technical engineering, product and process problems which need more of an empiricist technical procedure and tools to assess and quantify the environmental problems. Furthermore, it is essential in developing the SMS to use quantitative environmental tools to quantify and estimate the scale of environmental issues from an engineering and technical stand. Thus, the major part of this research is classified under the banner of positivism (quantitative approach).

In addition, when investigating sustainability related issues from the human perspective, it is necessary to measure the participant's perceptions and attitudes using quantitative methods. As highlighted above and based on the aim and objectives of this study, it could be assumed that this study is suitably situated mostly within Interpretivism and certain aspects of the research will be following the positivism approach. It is deemed an excellent practice to use a mix method approach (quantitative and qualitative) to strengthen the research findings and follow inductive approach.

4.4 Research Design

Choosing a robust and precise research methodology is an important academic practice when conducting a research project. The methodology is defined as "a way of thinking about studying social reality" (Strauss and Corbin, 1998). In other words, the methodology is the means by which the research aim and objectives can be successfully achieved and results authenticated (Fellow and Liu, 2008). The research design is explained by Bryman and Bell, (2011, p. 718) as "*a framework for collection and analysis of data*". Mensah, (2013) states that the purpose of designing the research is characterised into two categories:

- The research aim and objectives;

- ❖ The type of contribution the research proposes to make to the body of knowledge.

4.4.1 Methodological Approach

In order to accomplish the objectives, this section describes the research methodology. Creswell, (1994) states that the research methodology is the whole process of a study. Collis and Husey (2003) claim that the methodology governs the entire approach to research. The methodology covers the philosophical assumptions and values that lead to the rationale of the study and criteria the researcher relies on for analysing and interpreting data and findings. The research methodology works as a control standard in determining the level of evidence and data needed to create knowledge. Creswell, (1994) provides three methodological approaches discussed below:

a) Deductive quantitative research approach. This relies on deductive approaches of testing defined hypothesises in a cause and effect flow. Normally, the deductive approach includes pre-defined selection of what data to use. It relies on quantitative research methods.

b) Inductive qualitative research approach. This follows the inductive research logic, from the general to the specific and comprises qualitative analysis which is tested inductively. Certain aspects are influenced by intuition. The approach uses qualitative research methods (Love et al., 2002).

c) Triangulation, which is also called the mixed method approach. It is the utilisation of the deductive research logic (quantitative methodology) to support, authenticate and corroborate the inductive research logic (qualitative methodology) and vice-versa (Mingers and Gill, 1997)

In the context of this research project, the third research approach, the triangulation, is viewed as suitable. The research process begins purely from an inductive qualitative research stand point then moves to a more quantitative inductive approach. The study is categorised under both descriptive and explorative research from the point of view of the kind of knowledge the research determines.

The study also uses quantitative methods for certain objectives. It comes under the descriptive banner since it explains and addresses practical industrial and management problems related to petroleum sustainability practices (initially started from theory and literature). Consequently, the study described the existing problems (reality).

The research is also explorative, from the logic that it largely explores existing sustainability and environmental management practices and approaches to develop an innovative and specific Sustainability Management System (SMS) for Libyan petroleum companies. Hence, this study involves “explorative research”.

4.5 Research Strategy

The research strategy is the broad general orientation considered in conducting research (Robson, 2011). The strategy of the research usually indicates the methodology and the mixture of techniques used to investigate a precise situation. Research strategy is established based on the research philosophical assumptions and paradigms accepted by the researcher and deemed suitable for knowledge enquiry relevant to the research study. The strategy for data collection is categorised in two different classifications, namely: qualitative and quantitative approaches. The following Table 4.2 displays the differences between these strategies.

Table 4.2: Difference between quantitative and qualitative

Quantitative	**Qualitative**
Numbers	Words
Opinion of researcher	Opinion of participants
Researcher distant	Researcher near
Theory testing	Theory emergent
Static	Process
Structured	Unstructured
Generalisation	Contextual understanding
Hard, reliable data	Rich, deep data
Macro	Micro
Behaviour	Meaning
Artificial settings	Natural settings

In its place, Hunter and Kelly (2008) offered a meaningful classification among the strategies and relevant methods as shown in figure 4.1.

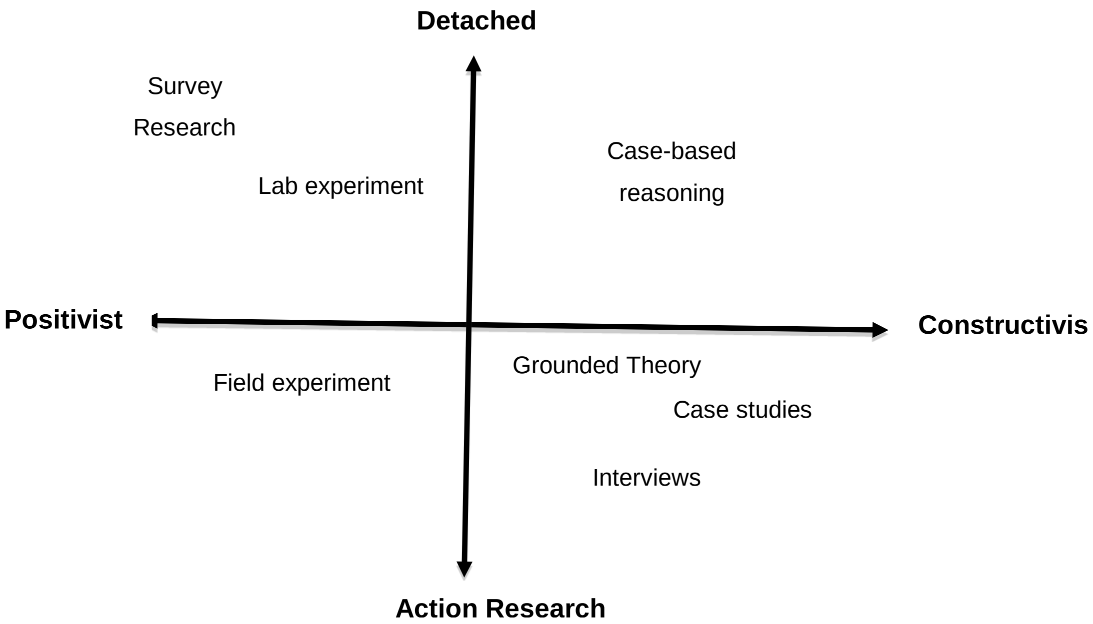

Figure 4.1: Research strategy (Hunter and Kelly, 2008 p. 87)

The nature of this research recommends that the strategy to be implemented is the triangulation, qualitative and quantitative strategies (mixed method approach) with more dominance for the qualitative strategy, constructivist and post-positivist approaches. Nevertheless, the quantitative strategy (positivist approach) is applicable to certain sections of the study methodology to authenticate and confirm results as deemed appropriate.

The study uses methodological triangulation as it also contains quantitative research. The triangulation research is deemed appropriate due to the nature of the research goals. The research begins with purely deductive qualitative approach. The literature review Chapter identified a research gap. It then moved onto an explorative field work in a form of a case study and semi-structured interviews. These illustrate from the participants (Libyan petroleum sector employees) the real problems in place. It fully relies on the deductive research logic because the variables and issues identified are contextual, intangible and associated with the participant’s attitude, awareness, opinion and the organisation management and culture. After beginning as a deductive study, the scope of the research moves towards an inductive quantitative approach to strengthen and verify the findings of the qualitative approach.

The triangulation approach (mixed method approach) has been widely complimented by research methods scholars (Bryman and Bell, 2011; Denzin, 2012) as it allows researchers to tackle the research question from various relevant angles and having more than one investigative perspective. Many research studies owe their validity and existence to the methodological triangulation approach. Triangulation is also well-regarded because it can offer the best of the both worlds. In-depth, natural and contextualised understandings of qualitative research linked with more efficient, specific and persuasive power of quantitative research (Teddlie and Yu, 2007). Denzin, (1970) describes four types of triangulation;

- Methodological triangulation: this is the mixed method approach which compromises the use of both qualitative data and quantitative data.
- Triangulation of theories: using theories from one discipline to be applied to describe phenomenon in another discipline.
- Data triangulation: this is concerned with collecting data from multiple different sources in different times.
- Researcher triangulation which is concerned with different investigators researching the same phenomena separately and comparing the findings.

In the context of this study, the research uses methodological triangulation. This approach uses quantitative and qualitative approaches in the same study. Creswell, (1994) argues that there are three models for joint triangulated designs which are:

- Two-phase design approach. The researcher conducts clearly separate approaches in two distinct phases.
- Dominant-less dominant design approach. The researcher conducts the research using a single dominant paradigm with one minor component of the research drawn from the paradigm.
- The mixed-methods design. This approach uses the highest mix of methods among paradigms at various methodological steps of the design.

In this study, a multi paradigm is utilised with a mixed method of dominant and less dominant design approach (i.e. qualitative (dominant) and quantitative (less dominant). Maxwell (1994 p 21) states that the main goal of qualitative research is to address practical issues. It is beneficial in: (1) producing findings and theories which are experientially reliable and comprehensible; (2) providing in depth and detailed findings and analysis by investigating attitudes, feelings and behaviour, therefore works well with complex data; and (3) appealing in collaborative research with researchers or participants. Therefore, this research study, like numerous other exploration studies, is implemented dominantly using the qualitative strategy with some use of quantitative strategy. Easterby-Smith et al., (2008) point out that embracing a qualitative methodology is associated with applied research that aims to investigate a precise problem which is the case of this study.

Qualitative research scholars have suggested numerous data collection strategies to be utilised and classified on the type of analysis they imply. Farrell (2011), Hancock et al, (2007) and Hunter and Kelly (2008) provide various qualitative data collection approaches which include: (1) action research, (2) case studies, (3) surveys, (4) discourse analysis, (5) experiments, (6) ethnography, (7) content analysis, (8) grounded theory, and (9) narrative analysis. Yin (2009) categorises them into: (a) experiment, (b) survey, (c) archival analysis (d) history and (f) case study. The qualitative methods are discussed further in the following sections.

Similarity, quantitative research strategies and methods according to Yin, (2009) and Yoshikawa, et al,. (2008) include: (1) questionnaires, (2) interviews, (3) observational research, (4) documentary research, (5） experimentation. This approach pursues the factors of social phenomena with little consideration of the individual subjective state. Consequently, the positivist approach improves the objective logical reasoning in examining the research problem. The quantitative strategy used is further detailed in the following sections (Collis and Hussey, 2003).

4.5.1 Qualitative Strategy

The research ontological and epistemological assumptions were reviewed and it was concluded that the main research approach for this study is the mixed method approach (methodological triangulation) with higher dominance for the qualitative interpretivist approach. Thus, this section discusses the considerations of qualitative strategy used for this study.

In simple terms, the central principle of this study is to investigate and explore sustainability related issues, impacts and barriers in order to create a sustainability system to solve the issues and enhance the sustainability performance. This idea has little support in the literature. For that, the research project adapts a two-phase design approach, beginning with the qualitative approach. Qualitative research is defined as "*any type of research that produces findings not arrived at by statistical procedures or other means of quantification*" (Strauss and Corbin 1998 p. 10). The qualitative research focuses on what "real life" is like as it concentrates on naturally happening, ordinary events in natural setting (Maxwell, 1994 p. 17). The qualitative methodology has its own merits and strengths and is not just an opposing method to the quantitative strategy.

The key strength of the qualitative strategy is gained from its inductive reasoning approach as it focuses on people or situations. The qualitative inductive approach is investigative and explorative in nature concerning the attitudes and behaviours of the participants and the issues. This study is a perfect example, which focuses on a specific problem within the petroleum industry (i.e. environmental sustainability management). This viewpoint of this study is contrary to the traditional methodologies regarding environmental sustainability management. The latter is based on numerical and statistical procedures, maybe due to the assumption that all environmental sustainability issues are the same and only quantifiable.

Research studies concerning these environmental sustainability are mostly quantitative, thus do not allow policy makers and managers to understand their social reality. Invention is the principal goal of qualitative research while understanding can be described with the results of this type of research as highlighted by Easterby-Smith et al (2008). Bryman and Bell, (2011) point out that being qualitative is what distinguishes explorative research. Hence, this is also very convenient for this study.

It is important to note that the focal point of this study is understanding the natural reality in the context of environmental sustainability management. Thus, the experiences and the viewpoint of participants (employees) are essential to the understanding of the issue wholly. Maxwell (1994 pp. 17-18) argues the key objectives of the qualitative strategy is to understand the meaning and specific context within which the participant acts and behaves. In addition, qualitative research helps understands the process by which events and actions take place and aids the development of causal explanations. Quantitative scholars focus more the relationship between two variables or factors and to what extent each variable affects the other. On the other hand, qualitative scholars are more interested in understanding how variable ‘A’ causes ‘B’ and how both variables are connected (Maxwell, 1994 pp. 17-18)

It is claimed by Miles and Huberman (1994) that qualitative research has fullness and holism with a good ability of exposing complexity which offers “thick descriptions” that are put in a real context. This is very consistent with this study in which an integrated sustainability management system developed to reduce the environmental impacts and encourage organisations to adopt sustainability practices in Libya, also affects the sustainability picture more globally. As a result, qualitative research was deemed suitable for adoption and its implementation is discussed below.

4.5.1.1 Implementing Qualitative Research

There are six key stages in conducting qualitative research as recommended by Bryman and Bell (2011) (see Figure 4.2). These stages are also supported by Strauss and Corbin (1998) and were referred to as a grounded theory. Grounded theory is “*theory that was derived from data, systematically gathered and analysed through the research process*” (Strauss and Corbin, 1998: p. 12).

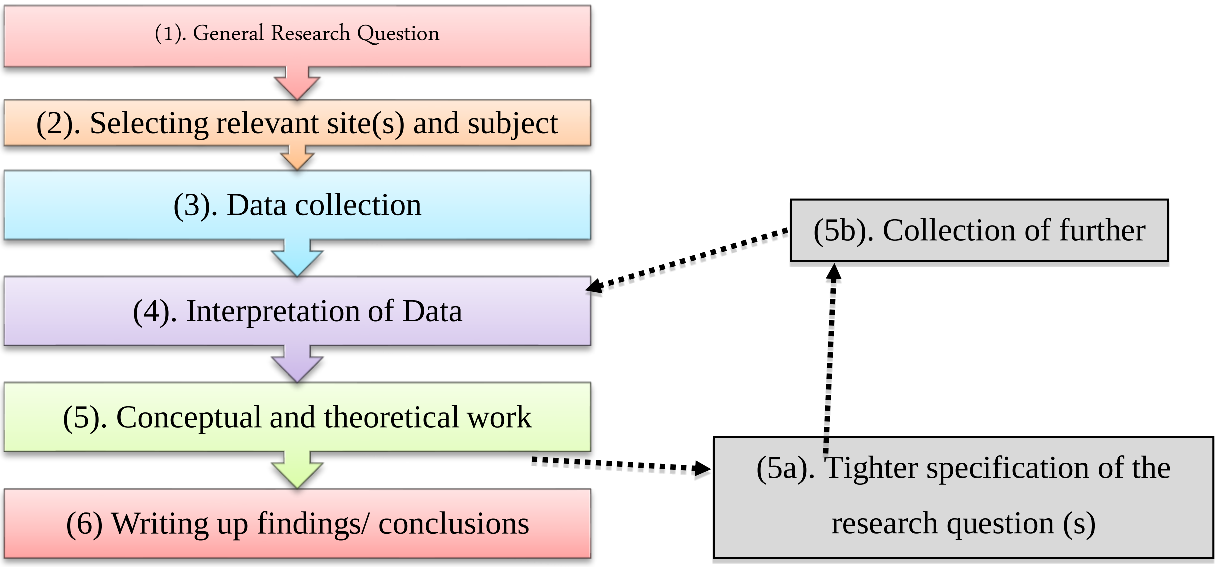

Figure 4.2: Qualitative research implementation

4.5.1.2 Limitations of Qualitative Research

There are numerous limitations of the qualitative strategy mainly put forward by opposing positivists (quantitative researchers). A list of these criticisms are provided by Bryman and Bell, (2011) which include: (1) too subjective, (2) hard to replicate, (3) lack of transparency, (4) difficult to generalise findings. Easterby-Smith et al. (2008) provided an overview of the limitations that are associated with the qualitative research approach, as did (Strauss and Corbin 1990; Yin 2009; Night and Ruddock 2009; Bryman and Bell 2011; Farrell 2011; Easterby-Smith et al. 2008). Strengths and weaknesses of qualitative research are highlighted in Table 4.3.

Table 4.3: Strengths and weaknesses of using qualitative research approaches (Easterby-Smith et al. 2008)

Strengths	**Weaknesses**
Good for process and meaning	Time consuming
Good for theory generation and flexible	Difficulties in analysis and interpretation
Data collection less artificial	Credibility issues with policy makers (based on subjective opinion)

4.5.1.3 Evaluation of Qualitative Strategies

This section discusses the appropriateness of strategies for this research.

- **Grounded theory**

Grounded theory is a "*methodology that involves a systematic process of gathering and analysing a finite set of data to develop a theory based upon the data*" (Hunter and Kelly, 2008: p. 86). The term "grounded" is used to highlight that theory is extracted from the data but not from assumption or preconceived ideas. Grounded theory according to Hunter and Kelly, (2008) is an inductive research which is unlike ordinary scientific research methods. Typical data collection methods of grounded theory are interviews and literature. It is possible to conduct interviews and carry field research in case studies to create theory. This falls under the banner of grounded theory, nevertheless, there is a difference between the collation of data and the analysis.

In grounded theory, the data collation and analysis are conducted simultaneously. Meaning that the analysis in carried out in conjunction with the collection which makes the research very involved in research and lead to the results to be very subjective and subject to bias. This is one of the main disadvantages of grounded theory as identified by Dainty et al. (2000). Other drawbacks of grounded theory include; high amount of data accompanied with extensive analytical processes and a very complex procedure.

Creating theory is the key goal of grounded theory in regards to the contribution of knowledge. In this study, even though the theory generation is required, the focal point is to use the findings (theory) to develop the sustainability management system. Thus, it is deemed unsuitable to implement grounded theory, yet its data analysis technique is viable for this study.

- **Interview**

Qualitative research interviews seek to describe both the factual information and the meaning level (Kvale, 1996). It is very useful in gaining insight of the interviewee's experiences as it allows in depth information surrounding a topic. Yin (2009) categorises interviews into in-depth interview, focused and structured. This categorisation is also consistent with Bryman and Bell, (2011) of unstructured, semi-structured and structured interviews. However, Bryman and Bell, (2011) further categories them into quantitative interviews (structured) and qualitative interviews (unstructured & semi-structured).

The unstructured qualitative interviews are very similar to a conversation. The interviewee in this type of interview is given the chance to respond freely to a single general question where the interviewer could guide the interviewee to clarify various points along the conversation. It is argued that the interview is a guided conversation where the research tracks a line of queries (Yin, 2009). In a semi-structured interview, there are specific areas of enquiry pre-defined by the interviewer which is also known as the interview guide. The advantage of the unstructured and semi-structured interview is their flexibility but they have the limitation of failure to reproduce. Yin, (2009) states that in addition to the key purpose of the interview which is generating information for the inquiry, the environment should be friendly and non-aggressive for the participant.

For this study, the qualitative interview approach (unstructured and semi-structured) is believed suitable. This study sets out to critically investigate the industrial sustainability related problems which needed detailed focused interviews. Qualitative interviews (semi-structured and unstructured) were deemed appropriate as they strengthen the evidence and improve the reliability of the findings (Yin, 2009; Bryman and Bell, 2011).

- **Case Study**

Another applicable qualitative method is the case study. Case study is defined as "an empirical inquiry about a contemporary phenomenon (e.g., a "case"), set within its real-world context especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2009: p. 18). Case studies are not completely qualitative, but they have been widely utilised. Baxter and Jack (2008) argue that case studies are appropriate when addressing a descriptive question (i.e. what is happening or what happened?). In addition, case studies are also favourable approaches when the emphasis is on a phenomenon within its real world context. Case study methods choose the collection of data in ordinary locations, compared with relying on "derived" data (Bromley, 1986, p. 23).

It is highlighted that case study research is very appropriate for a project driven industry which is made up of various sections, projects and organisations. The petroleum industry in Libya is multi-phase involving a collection of upstream and downstream operations and projects, case study research is therefore deemed very appropriate. The case study research is extensively exploited in different disciplines including social science research so that social, organisational and individual aspects of phenomena can be investigated (Robson, 2011).

4.5.2 Quantitative Strategy

This research study is predominantly classified under the qualitative strategy, however as it follows the mixed method (approach triangulation), this section introduces the quantitative strategy and its methods adopted for this study.

Quantitative positivist paradigm pursues the factors of social phenomena with little thought of the researcher's subjective state. Therefore, the positivist approach improves objective logical reasons in exploring the research problem. The quantitative approach could work as a mitigation measure to the limitations of the qualitative methodology utilised in this study. Collis and Hussey (2003) highlight that the positivist approach is linked with four key kinds of research; Cross-sectional studies, experimental studies, longitudinal studies, and surveys. Creswell (1994) states that quantitative methods are of two kinds; experiments and surveys. Surveys using structured interviews or questionnaires. These include cross-sectional and longitudinal studies with the purpose of generalizing from a sample to a population.

- **Survey Research**

A survey is a positivistic methodology whereby a sample of subjects is drawn from a population and studied to make inference about the population (Hussey and Hussy, 2006). The authors discuss two main types of surveys:

1) Descriptive surveys, this type of surveys is concentrating on recognising and counting the occurrence of population, either at one point or numerous times for evaluation.
2) Analytical surveys, which aims to find out if there is any relationship among dissimilar variables.

In the context of this study, survey research is a quantitative research method to provide a basis of knowledge, generated by data from the Libyan petroleum industry to allow the qualitative interviews to be conducted in more specific and tailored procedure. The type used for this research is “analytical surveys” due to the fact that it aims to assess the awareness of sustainability management systems and approaches, performance improvements towards sustainability and the management and employee relationship and their practices. Further details will be provided in the survey results chapter.

The research study utilises a mixed method approach (triangulation) as a research design with higher dominance for the qualitative over the quantitative research strategy. Selected research strategies following the research design are shown in Figure 4.3.

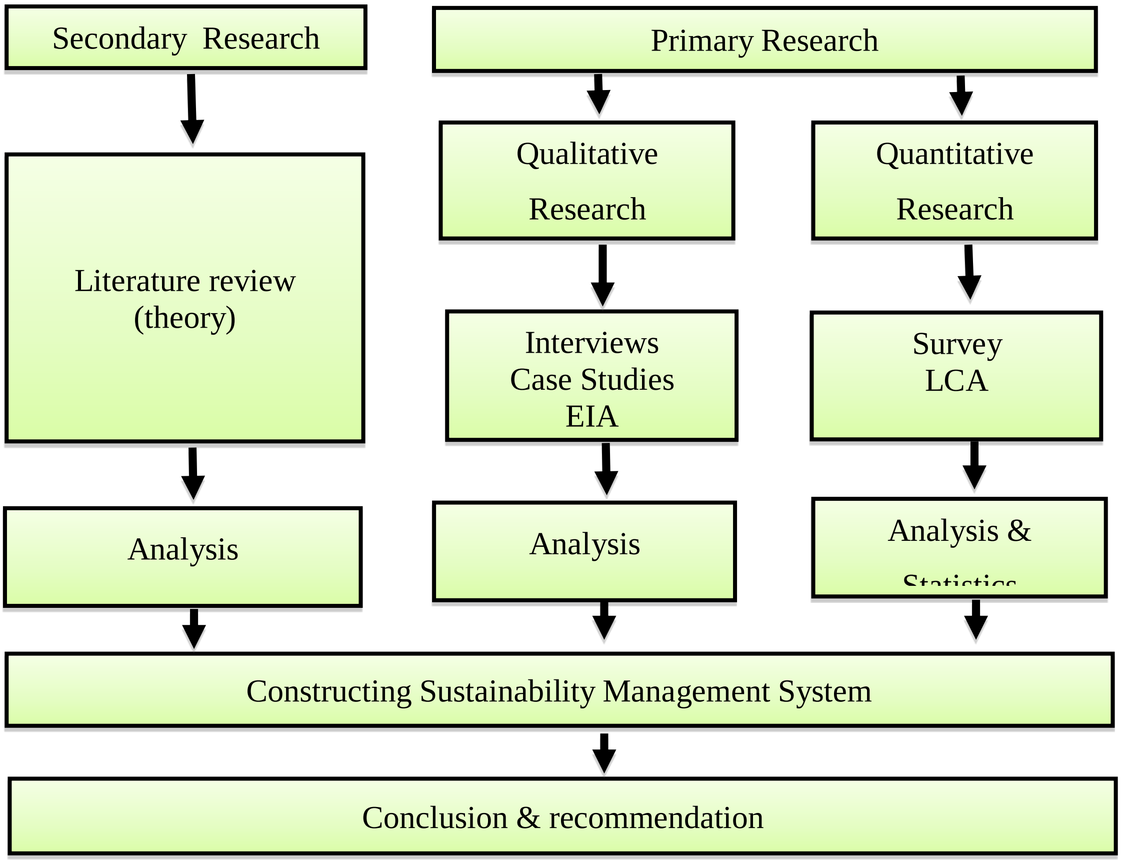

Figure 4.3: the research design

4.6 Research Methods

Bryman and Bell, (2011) point out that research methods are techniques in which specific tools are used to collect data. Among the tools which can be used include literature documentary data, surveys, interviews and observations. The study research questions play a significant role as deciding criteria of the research instruments as argued by Strauss and Corbin, (1998) and further validated by Yin, (2009).

It is common that explorative research similar to this where research questions address the "what" question normally follows the qualitative approach (Neuman, 1994 and Robson, 2011). Yin, (2009) adds that if the "what" question is explorative research, any research strategy could be applied. Interviews are one of the most commonly applied methods in the qualitative research (Patton, 2005). Proverbs and Gameson (2008) argue that case studies are very pertinent to project driven industry (i.e. petroleum industry) and it is a favoured technique when "how" or "why" questions are introduced (Yin, 2009). In the context of this research, this fits well with the research questions and objectives.

Nevertheless, the selection of the research methods is not necessarily controlled by the type of the research question, as methods have their own merits and limitations. Therefore, it is important to take into consideration the practical strengths and weakness of the research methods in relation to the study e.g. time, resources, funding and access to data (Farrell, 2011). The research methods used must be sufficiently and precisely utilised so that deficiencies are minimised and key elements are not missed in the research investigation process.

4.6.1 Selection of Data Collection Methods

As stated above, the study aims to critically investigate existing sustainability problems associated with Libyan petroleum operations to enhance their sustainability practices and to develop and evaluate a sustainability management system. To accomplish this, there is a need to collect data using numerous methods.

It is deemed appropriate for this study to utilise the mixed method approach with more dominance to the qualitative research strategy. Qualitative methods to be used for this research are interviews (semi-structured and unstructured) and case studies. Environmental Impact Assessment (EIA) which is conducted in a case study format, is assessed qualitatively and is also utilised in this research. Quantitative data collection methods are also used mainly to collect the bulk of the data. In addition, another technical quantitative tool (Life Cycle Assessment) is used to strengthen the results of the research and it is believed this can be classified under the banner of quantitative strategy. These methods are designed and used to help achieve the research aims and objectives

- **Interviews**

Interviews are generally classified as unstructured, semi-structured and structured (similar to the questionnaire) (Bryman and Bell, 2011). The most widely utilised type is the semi-structured interview. Semi-structured interviews are semi-controlled by the interviewer. In other words, the interviewer uses a pre-established interview protocol to guide the direction of the interview course, yet the interviewee is made to feel comfortable to express in depth explanation of the topic under study which in most cases might lead to new questions and further understandings. The interviewer's opinion must be kept vague. Interviews allow in-depth understanding of the topic which can be difficult to establish by other means such as questionnaires. The following table demonstrate the advantages and disadvantages of interviews.

Table 4.4: Advantages and disadvantages of interviews (Robson, 2011; Recker, 2008 p. 109)

Advantages	**Limitations**
Used for issues and thematic analysis	Time consuming
Useful for small samples	Training for interviewer (personal skills and sensitivity) is preferable
Allows subjects to speak for themselves	Normally needs transcribing
Permits teasing out underlying issues	Potential lack of precision
Allow collection of rich and deep knowledge	Need for rigorous thematic analysis
Can serve as foundation for extending the study, e.g. formally test the emergent patterns and relationships	Time, trust and confidentially

Semi-structured interviews are very popular and widely used by qualitative researchers. This is due to their usefulness in gathering rich and in-depth data. Yin, (2009) argues that the interview method is used for methodologies such as action research, ethnography and grounded theory. Mensah, (2013) states that interviews are mostly used in case study research.

- **Case Study**

The consideration of using a case study as a research method stemmed from the fact that case studies are excellent methods for researchers to study complex phenomena within their contexts. It includes in-depth and detailed examination of a subject of study (the case), as well as its related contextual conditions. Yin, (2003) argues that it permits the researcher to investigate individuals or companies, simply through complex interventions, relationships, communities, or programs. Yin, (2009) states that the case study approach is appropriate when considering (a) the focus of the study is to answer "how" and "why" questions; (b) it is possible to influence the actions of those included in the study; (c) there is a need to go through contextual situations since they are deemed relevant to the phenomenon under study; or (d) the boundaries are not clear between the phenomenon and context. Baxter and Jack, (2008) add that case study is very useful especially in the situation where the understanding of the topic under study (case) is fully considered within its natural occurring context.

There are various data collection methods for case studies which include according to Yin, (2009: p. 102) interviews, archival records, physical artefacts, direct observations, documentation and participant observation. The case study method has various critics as they are time consuming due to the variety of data collection methods and methodologically weak. The wide range of data collection tools cause it to be open to bias and make it hard to be representative. These criticisms have been acknowledged by Yin, (1994, 2014) who suggests that in order to mitigate these points, the researcher needs to ensure the research is theoretically grounded and have mitigation measures in the research design.

The author views only three data collection methods for the case study as appropriate for meeting the research objectives which are (1) documentation, (2) interviews, and (direct observation). The remaining methods were viewed as unsuitable as they are irrelevant to this study. Archival records are concerned with data in the past, physical artefacts focus on the physical dimensions of the study whilst participant observation is concerned with the participants behaviour, these are all unrelated to the study.

A number of case studies in multiple petroleum companies are conducted. One of the case studies was specifically designed as an environmental impact assessment study to a specific project area.

- **Environmental Impact Assessment Case study**

One of the case studies utilised is an Environmental Impact Assessment (EIA). EIA has been briefly explained in the literature review chapters and it is one of the environmental tools used to assess and quantify the environmental impacts and issues in a specific project area. The author conducted an EIA which is explained in the analysis chapters in more detail.

- **Survey**

Survey methods in normal circumstances follows a positivistic methodology. To satisfy the positivists quantitative approach utilised for this study, a survey tool is selected. Collis and Hussey, (2003) state that there are two types of surveys; (1) analytical surveys, which intends to define if there is an association “relationship” among various variables, and (2) descriptive surveys, which focus on quantifying and identification of the frequency of a precise population, either at one point or numerous times for comparison. Based on this classification, this survey is classified as “analytical”. The consideration of using analytical survey tool for this research is to collect the bulk of the data from the wider population (Libyan petroleum sector) and to test general hypothesises generated from the interviews and case studies findings such as level of awareness about sustainability and environmental issues and the key current management problems. The survey aims to examine the importance of linking the findings of the qualitative methods (i.e. interviews and case studies) to the results of the questionnaire.

In line with the research aim and objectives and in particular the findings of the interviews and case studies, the questionnaire is designed to test the findings from the interviews and case studies to a wider population. It is distributed for a wider population to see if the results confirm or/and contrast with the findings of the interviews and case studies. The survey is selected for triangulation purposes among the chosen paradigms to confirm the outcomes of the qualitative methods and works as a mitigation measure for the bias associated with the qualitative methods (interview and case studies) as advocated by Yin, (2014).

- **Life Cycle Assessment (LCA)**

One of the tools for assessing quantitatively environmental sustainability impact is Life Cycle Assessment method (LCA). Life Cycle Assessment (LCA) is a method used to evaluate the potential impacts on the environment of a product, process, or activity throughout its life cycle (Gillani et al, 2010). It uses numerical data and statistics in its quantification methodology. The procedure of LCA studies is established by ISO, (2006.

LCA allows estimation of the environmental impacts resulting from all life cycle stages such as transportation, raw material extraction, processing and the end of life disposal, etc.). The evaluation of the impacts is carried out throughout all stages which enables a realistic comprehensive view of environmental aspects of a “process” or “product” which enables efficient and well informed decisions and product trade-offs.

The results from LCA can be linked with the findings of the other methods which will help attain the research objectives and the establishment of the Sustainability Management System.

There are sets of limitations for the LCA studies which mainly include (1) LCA results are only valid under the assumptions of the study and (2) LCA is associated with considerable uncertainty. The uncertainty is caused by lack of accurate input data and exact real inclusion of processes. However, in the context of this study, the LCA studies conducted intend not to achieve high accuracy of results, but to establish a realistic understanding of the major environmental issues and their impacts. Furthermore, gaining a clear understanding of the processes which cause the marginally higher impacts to the environment. The author will take all means possible to ensure LCA studies are as realistic and accurate, so that the limitation of uncertainty cannot jeopardise the results significantly. In other words, LCA is normally used to aid decision making when comparing between two products or processes in order to make more environmentally conscious decisions. In this study, this is irrelevant, as the aim of the LCA studies are only to provide guidance to the type and scale of impacts and their processes which will be used with the findings of the other methods in the study.

4.7 Research Process

The research strategies as well as the philosophical assumptions were discussed and presented in the previous sections as well as the methods that are relevant to this study. This section is concerned with the research process followed in this study. It demonstrates the relationship between the research objectives, questions and methods. Broadly speaking, the research process encompasses the whole research journey which includes the identifying, locating, assessing, analysing and then developing and communicating ideas. In other words, it is the logical sequence of actions and procedures that links empirical data to its initial research goals and eventually, to the conclusion.

In this study, the research process is contained from the following interconnected and intersecting stages. Most of these stages were conducted through four phase fieldwork. These stages are:

- Stage 1. Literature Review

- Stage 2. Interviews (36)
- Stage 3: Case Studies
- Stage 4: Survey (Randomly selected Western of Libya, 327 participants).
- Stage 5: LCA
- Stage 6: Development of Sustainability Management System (SMS)
- Stage 7: SMS evaluation and validation case study

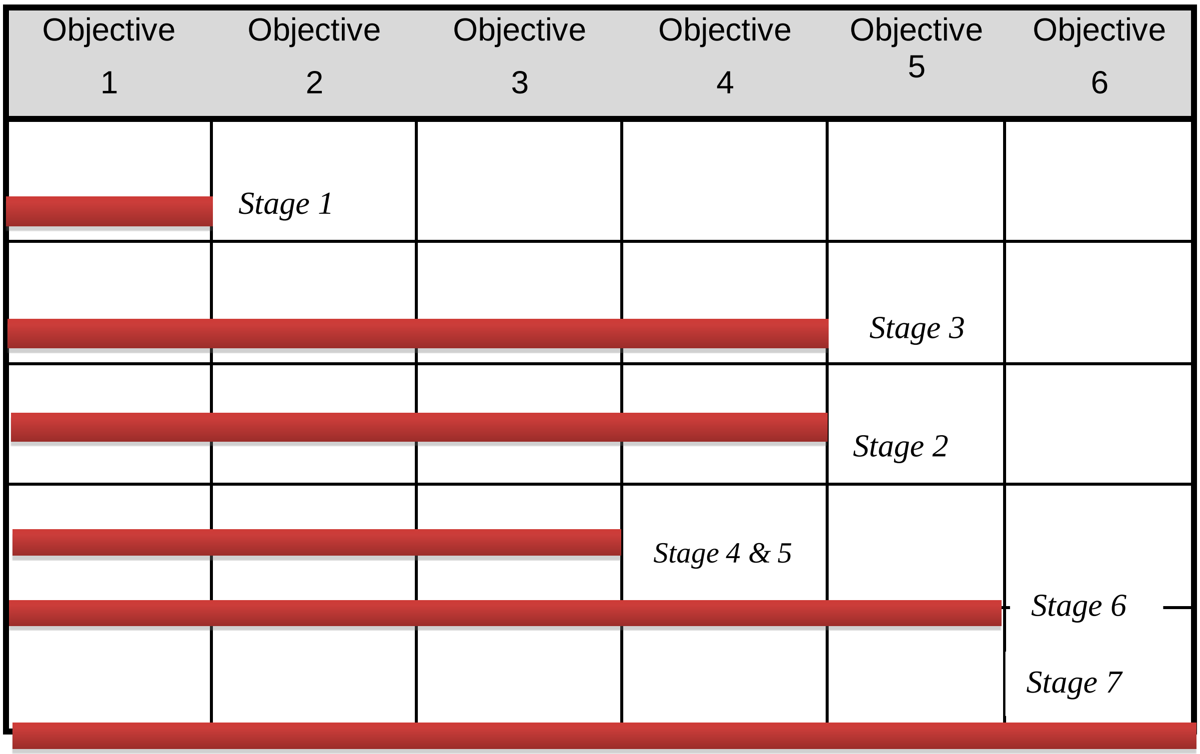

Figure 4.5: the research process adopted for this study

Figure 4.5 shows how the research process is conducted. The research objectives are realised in multiple overlapping research stages. For instance, research objective 1 is fully achieved by the literature review (stage 1). Objective 2 and 3 are achieved in multiple overlapping research stages (2, 3, 4 and 5). The overlap of these research stages is to strengthen the findings and attain the objectives from various dimensions using dissimilar methods. Objective 4 is achieved by the literature review and explorative case studies (stage 3). Stage 6 responds to objective 5 and similarly stage 7 to objective 5. Likewise, Figure 4.6 shows the alignment of the research questions with the objectives.

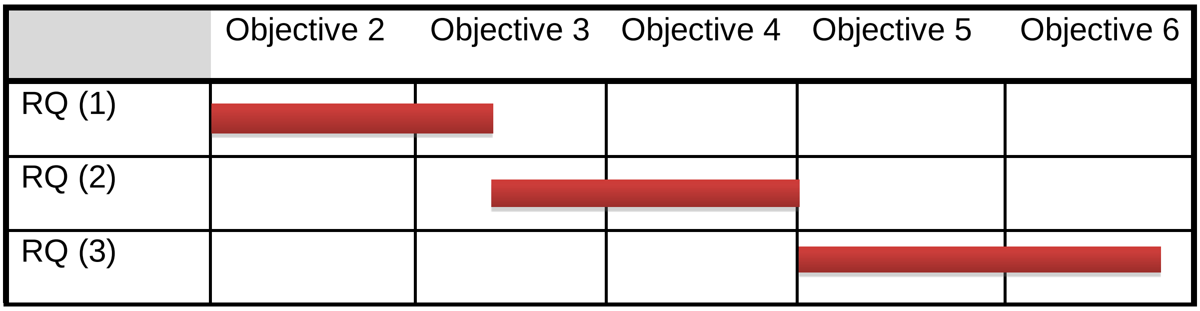

Figure 4.6: Alignment of research questions with the research objectives

4.7.1 Fieldwork

Before explaining the research process stages, an overview of the fieldwork conducted is needed. A four-phase fieldwork was planned to collect all primary data required for this research. Fieldworks were planned due to the essential need to gain empirical data from its natural setting to gain better understanding of the situation. In addition, the researcher could empirically observe current practices. The researcher first contacted his sponsor, the Libyan embassy in London, to issue an official letter for him to the National Oil Corporation (NOC) in Libya. The NOC is the leading government body which runs the Libyan petroleum sector. (See appendix 1 for embassy letter).

Four field trips were completed as follows:

- **Field Work 1 (July 2012)**

The first field work was conducted in July 2012 and lasted for 6 weeks. The main purpose of this trip was to confirm approval from the National Oil Corporation (NOC) to conduct this research project, including collecting data through interviews and case studies and in addition, to visit oil fields and refineries. With the support from the Libyan embassy in London and the Libyan ministry of Higher education, an approval was obtained. Furthermore, 12 unstructured and semi-structured interviews were conducted during the first visit.

- **Field Work 2 (Feb 2013)**

The second Field work was conducted in Feb 2013. The aim of this field trip was to conduct two case studies, one at a downstream petroleum company then a second at an upstream petroleum company. The field work included empirical visits to working sites, refinery and plants. Furthermore, 10 semi-structured interviews were carried out as part of this phase.

- **Field Work 3 (July 2014)**

The third field work was conducted in July 2014. It involved a further case study at another upstream petroleum company and interviews from a number of workers. At this stage, the Environmental Impact Assessment (EIA) study was conducted in a specific project area (upstream petroleum operations) and some data were collection for the Life cycle assessment. 14 interviews were carried out at this stage.

- **Field Work 4 (September 2015)**

This field work aimed to evaluate the developed sustainability management system for validation purposes. The evaluation and validation case study (4) were conducted in this fieldwork.

4.7.2 Stage One – Literature Review

A literature review is a collection of information and analysis of existing research which is pertinent to the research topic. It clarifies and justifies how the investigation may help answer some of the questions or gaps in this current research study. It discusses published and unpublished information in a particular subject area (Hart, 1998). The literature review intends to critically evaluate the existing knowledge from the literature and synthesise ideas. Bryman and Bell (2011 p. 91) stress that it is a compulsory part of any research due to the need for evidence that the researcher is aware of all the relevant and related knowledge about the topic and that he can appropriately critique it, leading to a strong research foundation, identifying gaps and establishing its significance. Hart (1998) adds that the literature review's purpose is to demonstrate the researchers' analytical abilities and evaluation skills on conducting library research, understanding of the subject under study and justifying the research topic. Thus, the author ensured that these are fully covered in the literature review chapters (1 to 4).

The research is conducted continuously throughout the whole research project period. This is to ensure that published and unpublished materials are up to date, not overlooked and relevant to the topic under study. The researcher has used various sources including, books, e-books, published journal articles, government websites, professional websites, and conference proceedings. These sources were targeted and searched using numerous access databases and tools such as Google scholar, science direct database, Emerald, Scopus, and Nottingham Trent University library catalogue. Sources were streamed and collected, and the unavailable sources were loaned through the library loan scheme. This has allowed the researcher to collect much relevant and related literature which was used for this project and is cited as relevant and listed in the reference section. Other sources which were reviewed but not used are also provided in the bibliography.

4.7.3 Stage Two – Interviews

Interviews are highly recommended when the researcher is concerned with in-depth detailed findings for a study (Fellows and Lui, 2009). In this stage, the author conducted 36 interviews. Stage 2 is initiated after stage 1. The interviews are designed to respond to objective 2 and 3 which are (1) empirically investigate the sustainability situation at the Libyan petroleum sector in order to identify and assess sustainability related issues and environmental risks and (2) Identify and critically analyse the barriers and success factors of implementing sustainability approaches and environmental management systems in the Libyan oil industry.

Firstly, based on the literature, petroleum companies have different sustainability practices and the initial interviews aimed to investigate the current situation in regard to sustainability related practices. Also, the interviews are designed to address the management issues in dealing with sustainability. The research also aims to develop a sustainability management system which addresses sustainability related problems, thus investigating and understanding all relevant issues in depth was essential. Furthermore, there are numerous existing sustainability and environmental management approaches which are implemented by companies in the petroleum and other sectors. Therefore, there was a need to examine the implementation of these approaches, and identify the barriers and success factors of implementing sustainability approaches in the Libyan petroleum sector.

Interviews protocol

This research used unstructured and semi-structured interviews. It comprising the major topics raised from the research questions. The first set of guidance was for interviewees working in the Libyan petroleum sector and the second for non-business organisations (governmental agencies and NGOs). These proved to be advantageous in terms of maintaining the reliability of the research, by ensuring that the same questions (topic) were asked of all interviewees. Nonetheless, topics for discussion were not exhaustive to allow interviewees to raise new information that was beneficial for the research and the author took advantage of using this information in follow up interviews. Such flexibility in the interview process provided much assistance in gathering the required information.

After gaining permission from the NOC, interviewees were contacted by phone to arrange appointments, which proved very challenging as the researcher had a limited time to complete the fieldwork. An official letter stating intent to conduct the research was also given to the participant organisations. The most challenging stage of this process was scheduling the interviews with the officers from the Libyan Environmental Agency. The task of interviewing the appropriate personnel took two months to complete. Several integrated factors such as location, interviews time and the need to reschedule some interviews all affected the amount of time spent. In most cases, interviews were conducted in an average of 35 to 50 minutes. For some of the managers, the interview took 2 to 3 hours as they were very willing to share their experiences and provided factory visits to allow observations.

Whilst conducting the interviews, every effort was made to follow the interview procedures and ethics, especially in building good relations with the informants, gaining their trust and achieving a conducive interview situation. In this case, several suggestions by Mason (1996) and Taylor and Bogdan (1998) were followed such as: make sense and be meaningful to the interviewee, be non-judgemental and patient, relate to the interviewee experiences, be sensitive, help the flow of the interview and ensure that appropriate focus on issues and topics relevant to the research questions are maintained.

Some of the interviews were recorded with the permission of the interviewees but in cases where they were reluctant to be recorded, interview notes were taken instead. Before the interviews started, the author asked for interviewees consent to use any information given in the interviews for the study. They were also assured that all information was confidential and would be used solely for the research. Surprisingly, none of the interviewees requested the transcription of their interview, but a few companies and managers did.

The average length of the interviews was around 30 to 60 minutes as reported in chapter six. An interview protocol was used (see appendices) to guide the interviews in which various stakeholders in the petroleum industry in Libya participated and reflected upon their views in relation to sustainability and environmental management in this sector. Specific questions were asked about the barriers petroleum companies face in implementing sustainability and environmental management systems and what are the success factors required to achieve that from their prospective. The interviews were carried out at the convenience of the research participants which was flexible in style to allow participants to express their opinions and experiences freely. The style that was adopted is unstructured and semi-structured interviews to ensure that any emerging questions are asked during the interviews.

Sampling

There are two main types of sampling techniques as advocated by Saunders *et al.* (2009), namely: probability and non-probability sampling. Probability sampling is associated with the quantitative approach whereas non-probability sampling is linked to the qualitative approach (Saunders et al. 2009).

Saunders et al. (2009) adds that there are five types of the non-probability sampling which are: (1) quota, (2) purposive, (3) snowball, (4) self-selection and (5) convenience sampling. He explains that, quota sampling is used for structured interviews (surveys) and it is claimed that "it is almost as good as a probability sample" (Bryman and Bell, 2011: p. 190).

The purposive sampling which also named judgemental sampling, allows the researcher to freely select the cases which allow him/her to achieve his/her research objectives. This is commonly used for the case study approach. When researchers find it hard to identify the targeted participants, snowball sampling can be used as it will help reach a larger sample through the first participant. Self-selection sampling is used when the participant volunteers to take part in the research through publicity. The last type is convenience sampling, which focuses on the easiest cases to find, typically through random selection. Among all these, the researcher chose snowball and purposive sampling for the interviews.

Three sampling groups were identified which are : senior industrial practitioners, policy makers from the Libyan petroleum sector and Environmentalists from the Environment General Authority. The selected participants have first-hand experience in the environmental and petroleum sectors in Libya. These groups were selected to avoid biased understanding from senior managers. Policy makers and environmentalists were selected using the purposive sampling technique. Inclusion criteria were used to select the policy makers and environmentalists and it was decided the interviewee should:

- Be a policy maker who is employed or was employed as senior consultant in the National Oil Corporation (for policy makers only).
- Have awareness of the current issues within the petroleum industry especially regarding sustainability and environmental management.
- Have a least 15 years' experience.
- An employee for the Libyan Environmental General Authority (EGA), the environment watchdog (for environmentalists only).

The minimum criteria for sampling the senior industrial practitioners include that the interviewee should:

- Be a senior manager at a Libyan petroleum company (NOC fully owned or joint venture)
- Be involved to sustainability, environmental management and Health and safety
- Have at least 5 years' experience in a senior position.
- Familiarity with the petroleum industry in Libya and in particular to the environmental issues

Local contacts known to the researcher were used to arrange and identify prospective interviewees from the National Oil Corporation and Petroleum companies. The sample size was not pre-arranged contrasting to quantitative research. The interviews were conducted to get deeper understanding of the issues associated with the petroleum sector until saturation was obtained. In other words, when the researcher believed that no new information would be forthcoming from the participants.

19 interviews were carried out in the early stage of the qualitative phases which involved two policy makers from the NOC, three environmentalists from Environment General Authority and fourteen senior industrial practitioners. Follow up interviews were conducted with six of the senior industrial practitioners, in which data saturation was realised. Figure 4.7 shows the interviewees representation.

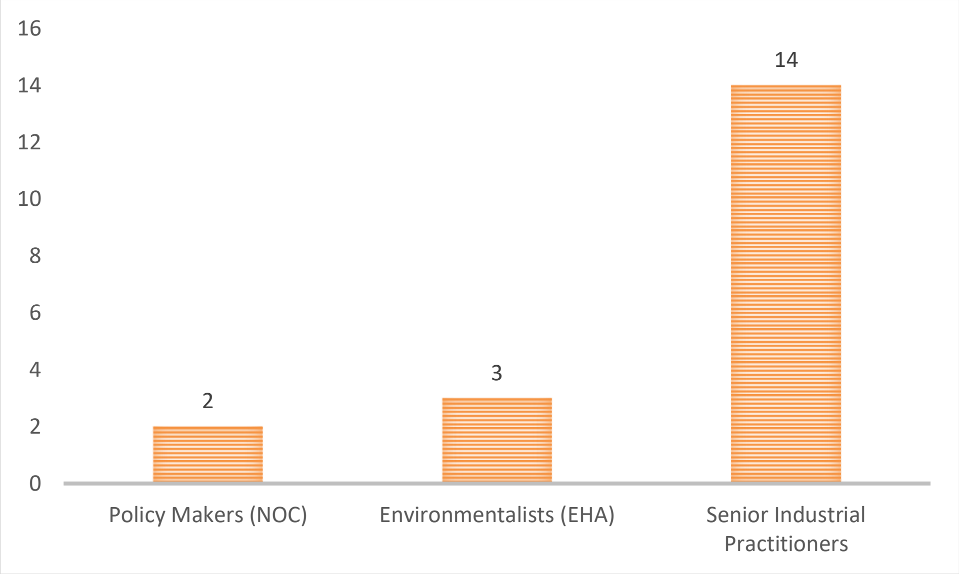

Figure 4.7: Samples of interviews

Interview Analysis

Data collected were qualitatively analysed. Bogdan and Biklen (1992) define qualitative data analysis as 'working with data, organising it, breaking it into manageable units, synthesising it, searching for patterns, discovering what is important and what is to be learned and deciding what you will tell others'. These are not easy tasks as there were piles of interview transcriptions, interview notes, observation notes and relevant documents to be analysed.

A number of guidelines in analysing qualitative data are presented in various qualitative research literature items, but none of these represents fixed guidelines. One of these is conceptualisation. Saunders et al. (2009) consider this type of analysis is based on developing a conceptual framework and a grounded approach. A researcher can use any information in any way that they think is appropriate to 'unearth' the meaning and to answer the research questions, but the guidelines used must have their own justification within the theoretical and methodological framework. Qualitative researchers tend to use inductive analysis of data, meaning that the critical themes/ categories would emerge out of the data (Straus and Corbin, 1990; Patton, 1990; Morse, el al., 2002). It also requires some creativity to place the raw data into logical, meaningful categories; to examine them in a holistic fashion; and to find ways to communicate this interpretation to others (Hoepfl, 1997).

Significant amounts of data for this research was from the interview process with interviewees in industrial organisations and non-industrial organisations. Interview guidance which contained the major topics to be asked provided a good foundation in creating conducive interviews with the interviewees. Yet, the interview guidelines were flexible because the interviewing process often produced new ideas or major issues which were beneficial to discuss with other interviewees. Data analysis from interview methods comprised of various stages.

There are three main types of the qualitative analysis process as described by Saunders et al (2009). The first type is the process of summarising of meanings, followed by the categorisation of meaning and the final type is using narrative to structure meanings. In other words, the summarising process involves the need to condense large amount of text into few words so that categories can be developed by linking these words to become meaningful themes. Thus, the use of narrative to structure data is about ensuring that the data is grouped as per the social or organisational context of the study.

The data analysis procedure utilised for the interviews are graphically represented in Figure 5.8 as adopted from Kvale, (1996) and Aiyub, (2007). It started during the interview process itself. During this stage, a procedure, called “self-correction interview” was adopted (see Kvale, 1996). This involved counter-questioning by the researcher to the subject. Self-correction interviews require the researcher to interpret the meaning from the subjects' feedback and condense them and send back the meaning to the subjects for clarification.

In this research, a bespoke grounded approach was adopted for this analysis. To start the analysis, all of the interviews were transcribed and manually analysed. This involved the process of coding the participants so that they are not identifiable. For example, codes IN1, IN2, IN3 were given to the transcripts. Each interviewee represented different organisation as pointed out in the following chapter. Anonymity was ensured at all times during the analysis and the reporting of the qualitative results. Unfortunately, 70% of the interviews were done in Arabic so there were major issues with translation, but some interviews were done in English. The interviews in Arabic was transcribed first in Arabic and then translated into English. Transcribing was done word-by-word. The transcribing process also involved a clarification process where non-essential material was eliminated. Transcribing all the interviews afforded the author a valuable opportunity to clearly understand the issues of, getting 'inside' the interviewees experiences and do some early interpretation which was noted down separately. This opportunity was also used to make the initial guide for choosing categories. This stage not only produced interview texts but also developed initial interpretations and categories. The texts were read and re-read to pull out categories of importance to this research. The interview guidance was used as a basis for creating the categories.

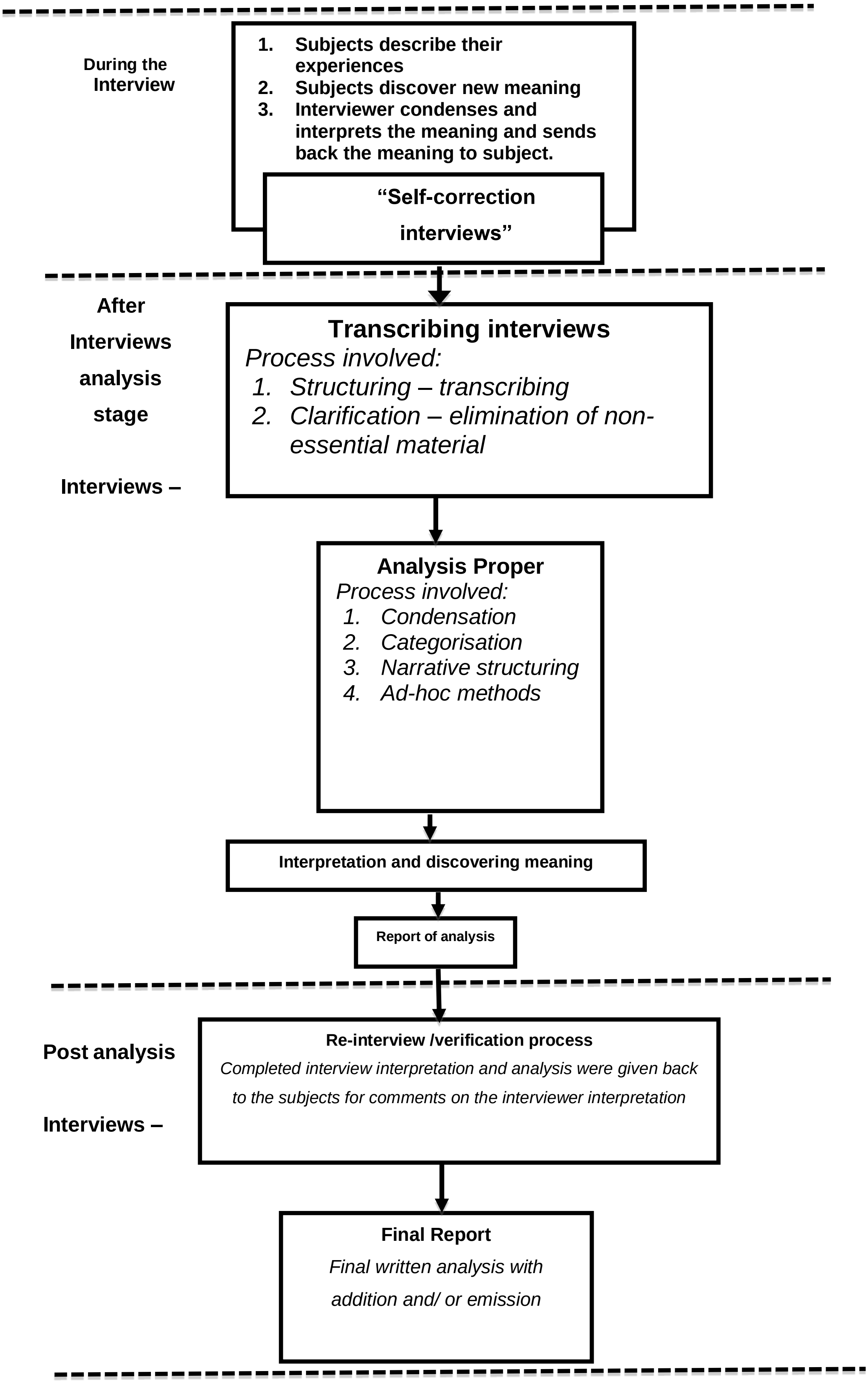

Figure 4.8: Interviews data analysis process

The next stage involved interpretation and discovery of the meaning from the richness of information gathered. This process was done in categories. In each category, new sub-categories would emerge to aid better understanding and explanation. The interpretations of the meanings were not done solely through interview texts, but with the combination of field notes, initial interpretations from the process of transcribing, interview notes and analysis of documents. This practice not only clarified each issue previously discussed and discovered real meaning, but also represented triangulation efforts to confirm and validate the interview data. Wherever possible, theoretical perspectives on the research field were brought together to either confirm the findings or to criticise them or even advance the theory in practice.

Finally, this interpretation process would produce the expected research report. Throughout the report, in order to support the findings and interpretations made, selected quotations by interviewees were presented in the text. Straus and Corbin, (1990) described it as the 'voice' that clarifies the issues being described. In writing the report, it is necessary to re-examine the categories to identify the linkages between them which the author believes can foster understanding of the whole research issue. There is no doubt that some factors will influence the others and their interrelations in a rather holistic manner. Straus and Corbin (1990) also mentioned that the research report should be a rich, tightly woven account that 'closely approximates the reality it represents'.

All the interviewees were sent the draft report and asked to give comments on it in terms of providing additional information or omitting any interpretation that did not represent their views. For this purpose, one week was given (due to limited time in the field trip) and if there were no responses from them within that timeframe, the report was considered to be agreed by the interviewees. This process of data clarification and validation is an important aspect for qualitative research. Finally, the draft reports were rewritten, to include additional responses and information and omit any irrelevant information. Chapter six presents the detailed analysis of the interviews in which themes are discussed.

4.7.4 Stage Three – Case studies

In order for this study to develop a sustainability management system (SMS), it was important to carry out this stage of research. A case-study was adopted so that raw results can be achieved. A case study is the study of a situation, group, organisation or almost anything which, can be considered as the case including an innovation or service (Robson, 2011). The case itself is defined as a specific, complex and functioning thing subject to boundaries (Stake, 1995).

Case studies are unique in their ability to practise research of real people in real situations, (Cohen et al., 2000). It was highlighted by Fellows and Lui (2008) that having in-depth investigation of a particular problem within a particular field can be achieved through the adoption of case study design. Hence, the adoption of a multiple-case study is more efficient than using a single cases so that more depth can be achieved. This was supported by Yin (2014) who states that findings, interpretation and conclusions of the study can be further improved and enhanced through the adoption of a multiple-case design.

Both downstream and upstream oil companies in Libya were selected as part of the sampling process. Yin (2003) recommended the use of personal contacts to arrange the sampling and access to research participants. This was the approach adopted using local contacts to arrange the sampling process. As highlighted above, different tools for data collection such as interviews, documentary analysis and observation were used to collect data as part of the case-study design.

- **Planning the Case Study**

It is important to ensure that case studies are planned and structured to obtain the best results possible. Case studies are criticised for not following a logical sequence and therefore the researcher has followed the case study process adapted from Mensah, (2013: p. 131) (see Figure 4.9) to mitigate against potential pitfalls.

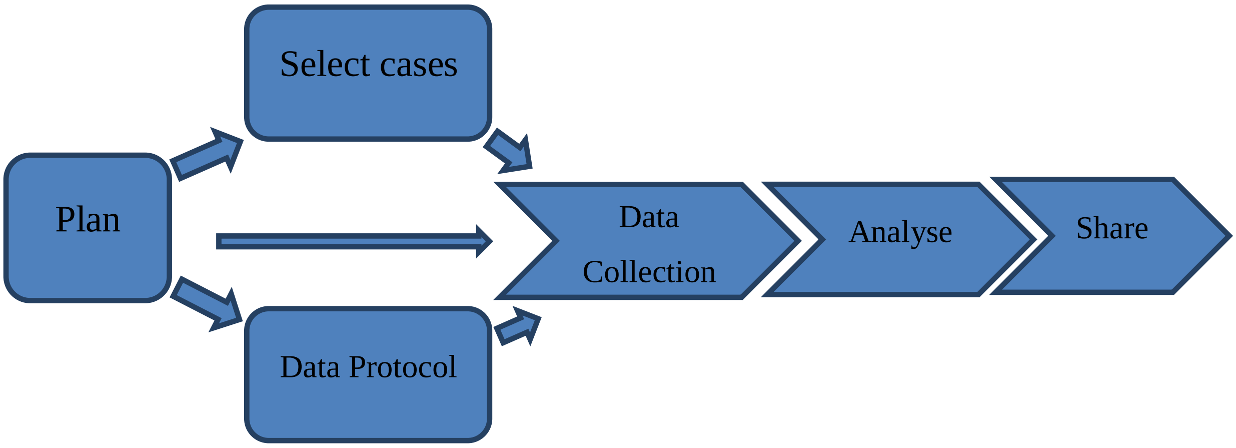

Figure 4.9: Case-study planning

Case studies are carried out via three multiple fieldwork trips and planning the time was very important due to limited time available. Case studies were conducted between February 2013 to October 2015.

- **Selecting Cases**

Purposive sampling was used in selecting the cases, which is common when a small sample is needed. In other words, the purposive sampling aims to choose cases that can help answer particular questions. A number of criteria were used to select the case studies such as the type of oil companies to target (i.e. upstream or downstream), company ownership (must be either fully owned by NOC, or joint venture) and accessibility for the researcher within the time-scale and cost constraints.

Stake (1994) points out that in case study research, more focus should be given to the issue of case sampling. Stake asserted that balance and variety are vital in order that the findings to be strengthened. Sustainability management which is the core of this research is predominantly carried out by upstream and downstream petroleum companies. Libyan petroleum industry includes numerous petroleum companies around the country which specialise in upstream operations (oil and gas extraction and production) and downstream operations (transportation, refining and sales). To ensure a balanced selection, the researcher chose three different companies: two upstream companies; and one midstream company as case studies.

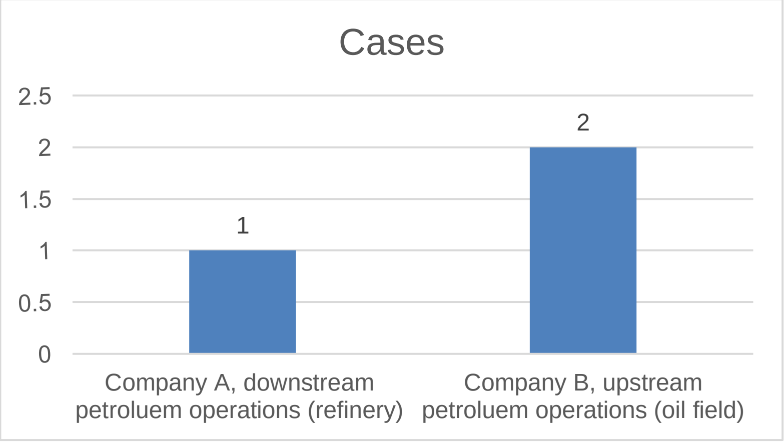

Figure 4.10: Selected case-studies

The three case studies were restricted to the western region of Libya due to the constraints of time and cost. The selected case studies are discussed below.

Case Study 1: CS-01[1]

The CS-01 is a downstream petroleum company fully owned by the NOC. The company has over 45 years' experience in downstream oil and gas operations. It specialises in refining crude oil products. It is the main supplier for oil products nationally. It refines around 120,000 barrel of oil a day. Table 4.5 shows the refinery products:

Table 4.5: Daily produced products in its cubic meter quantities M^3

Natural Gas	gasoline	Airplane fuel	Diesel	Heavy fuel	Asphalt
400	2500	2900	5500	4800	680

The company does not have an EMS in place, however, the company recently established a new environmental protection department. The company's senior environmental manager expressed his strategic intentions for EMS implementation in future. The company was very pleased to conduct this case study and associated interviews and pilot work around the refinery processes. The researcher was able to investigate most of the downstream activities including the refinery processes and separation units. A good understanding of how the company deals with waste was obtained.

Case Study 2: CS-02- Environmental Impact Assessment Study

The CS-02 project was conducted in the western Libyan desert in an oil field run by a joint venture upstream petroleum company. The main aim of this case is to conduct an EIA study in the project area along with some interviews. The production stages of crude oil and natural gas were investigated by the researcher as part of this case-study analysis. The researcher had the opportunity to observe how operations are being managed on site.

Case study 3: CS-03

Case study 3 is also an upstream petroleum company in the south west of Libya. The firm specialises in upstream operations including the production of crude oil and natural gas. The oil field has been in operation since 1980. The daily production of this oil field is approximately 300,000 barrels per day.

Data Protocol and Collection

[1] For the confidentiality of the case study, codes were used. For example CS-01 denotes case study one.

A protocol for conducting the case studies was developed. Interviews (unstructured and semi-structured) were conducted in addition to observations and documentary research. These were the main sources of information. Following very similar ethical procedures of presenting consent forms and ensuring permissions are received when and wherever applicable, led to a friendly relationship with the cases and the people in the cases. This is also referred to as a soft protocol as suggested by Mensah, (2013) as it enhances the case study procedure and increases the cooperation of the participants. In fact, the soft protocol worked very well, as the researcher was allowed to view various document and go around process plants to visually observe the issues. Unfortunately, photographs were not allowed in the project areas due to security concerns.

Interviews, documentary analysis and observations were the tools used as part of the data collection process in this case-study as highlighted in Figure 4.11.

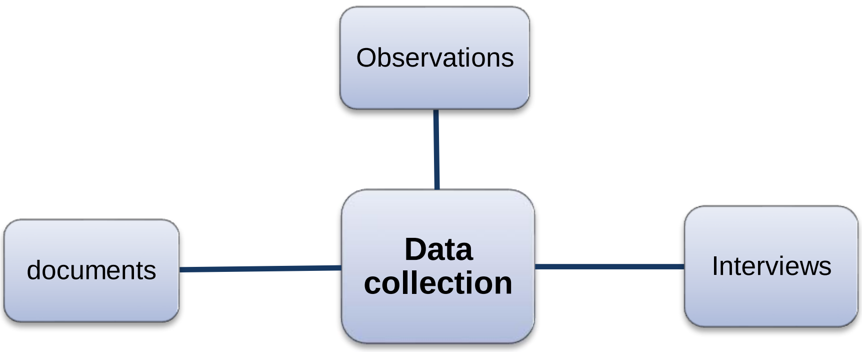

Figure 4.11: Case Study data collection method

Documentary research offers an in-depth and detailed overview in the case study procedure. Robson, (2011) states it has been overlooked by researchers and Mensah, (2013) explains that it is due to the dominance of other methods such as interviews and surveys. It is important to note that unsurprisingly, there were not many documents to review in relation to environment and sustainability. Lack of documentation and recording is one of the major issues identified through these case studies, yet few reports are found to have some relevance.

Observations were also conducted throughout the fieldwork trips and project sites. Observation was essential to comprehend the usual conditions and complications.

Therefore, observation was one of the best methods to attain this drive. “Real world” problems require empirical investigations and observation in the petroleum industry. Literature reviews and other conceptual methods are inadequate if solely used. The observations were unstructured in the protocol, yet they focused on the environmental sustainability management in the companies and worksite as well as any other problems related to sustainability such as health and safety, waste management and management procedures. While observations were taking place, notes and comments were recorded.

The document research and the observations formed some questions for the unstructured interviews in an attempt to seek clarifications and in-depth understanding. Unstructured and semi-structured interviews were carried out to ensure that participants are given the opportunity to reflect upon their experiences and perceptions freely as detailed in chapter six. Despite being open, the time frame for the interviews was set at 60 minutes. The interviewees were mainly managers ranging from top management, senior managers and team leaders. A total of 7 unstructured interviews were conducted throughout the case studies.

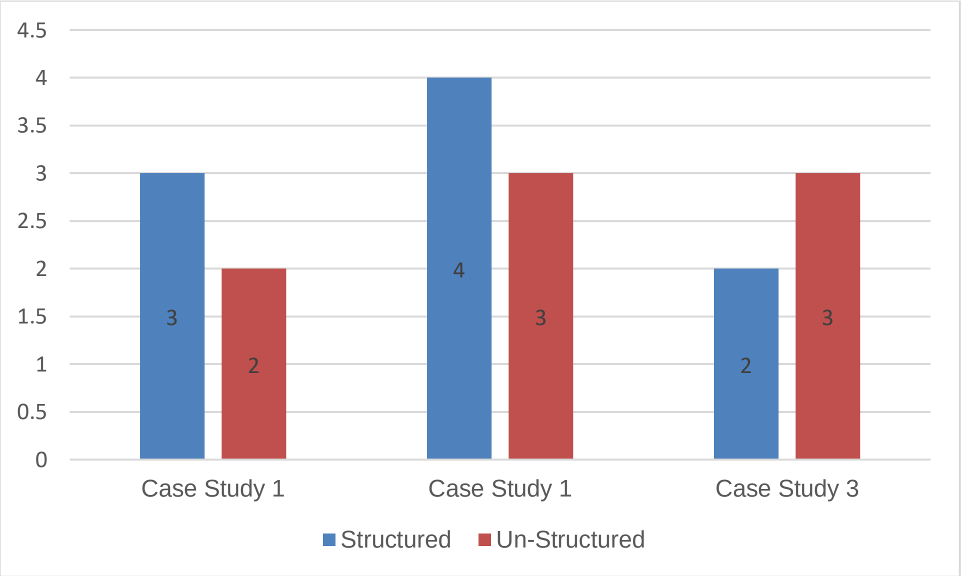

Figure 4.12: Participants in the interviews (from case-studies)

The semi-structured interviews followed similar protocol to the interviews conducted stage 1 in terms of consent and procedure. It focused on the management side of issues and the opinions of the interviewees in regard to these issues. Semi-structured interviews were conducted with managers, supervisors, environmentalists, health and safety officers and production managers. Semi-structured interviewees were planned not to last over 45 minutes. Overall, 10 structured interviews were conducted across all the case studies.

Data Analysis

In order for researchers to make sense of the data that was collected, data analysis is essential and integral element of all research studies. The study adopted different methods in which different analysis techniques were used. A qualitative analysis approach is conducted to analyse and make sense of the case studies findings. Interviews are coded based on the case study and the position he holds. List of interviewee codes are shown in figure 5.1 (Chapter Five). The analysis for interviews follows the same procedure discussed in the stage 1. Findings of each method is then cross analysed together. Thematic analysis and groups were used as detailed in Chapter Five.

Case Study Limitations

This research study is based on the use of a case-study design which has many advantages as listed above. However, some argue that case study method may contain weaknesses in terms of its lack of rigour and an excess of bias. In other words, it could be argued that using subjective judgements during the data collection process may influence the validity and reliability of the findings. Thus, such concerns are taken into account by the researcher and subjective judgments are not made during the process of data collection. It is argued by some that scientific generalisation cannot be made throughout the case study method as pointed out by Yin (1994) and Remenvi et al (1998).

Conversely, it could be argued that the findings of this study provide a detailed understanding of the patterns and linkages associated with sustainability practices in the petroleum sector in one developing country in which some aspects can be generalised as they are linked with the theoretical foundations of the study. The researcher utilises a validation process in this research to mitigate the limitations of the qualitative interviews and case studies, so that findings can be validated and further generalised to the Libyan petroleum sector.

4.7.5 STAGE Four – SURVEY

In the quantitative stage, the researcher had two goals, first, to gather information about the level of awareness, attitudes and performance of sustainability of a large sample of the Libyan petroleum sector. Secondly, it aimed to test the key findings from the interviews and case studies against a larger sample excluded from the previously used participants. The research triangulated the data required through the most popular research method (questionnaire survey). The questionnaire was designed with two key themes in mind, first the sustainability awareness of the petroleum sector and second, testing the findings from the interview to see if the larger population agrees/contrasts with the findings of the qualitative tools.

The questionnaire was designed and tested before distribution. A questionnaire survey is used for collecting the bulk of the data. The sample of questionnaires is distributed to target 306 participants from the Libyan petroleum companies operating in the western region of Libya. The reason for selecting the Western region exclusively is due to the fact that the researcher was unable to conduct interviews and case studies further afield due to constraints of time and cost.

According to the NOC, (2012) there are around 1500 employees at the petroleum companies operating in the western region of Libya. Using the table for determining the sample size of a given population by Krejcie and Morgan, (1970) the minimum sample should be 306 participants. It is important to note that the companies selected for the stage 2 (interviews) and stage (3) case studies were excluded from the survey questionnaire. This is because the purpose of the questionnaire is partially to test the findings from stage 2 and 3 and it was deemed appropriate to avoid these companies to gain a wider overview.

Due to the constraints of time and budget, the researcher was unable to target all the Libyan petroleum companies, but all Libyan companies fully owned by the NOC have exactly the same rigid management structure, business culture and working procedures which allow the generalisation of findings of this study to the whole of Libyan petroleum sector. The questionnaire was distributed to participants using various methods such as company websites and social media (Facebook). The researcher's personal network also helped distribute the questionnaire. A copy of the questionnaire is available in appendix 3.

4.7.6 STAGE Five – Life Cycle Assessment (LCA)

The researcher has utilised various methods to strengthen the findings of this research project. Previous research methods focused on the human perspective and attitude towards sustainability. Stage 5 differs as it focuses on the products and processes instead. LCA is a widely used quantitative tool to assess environmental products and processes as discussed previously in the literature chapters. The researcher conducted LCA studies to assess and evaluate impacts associated with crude oil production and processes which could help the research in developing the sustainability management system. LCA follows the ISO framework and methodology.

4.7.7 Stage Six – Development of Sustainability Management System

As detailed in chapter 2 in this thesis, the above stages have paved the way for the development of the SMS which is the integral aim of this research study. This stage involved the alignment of the overall study findings so that a model can be developed. Hence, the findings of the LCA, EIA, Survey Study and the Qualitative Interviews have fed the development process. The SMS was developed to:

- ✓ Provide an integrated approach to environmental sustainability management in the petroleum sector based on the limitations of the existing approaches.
- ✓ Minimise the environmental sustainability issues and impacts at the Libyan petroleum sector.
- ✓ Overcomes the implementation barriers sustainability and management approaches and systems.
- ✓ Enhance the environmental sustainability performance and practices in the Libyan petroleum companies.
- ✓ Promote sustainability awareness and improve corporate social responsibility.
- ✓ Create a foundation for other related functions and approaches such as quality management and Health and Safety

The development of the SMS relied on the understanding gained throughout the research investigations explorations in stages 1 to 4. The researcher has analysed the key industrial and management issues for the Libyan petroleum sector and has evaluated and quantified the environmental impacts associated with petroleum operations. In addition, an assessment of the awareness, attitudes and understandings of a mixed levels of employees and shareholders in the sector including policy makers, senior managers, engineers, environmentalists, technicians and external environmental regulators has been made. Chapter 9 of this thesis describes the process of sustainability management system development along with the validation process.

4.7.8 Stage Seven – SMS evaluation and validation

To strengthen and validate the developed SMS, the SMS was presented to some of the participants who showed interest in seeing the outcome of this research to hear their opinions of the system and provide an opportunity for further improvement. A revised SMS model was then developed as presented in Chapter 9.

4.8 Research Reliability and Validity

Key criticisms of the qualitative research approach are a lack of reliability and validity. Different to quantitative research, qualitative inquiry has a major task in demonstrating that the research, findings and interpretation can be reliable and considered valid in social research. In meeting these criticisms, scholars such as Walker (1974), Salner (1989) and Patton (1990) claim that qualitative research means that the viewpoints offered are judged by their relevance to, and use by, those to whom they are presented. Their perspective and actions are linked to the researcher's perspective and actions and to how real the situation is showed as experienced by the subjects.

Patton (1990) and Hoepfl (1997) stat that qualitative research should be judged differently from quantitative research. It is a reflection of subjectivity versus objectivity in the nature of the research methodology. According to them, qualitative research should be judged through its credibility, transferability, dependability and confirmability.

Credibility relies on the richness of the data gathered and how the information is studied by the researchers and the *transferability* of the research findings. Thus, the size of samples does not matter. Credibility of the research can be improved using data triangulation (Patton, 1990). In this sense, theoretical generalisation is an approach to qualitative research that is based on inductive strategies (Taylor and Bogdan, 1998; Mason, 1996).

Another aspect of trustworthiness is *dependability,* which contrasts with the reliability aspect in quantitative research. Reliability depends on measurement characteristics: results will be similar if repeated over time. Dependability is about findings consistency as a result of the process and the product of the research. It was argued by Lincoln and Guba (1985) that 'since there can be no validity without reliability, and thus no credibility without dependability, a demonstration of the former is sufficient to establish the latter'.

In quantitative research, objectivity is important because the measures are value free and therefore objective. Qualitative research holds on to conformability rather than objectivity, because its research relies on interpretation and is admittedly value-bound and considered subjective. For standard research, subjectivity leads to results that are both unreliable and invalid. Patton (1990) stays out of the debate of subjectivity versus objectivity but strives for 'empathy neutrality'. Empathy is a stance towards the people one encounters, while neutrality is a stance towards the findings. A researcher who is neutral tries to be non-judgmental and strives to report what is found in a balanced way. According to Lincoln & Guba (1985), conformability of the research refers to the degree to which the research can demonstrate the neutrality of the research interpretations.

Furthermore, validity contributes to the trustworthiness of the research and can be achieved through continuously checking, investigating falsification procedures, as well as questioning and theoretically interpreting the findings. In assuring the truth, Kvale (1989) discerned three criteria, which are: (1) correspondence - whether a knowledge statement corresponds to the objective world, (2) coherence- refers to unity, consistency and internal logic of a statement, and, (3) Pragmatism - relates the truth of knowledge statement to its practical consequences.

In achieving validity for this research, the author followed those procedures proposed by several researchers (e.g. Lincoln and Guba, 1985; Patton, 2005; Hoepfl, 1997; Creswell and Miller, 2000) which included triangulation, disconfirming evidence, member checking and thick and rich description. Triangulation is a validity procedure where the researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Denzin, 1970; Creswell, 1994; Stake, 1994; Miles and Huberman, 1994). The concept of triangulation is based on the assumption that any bias inherent in a particular data sources and method would be neutralised when used in conjunction with other data sources and methods.

The findings are also cross checked with a literature review by respondents and readers to the report. A methodical report with sufficient detail about the processes of data collection and analysis to demonstrate rigour and conveyed credibility often determines its validity (Patton, 2005; Miles and Huberman, 1994). It permits the audience, at which the research is aimed, to judge the quality of the resulting report. Hence, the validation burden is shared with the readers of the report. In this research, every effort was made to use this procedure. Cross checking and counter checking procedures were applied between data, documents produced and published by the government's agencies, NGOs and the informants organisations themselves.

Another aspect in ensuring validity is the researcher's reflexivity. According to Creswell and Miller (2000), every researcher has their own beliefs and assumptions and even biases as early as the research starts. These can shape the way the research is undertaken. In countering these biases, researchers are advised to disclose them early on. In this research, Chapter's 2 and 3 have the details of the author's early expectations, assumptions and beliefs regarding businesses' motivating factors in implementing sound environmental management as one of their business strategies. However, even though everyone has our own beliefs and assumptions, these can be negated when sincerely and rigorously searching for the truth based on the setting and the informants' experiences.

Member checking is another procedure used to achieve validity. Lincoln and Guba (1985) describe it as the most crucial technique for establishing credibility. Some says that this can be done through peer review but on the other hand, some researchers refer to it as 'member' of the research; that is the participants/informants themselves. This study acts on Lincoln and Guba's (1985) suggestion of taking data and the interpretations back to the informants so that they can confirm the credibility of the information given.

One last method of ensuring validity is through written interpretation and description about the way the report is established. Qualitative research is rich with 'inside' information based on the experiences of the informants or subjects. A qualitative report is usually written in detail and is thick and rich with description compared to a quantitative report.

4.8.1 Reliability and Validity Implications

It is important that the research is utilised in a way that makes contribution to the overall academic and professional arena. Two basic groups were identified by Collis and Hussey (2009) in regards to the contribution of the research which are: (1) basic (pure or fundamental) and (2) applied (practice). Specific problems are solved through the use of applied research whereas the basic research aims to advance basic knowledge by focusing on theories and critically examining how the world is operating. Thus, the focus of basic research is generating more knowledge whereas the applied research focuses on solving problems and providing practicable solutions by focusing less on theory but more on practicability. It was argued by Neumann (1994) that empirical research should be designed in a manner that is valid and reliable in terms of its implications.

The validity aspects of the research are associated with its integrity and the uniqueness of the conclusions and their impact. This means that reliability is associated with the consistency of presenting the results of the research study whereas trustworthiness is associated with validity. It was highlighted by Bryman and Bell (2011) that both terms (reliability and validity) are important in research that is using quantitative methodologies. They also argue that parallel terms are used in the qualitative methodologies. For example, they stated that credibility, dependability, conformability and transferability are among the criteria that is used to evaluate the findings of qualitative research studies. Thus, a number of actions were taken as part of this study to enhance the quality of findings as reported in Table 4.6. These actions were taken throughout the research processes, data collection and analysis.

Table 4.6: Actions taken to enhance the quality of the findings

Qualitative Assessments	Description	Researcher's action
Credibility	How believable are the findings?	▪ A validation process was adopted at the end of this study to ensure that the developed model is of use to the system users. ▪ Statistical tests were done to assess the suitability of the survey tool. ▪ Detailed discussion on the research design and process is presented in this chapter.
Transferability	Do the findings apply to other context?	▪ Multiple case studies were conducted with different companies (upstream and

		downstream petroleum operations) and within different project settings. ▪ Participants are a diverse from employees, policy makers, stakeholders and regulators of the petroleum sector.
Dependability (reliability for quantitative approach)	Are the findings likely to apply to other times?	▪ Data collection procedures followed a well-planned and established protocol. In particular the interviews and case studies. The protocols are detailed in the methodology chapter. ▪ Maintained consistency throughout the research process ▪ Data analysed critically after data collection and storage. ▪ Sustainability management in the petroleum industry is the main field of this study in which the research design and process is based on the ontological and epistemological assumptions. ▪ Triangulation approach, triangulation of sources, triangulation of research approach and mixed methods increases the reliability and dependability of the research results and findings.
Conformability	Has the researcher allowed his values to intervene to a high degree?	▪ The use of multiple case studies was supported by methodological assumptions and philosophies. Each case study was analysed separately to minimise bias. ▪ A neutral position was taken by the researcher in the overall process of this research including the data collection and analysis.
Validity	How true the findings represent the phenomenon under study?	▪ Participants sampling was made very diverse and cover as many different companies as possible. ▪ Data triangulation: mixed methods and approaches were used to encounter the limitations of each other. ▪ Validation process were conducted with participants to give opinions about the initial developed SMS. ▪ Careful design for the questionnaire with pilot testing of the results of interviews and case studies.

Chapter 5
Interviews Results & Analysis

5.1 Introduction

The purpose of this chapter is to present and discuss the qualitative findings that are derived from the semi-structured and structured interviews that were carried out as part of this study. A total of 36 interviews were conducted for the purpose of this PhD dissertation in order for the researcher to seek and investigate the challenges that face petroleum companies in Libya. The interviews were carried out with various people working for the petroleum industry in Western Libya as well as environmentalists and NGO's activists and adhered to a pre-scheduled interview protocol as shown in the appendices. The aim of this phase of the study is to gain deeper understanding of the issues, barriers and challenges that face the Libyan oil industry from the perspectives of stakeholders who are fully familiar with the Libyan context.

The purpose of this chapter is to present the findings of the interviews and discuss the results in conjunction with the findings of the literature review, as well as to analyse the perceptions of the stakeholders in Libya in regards to the challenges and issues that are associated with sustainability management in the petroleum sector in the country. This will provide the foundations for the development of the Sustainability Management Systems for the petroleum sector.

5.2 Sample Profile

The sample that was included in this phase of the study involved 36 individuals as shown in the graphs below. These participants were working as policy makers, environmentalists, NGOs activists, and industrial professionals. The interviewees were mainly managers ranging from top management, senior managers and team leaders. The interviews focused on the management perspective and the opinions of the interviewees with regards to key issues. Semi-structured interviews were conducted with supervisors, environmentalists, health and safety officers and production managers. Figures 5.1 and 5.2 show the distribution of the participants in the interviews during the different stages of this PhD thesis. Some interviews were carried out during the field visits in the different case-studies as discussed in the methodology chapter.

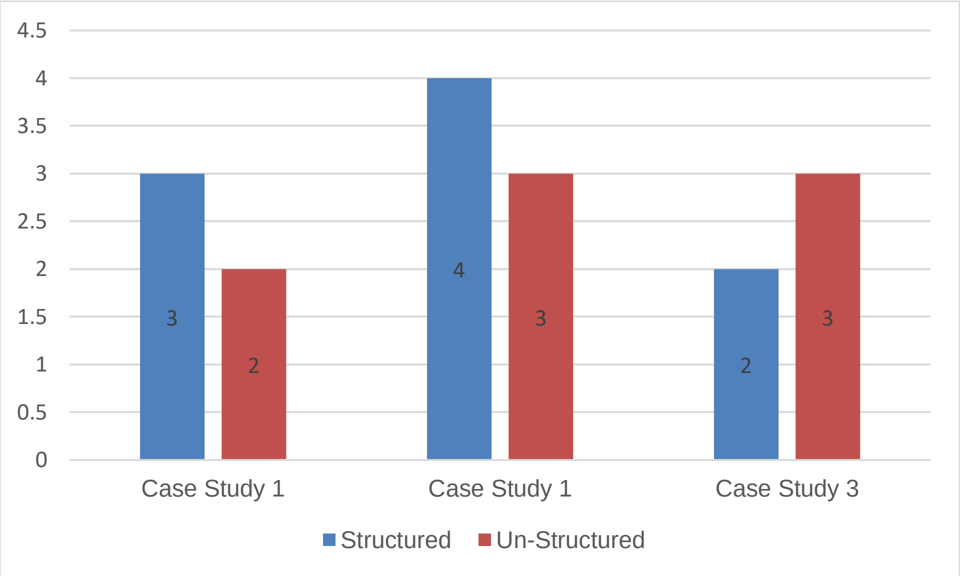

Figure 5.1: Participants in the interviews during the case-studies

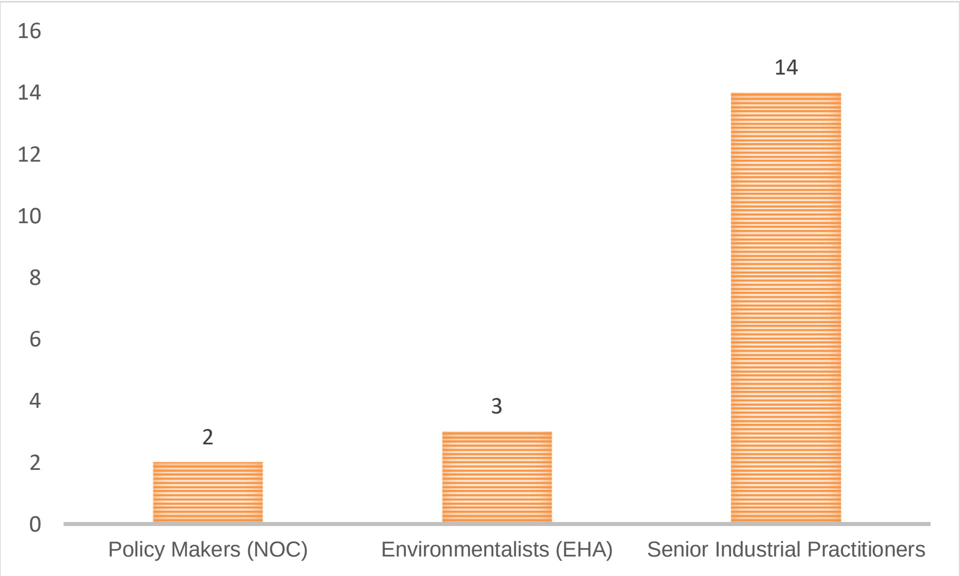

Figure 5.2: Participants in the interviews in the early stages of the research

The participants' roles and positions as well as their years of experience provided a valuable range of opinions which positively contributed to the discussions and results presented in this chapter. In other words, the variety in the sample provided solid findings in terms of the challenges and barriers that are associated with sustainability adoption and implementation in the petroleum sector.

Table 5.1: Demographics of the participants in the interviews

Interviewee Code	Age	Gender	Organisation*	Years of experience
IN1	37	M	NOC	12
IN2	42	M	NOC	20
IN3	41	M	NOC	15
IN4	29	M	PC	5
IN5	51	M	PC	23
IN6	38	F	NGO	13
IN7	37	F	NGO	11
IN8	42	F	NOC	15
IN9	44	M	PC	20
IN10	45	M	PC	23
IN11	28	M	PC	3
IN12	55	M	PC	25
IN13	39	M	PC	14
IN14	47	M	NOC	21
IN15	41	F	PC	16
IN16	40	M	PC	11
IN17	50	M	NGO	23
IN18	33	M	PC	7
IN19	37	M	EA	11
IN20	31	M	EA	6
IN21	29	F	EA	5
IN22	41	M	PC	9
IN23	41	M	NGO	15
IN24	45	M	PC	17
IN25	35	M	PC	9
IN26	37	M	NOC	11
IN27	32	F	EA	7
IN28	29	F	PC	6
IN29	42	M	PC	18
IN30	41	F	PC	15
IN31	39	M	EA	11
IN32	38	M	EA	9
IN33	48	M	PC	23
IN34	51	M	PC	25
IN35	47	M	NOC	19
IN36	37	M	PC	11

*NOC = National Oil Corporation, PC = Petroleum Company, EA = Environmental Agency, NGO = Non-Governmental Organisation

5.2.1 Instrument

An interview schedule and protocol were developed based on the findings of the literature review. The interviews were based on the key themes that were found to be critical in the development and implementation of environmental management systems in organisations. The instrument was designed to ensure that participants are given the opportunity to discuss additional issues that are relevant to interview questions. This is to ensure flexibility as well as enhance the validity of the findings. Most of the questions were open-ended so that the participants are given the opportunity and time to reflect upon their experiences (see appendices for a copy of the interview schedule and a transcript sample).

5.2.2 Procedures

As discussed in detail in the methodology chapter (Chapter 4), consent from the interviewees and all relevant approvals from their organisations were sought prior to discussions. The interviews were carried out either face-to-face or using online-communications where accessibility was an issue. Each interviewee was given enough time to answer questions and notes that were taken during the interviews were shared with the interviewees at the end of each interview to ensure that their answers reflect their experiences and perceptions accurately. It was also important to provide a final opportunity for the participants to share their insights or views about the overall study. The average duration of each interview was around 40 minutes. The participants had the opportunity to ask questions if they believe further clarification was required.

5.3 Data Analysis

Data collected were qualitatively analysed. Bogdan and Biklen (1992) defined qualitative data analysis as 'working with data, organising it, breaking it into manageable units, synthesising it , searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others' as shown in Figure 6.3. These are not easy tasks as there were piles of interview transcriptions, interview notes, observation notes and relevant documents to be analysed. A number of guidelines in analysing qualitative data are presented in various qualitative research literature items, but none of these represents fixed guidelines. One of these is conceptualisation. Saunders et al. (2009) point out that conceptual framework development using such analysis can be considered as a grounded and inductive approach.

A researcher can use any information in any way that they think is appropriate to 'unearth' the meaning and to answer the research questions, but the guidelines used must have their own justification within the theoretical and methodological framework. Qualitative researchers tend to use inductive analysis of data, meaning that the critical themes/ categories would emerge out of the data (Straus and Corbin, 1990; Patton, 2005; Morse, el al., 2002). It also requires some creativity to place the raw data into logical, meaningful categories; to examine them in a holistic fashion; and to find ways to communicate this interpretation to others (Hoepfl, 1997).

Significant amounts of data for this research was from the interview process with interviewees in industrial organisations and non-industrial organisations. Interview guidance which contained the major topics to be asked provided a good foundation in creating conducive interviews with the interviewees. The interview guidance was flexible because the process of interviews often generated new ideas or major issues which were beneficial to discuss with other interviewees. Data analysis from interview methods involves various stages and procedures. There are three main types of the qualitative analysis process as described by Saunders et al (2009).

The first type is the process of summarising of meanings, followed by the categorisation of meaning and the final type is using narrative to structure meanings. In other words, the summarising process involves the need to condense large amount of text into few words so that categories can be developed by linking these words to produce meaningful themes. Thus, the use of narrative to structure data is about ensuring that the data is grouped as per the social or organisational context of the study.

5.3.1 Thematic Analysis

In order for the research to come up with key themes as a result of these detailed interviews with various stakeholders in the Libyan petroleum industry, it was important to use the Thematic Analysis approach when analysing the data.

5.4. Results

A Thematic analysis approach as discussed by Miles and Huberman (1994) involves different steps; the first step is known as data reduction in which the researcher must focus on reading and re-reading the text of the interviews so that familiarity with the overall text and context can be achieved. This step also helps in searching for meanings and generating themes. Data display is the second step as outlined by Miles and Huberman (1994) which is mainly associated with presenting the results of the data reduction phase. Conclusion drawing and verification is the last step that should be conducted as it focuses on developing initial conclusions from the analysis and also presenting the key themes.

Following the analysis of the results of the interviews, several themes have been identified. These are based on the themes that were highlighted during the coding process of the data using the interviewees' notes and transcripts. Table 5.2, shows an example of the coding process that was used to highlight the key themes, supported by quotations from the participants.

Table 5.2: Example of coding process

Extracted Data from transcripts	Line-by-line coding	Parent Code
IN8 "I think that are many issues that prevent oil companies from using systems and international standards that mainly money, physical resources, technology as well as lack of knowledge about the benefits of such systems".	money, physical resources, technology lack of knowledge about the benefits	Technological considerations Training and education
IN13 "In the same time, I believe that human factors are important in reducing environmental impact. Because changing in our managerial and administrative systems is always difficult which makes it problem to adopt new change"	human factors are important in reducing environmental impact changing in our managerial and administrative systems is always difficult	Individual factors Organisational considerations Resistance to change
IN28 "well, education is vital because it helps clear our confusion about many issues but because we don't have strong training system in place, we cannot use advanced technology and new policies because we lack the skills and knowledge"	education is vital we don't have strong training system in place cannot use advanced technology lack the skills and knowledge	Training and education Technological considerations
IN17 "I think lack of culture about change and improvement is an issue in the oil sector in Libya, we use tools from 40 years ago which make our work even difficult"	culture about change and improvement we use tools from 40 years ago	Culture change Advanced technologies

Sketches were also used to develop diagrams using the line-by-line coding as well as the Parent codes as shown in the above table. These diagrams were sketched manually to ensure that most of the variables are categorised under each team correctly. Figure 5.4 and 5.5, shows a diagram categorising the process of environmental and technological considerations.

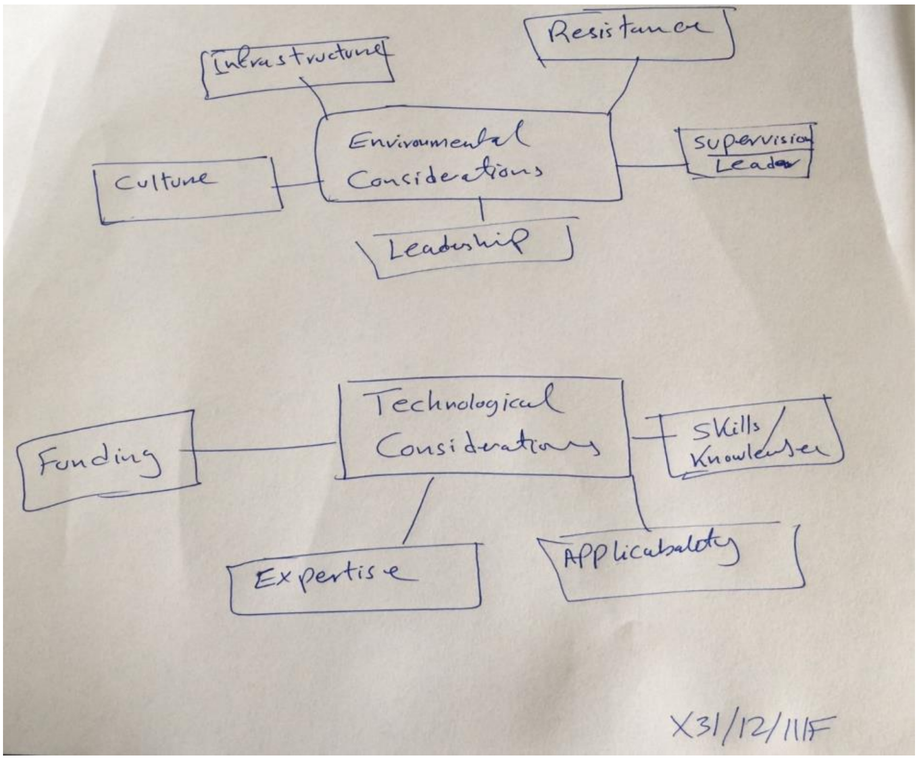

Figure 5.3: Qualitative Analysis diagram 1

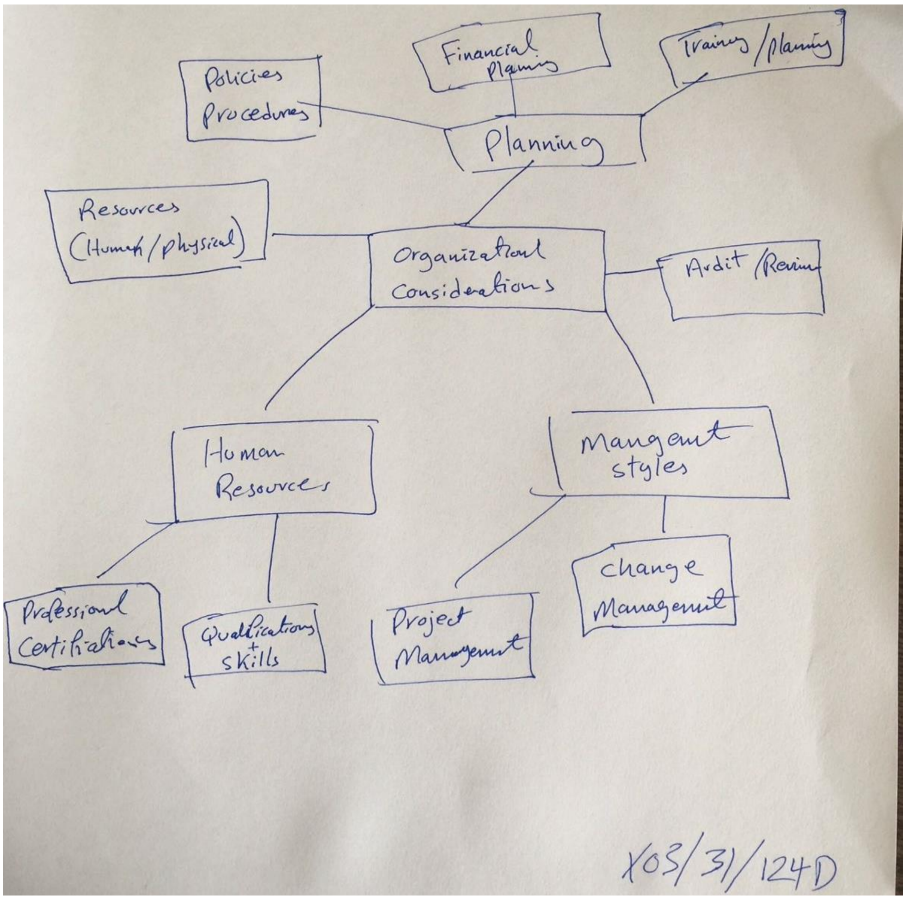

Figure 5.4: Qualitative Analysis diagram 2

Hence, using the notes and transcripts from the interviews, it was found that significant issues were raised which require urgent improvement in order for the Libyan petroleum sector to minimise environmental impact. The following key themes have been identified:

- **Technological Considerations**

One of the key themes raised by the participants in the interviews is the lack of technological resources within petroleum companies. In other words, the participants were concerned about the fact that petroleum companies in Libya rely on old and traditional approaches to planning and management of their operations which significantly impacts upon their performance when it comes to environmental management. For example an interviewee said:

"I believe that oil companies in Libya need to develop new technologies which are widely available, to improve the operational performance because lack of technology impacts on our performance".

Another interviewee stated:

“It is not just about good management and procedures, it is more about having technology and technical parameters that can help in identifying the environmental risks and also monitor our performance”.

Therefore, technological considerations in terms of resources such as equipment and tools that are used for measuring the environmental impact of the different operations is one of the key issues to address in oil and gas companies. This is because most of the participants believe that their environmental impacts are very high when answering Question number 4 in the interviews. One interviewee stated that:

“I think due to our bad and old systems, our impacts are very high and these can be reduced by investing in technology and innovation using our money”.

More importantly, it was noted that the participants believe their companies are not doing well in terms of investing in new technologies due to the lack of awareness about implementing technological approaches within the organisations that operate in the oil an industry. One of the interviewees who was a member of the environmental agency in Libya stated that:

“I have attended courses in UK and Germany and I have learnt about how environmental impacts can be minimised through technology, in Libya, oil companies are not investing in these technologies”.

This again affirms that one of the key challenges that obstruct oil companies from adopting sustainability practices is the lack of technological resources which are important for performance and quality improvement of supply chain operations.

- **Environmental Considerations**

The second theme identified was associated with a lack of clear guidelines and codes about environmental protection and management. In other words, the participants believe that due to the absence of clear guidelines from the authorities, petroleum companies are not committed to enhancing their performance. For example, an interviewee stated:

“In my view, we should not just blame petroleum companies for this poor performance but also blame the authorities that monitor the oil and gas sector in Libya”.

Another interviewee stated that:

"It very important to have guidelines, rules and laws in place to ensure that oil companies are improving their environmental performance"

This shows that all stakeholders need to be involved in the process of protecting the environment and not just the oil companies. However, petroleum companies should ensure that they have systematic approaches in place to improve their environmental impacts through the utilisation of technology and best practices based on lessons from other sectors and from other countries.

One of the interviewees stated:

"Law is number one, and guidelines are number two, and then the blame is on us if we don't follow these laws and guidelines".

This again points out that environmental protection and management in Libya requires a systematic and integrated approach that encourages all stakeholders to be involved in the process. Without this, it could be argued that all efforts will fail as there needs to be consideration of technological and environmental considerations that influence the adoption of such systems.

- **Organisational Considerations**

The importance of organisational conformance and management support was highlighted as very important to the adoption and implementation of sustainability and environmental management systems in the petroleum sector in Libya. Issues related to regulations and laws, management and leadership, human resources, planning, inspection and evaluation as well as the availability of financial resources were raised. For example, one interviewee when answering question five stated:

"Of course, the top management is the first and vital factors that influences on the practices of our organisation, because if the management is interested then all resources and support will be provided".

Another interviewee stated:

"I think all management and administrative efforts cannot be implemented without clear support and commitment forma all managers at all levels and especially from the top management because they make the big decisions".

This again shows that top management and leadership styles in the petroleum industry and awareness about the benefits and value of sustainability is important when it comes to developing and implementing sustainability management systems. This was affirmed by almost most of the interviewees including managers themselves. For example, one manager stated:

"Yes, I agree that top managements has a significant role to play in minimising environmental impact. This starts by making the right decisions and also providing the resources needed to reduce these impacts".

More importantly, it was noted by the participants that management decisions should not be focused on improving the financial performance or production levels but also on ensuring that all operations are being conducted in accordance with national and international laws. One of the interviews form an NGO stated:

"For us, management is not only about making profits and production increases in oil companies but also about ensuring that all of their work and operations are environmentally-friendly".

Another important element which was categorised under this theme is the availability of human resource personnel who are competent and qualified to develop and implement sustainability management systems. For example, one of the key issues that was raised by one of the interviewees is the lack of expertise in the field of sustainability management in Libya, the interviewee said:

"I think petroleum companies in Libya do not have the right skills or expertise to develop sustainability management systems as we lack professionals in this field".

Another interviewee stated;

"Petroleum companies should ensure that their human resources departments are working to meet the needs of their employees in terms of skills enhancement and development because we don't have experts in the field of sustainability management".

This also affirms that points that were discussed in the literature about training and development which are considered as success factors to implementing environmental management systems. Participants believe that their companies do not have the right skills or knowledge to implement sustainability management systems. Therefore, this could imply that petroleum companies need to have a systematic and integrated approach to sustainability management by developing the skills of their employees and also obtaining professional certifications and accreditations from international organisations. Furthermore, planning was one of the key themes that were also found to be very important as part of the organisational factors and considerations. One of the interviewees said:

"I think our environmental impacts are high because of our poor planning, we don't use methodologies such as environmental impact assessment tin our planning phases".

Another interviewee stated:

"It is not all about training and education but more about having the right tools for making efficient and effective planning where all risks are identified in the early stages so that control measures can be put in place to avoid such risks".

These important points highlight the fact that methodological approaches such as Environmental Impact Assessment and Life Cycle Assessment are badly needed in the petroleum sector in Libya as companies carry out different operations that cause significant environmental impacts including land and air pollutions. Therefore, organisational policies and arrangement should be developed by top management to ensure all employees are familiar with the different stages and tools that are used as part of the decision-making process. In addition to planning, evaluation and inspection were also noted amongst the challenges and barriers that hinder petroleum companies from adopting sustainability practices. For example, one interviewee stated:

"In my view the main issue about environmental management in Libya is lack of inspection and monitoring from all stakeholders, we don't have others monitor our work which means we don't feel that we can be held accountable".

Another interviewee stated:

"It is all about ensuring that plans and strategies are being implemented effectively, how can we do that if we don't have systems in place that monitor our progress or check upon our performance".

The issue of monitoring and evaluating performance is a core element of all managements systems including those introduced by ISO and other leading organisations. All organisations should ensure that their policies, practices and programmes are evaluated to ensure that they are accomplishing the goals that are desired. In terms of environmental management, it was noted that all the participants believe monitoring and evaluation of performance is significant as it helps companies correct their actions and also develop new strategies and plans that could help minimise environmental impact. One of the interviewee said:

"I think the government should have a role in minimising the environmental impact by establishing independent bodies that monitor the work of companies".

This highlights the lack of regulatory framework that organise and control the work of petroleum companies in Libya when it comes to sustainability and environmental management. Regulations and policies at the national level were considered to be among the key success factors that help petroleum companies minimise the environmental impacts. One of the interviewees stated:

"There should be strict laws and regulations that all companies that operate in Libya should adhere to, but laws alone are not enough without monitoring and evaluation from independent agencies".

It can be seen that some interviewees are concerned about the lack of a regulatory framework which provides a legal basis for petroleum companies to adhere to in order to improve their performance. It is clear that more work is needed to develop regulations and laws. This can be facilitated by learning from other countries and also appointing external consultants to help policy makers develop regulatory systems. Financial resources were another key concern raised by participants as a barrier to the adoption of sustainability management systems. One interviewee stated:

"Petroleum companies produce oil which is the main source of income to Libya but we don't have money to invest in technology or develop management systems as other foreign companies".

Another interviewee stated:

"I think there is bad financial management practices which limit our capabilities from learning or adopting new technologies".

Availability of financial resources is very important when it comes to sustainability and environmental management as it provides the tools that are needed to develop such systems in terms of physical infrastructure and also enhancing human competencies.

- **Individual/Human Considerations**

Individual and human considerations as a theme were based on the fact that most of the participants in the interviews were concerned about the awareness and competencies of staff as well as their motivation to accept change. One of the interviewees stated:

"In my view not only the organisation is failing towards sustainability or environmental management but also as employees, we don't like to adopt new rules as we are used to the old ones".

Another interviewee said:

"I think human factors should also be taken into account in terms of our ability to adapt to new changes in the organisations which prevents us from learning about new technologies or tools".

These factors are very important when it comes to developing sustainability management systems as the employees are the key members of the organisation who should perform the tasks required and also ensure that resources are being utilised efficiently. Resistance to change was seen as one of the barriers that might hinder petroleum companies from adopting new technologies. This is a serious problem as these new systems will require organisations to make significant amendments in the organisational structure as well as in the protocols, procedures and rules that are being practiced within the organisation. Human factors should be taken into account when developing environmental management systems and training as well as professional development should be offered to all employees to ensure their skills are enhanced and they are capable of meeting the challenges in the workplace. Employee empowerment and employee participation are also crucial when it comes to enhancing the environmental performance, as the top management needs to listen to the concerns of their employees. One interviewee stated that:

"I think in our organisation the issue of making decisions that impact long term performance of the staff and the organisation as a whole should be given a second thought".

This was also affirmed by another participant who stated that:

"More teamwork is needed and also employees should be involved in the decision-making process as that will help them come up with new ideas about their work".

Thus, the implication is that human factors are vital when it comes to developing and implementing environmental management systems which should be noted by policy makers.

5.5 Discussion

The findings of the qualitative phase in this study highlight that sustainability management in Libya requires a systematic and a holistic approach that takes into account several factors which have been categorised under technological, organisational, human and environmental factors above. It was pointed out by the research participants that sustainability management in the petroleum industry in Libya is not well-practiced due to the lack of a strict regulatory system in place as well as lack of awareness about the benefits of such systems. More importantly, the participants in the interviews were concerned about the level of support that is given to petroleum companies from all authorities in Libya and that the top management and leadership should be more committed towards reducing the environmental impact.

Furthermore, it was also seen that the interviewees believe that sustainability management in Libya cannot be accomplished without shifting the focus of all policy makers and stakeholders towards the value and importance of sustainability. A key issue that was raised by the interviewees is the lack of clear laws and regulators that put pressure on petroleum companies to improve their environmental performance and reduce their negative environmental impacts.

In terms of the use of methodological approaches, it was noted that none of the well-known processes such as the EIA and LCA are used in the planning stage of any operations or projects as highlighted by the participants. This shows that a holistic approach that involves planning, implementation and control phases needs to be considered when developing a sustainability management system for the Libyan petroleum sector. Furthermore, amongst the issues raised is the lack of resources either human or physical that can help companies implement sustainability systems, which is seen as vital.

In terms of the challenges that face the petroleum companies in Libya, it was found that organisational factors such as the lack of resources, lack of training and development, lack of education and support from top management and leadership are among the key concerns. Moreover, lack of advanced technology expertise is also noted along with the lack of financial resources, the latter being very surprising as the petroleum industry in Libya is considered as the main source of revenue to the country's economy. This could suggest that poor resource utilisation exists or staff are poorly informed about the availability of financial resources. The findings of the qualitative study are in line with some of the factors that were identified in the literature review (chapter three) which are associated with the successful implementation of EMS. Hence, these findings also support the aim of this study and the problem statement which outlines that an integrated approach to sustainability management in the Libyan petroleum sector is essential.

The rest of this dissertation will present the findings of other empirical work that was carried out as part of this PhD thesis to highlight the challenges and issues associated with the petroleum sector in Libya, so that a holistic approach can be developed to minimise the environmental impact.

5.6 Chapter Summary

The aim of this chapter was to present the key findings of the qualitative phase. A total of 36 interviews were conducted with several stakeholders in the petroleum sector in Libya. All interview data were analysed using a thematic content approach and a number of themes have been identified. Based on the interviews, it was found that an absence of a regulatory framework which is a principal role of the government or state was seen as a major obstacle towards adopting sustainability and environmental management systems.

It was highlighted by participants that further information and support is required in order for the petroleum companies to adopt sustainability indicators and that stakeholders should be involved in the process of strategic planning to ensure any obstacles are identified and managed. Among the themes is the need for having organisational, technological and governmental arrangements in place to ensure that petroleum companies are meeting their environmental obligations.

Funding and resources are also among the factors that were seen to be of high importance for companies to develop environmental management systems. It was noted that training and educational programmes and obtaining external expertise and the use of advanced technologies as well as using methodological approaches such as LCA and EIA could further assist improvement.

Interviewees believe that using international standards can help domestic companies reduce their environmental impacts. However, some of the barriers were associated with the lack of support at the governmental and management levels. Lack of expertise in the field as well as lack of awareness about the benefits of sustainability and its impact on the organisational performance are also noted. Hence, the findings indicate that petroleum companies in Libya struggle in terms of adopting sustainability practices. There are very low levels of awareness about the value and benefits of sustainability.

The following chapter presents the findings of the quantitative study that was also carried out in Libya.

Chapter 6
Survey Results & Analysis

6.1 Introduction

The purpose of this chapter is to submit the quantitative findings that were established through analysis of a questionnaire survey. A general discussion on the main themes and findings is also presented.

6.2 Reliability Analysis

It is important to check whether the questionnaire or the tool we are using for research is reliable. Authors have different ideas about Reliability Analysis but Helms et al (2006) suggest that reliability analysis measures the consistency of the instrument i.e. to what degree instrument provides the reliable scores at all times. The most widely used measure of reliability in social sciences is Cronbach α (alpha) that refers to the coefficient of internal consistency (Cronbach, 1951). Cronbach α measures the reliability using the following formula:

$$\boldsymbol{\alpha = \frac{N}{N-1}\left(1 - \frac{\sum_i^N = 1\, \sigma_{Yi}^2}{\sigma_X^2}\right)}$$

where N is the number of components (items or testlets), σ_X^2 is the variance of the observed total test scores, and $\sigma_{Y_i}^2$ is the variance of component i.

The criteria of acceptability of Cronbach's α is that if the value of α is above 0.9, it is considered excellent, 0.8 to 0.9 is considered great, 0.8 to 0.7 good, 0.7 to 0.6 acceptable, values below 0.6 questionable and 0.5 and below poor.

In this research, the questionnaire was distributed among 15 employees of the same organisation in order to check the realibility of the questionnaire. The Reliability analysis was conducted using Cronbach's Alpha results tool in SPSS software. Following is the Cronbach's Alpha result of the entire part 2 of the questionnaire:

Reliability Statistics

Cronbach's Alpha	N of Items
0.861	35

We can see from the above table that the value of Cronbach's Alpha for the entire questionnaire is 0.861, which falls under the 'great' category. This means that the questionnaire is reliable enough to be used for this research.

It is not only the complete questionnaire that should be reliable but also the reliability of each variable in the research because if the items for each variable is unreliable, that variable might hamper the research as a whole. So in order to check the variable reliability, the researchers did a reliability check of each variable one by one.

6.2.1 Sustainability practices:

There were a total of 5 items of this variable in the questionnaire. The researchers completed the reliability analysis and the following result was found:

Reliability Statistics

Cronbach's Alpha	No. of Items
0.721	5

The Cronbach's alpha is 0.721 which is in the range of 'good', which means that the questions / items made for this variable is reliable enough to be used in this research. Reliability of other variables is shown below.

6.2.2 Barriers to introducing sustainability:

Reliability Statistics

Cronbach's Alpha	No. of Items
0.822	8

6.2.3 Factor contributing to the success of Sustainability:

Reliability Statistics

Cronbach's Alpha	No. of Items
0.901	7

6.2.4 Motivations for implementing Sustainability Management Systems:

Reliability Statistics

Cronbach's Alpha	No. of Items
0.872	6

6.2.5 Solution for reducing negative environmental impact:

Reliability Statistics

Cronbach's Alpha	No. of Items
0.792	5

So all the variables and the items are deemed reliable enough to be used in the research.

6.3 Demographic Analysis

The first part of the questionnaire used in the study is comprised of Demographic information. Demographic analysis is a technique used to develop an understanding of the age, sex and racial composition of a population and how it has changed over time through the basic demographic processes of birth, death, and migration (Maxwell et al., 1972).

In the current research, the respondents are asked different demographic questions in order to record the participants' age group, occupation, education level and other relevant information. According to Wunsch, (2012), in any kind of research which is based on a survey analysis, the researchers should keep in mind the importance of the demographic data. If the demographic data is available, the researchers might, for example, decide to exclude a certain age group from the analysis, to give a more tailored response (Yusuf et al., 2014).

The following section of this chapter encompasses the analysis of all of the demographic data from the first part of the questionnaire. There were total of 6 questions in this part which were about age group, company details, industrial experience, involvement in different kinds of petroleum operations, position in the company and how respondent's believed their company is performing on sustainability front.

The first question in the demographic part of the questionnaire is related to the age of participants.

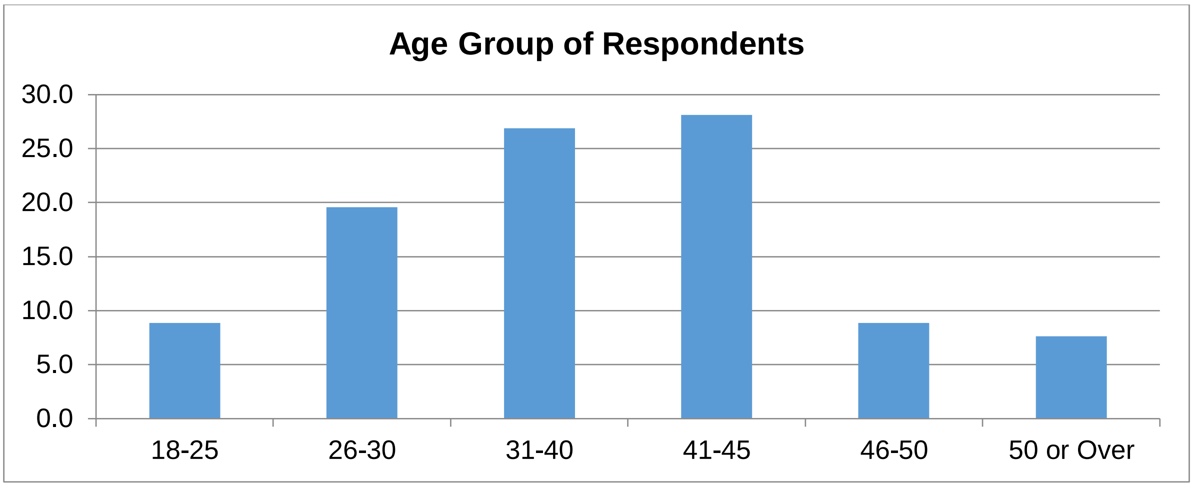

Figure 6.1: Age groups of respondents

It is apparent from the above graph that participants are mainly from three age groups: 19% from 26-30, 27% from 31-40 and 28% from 41-45. Thus, nearly 2/3rds of participants are between the ages of 26 to 45. This means that they have experience in industry or can be considered a mature workforce. It is said that the petroleum industry has the capacity to retain its workforce because it is a sustainable industry with lucrative packages for its employees (Hosie et al., 2013).

The current data highlights the literature findings. This is the time when people are more worried about their career path and if they choose to stay with the company, it shows that the industry is providing enough for them and their family to at least survive or even to thrive, or they believe that the company provides positive opportunities.

Company Type

The second item in the questionnaire is about the type of company the respondent is working in. The reason for this question is because it allows the researchers to differentiate between the responses of the employees from different industries.

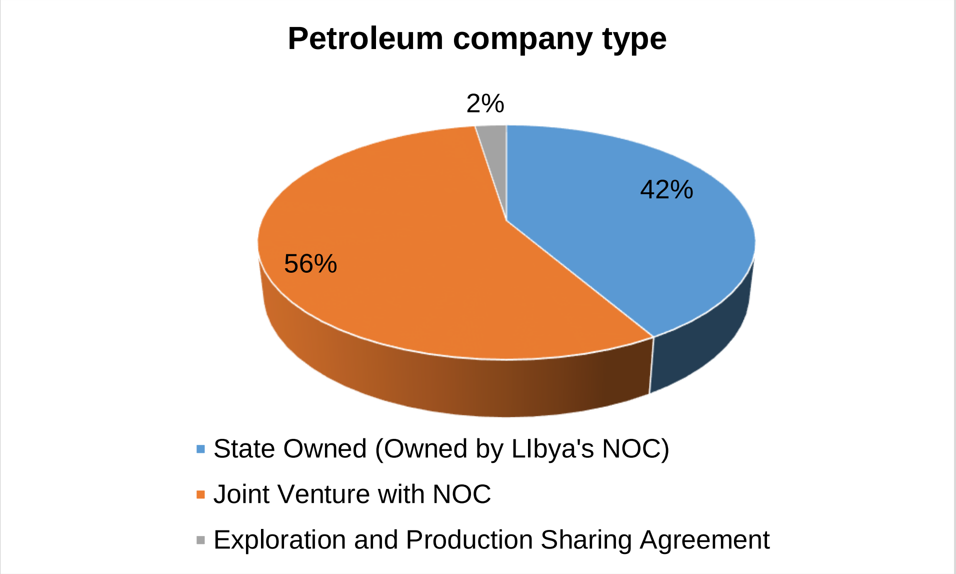

Figure 6.2: Petroleum company type

Over half of the participants are working in Joint Ventures with NOC. 42% are employees of fully owned companies, and only 2% are working for EPSA companies. It is no surprise that the majority of participants are within the Joint Venture category, as over 70% of the Libyan petroleum sector is made up this way (NOC, 2015).

It was obviously taken into consideration that there should be no bias in the data collection and for that reason, the reseachers decided to collect data from as many different sources as possible. As the above data shows, however, more than half the data is collected from a single source i.e. Joint Ventures with the NOC, which is not ideal. The reason for this single source data is that more Petroleum companies in Libya have decided to engage in Joint Ventures with the NOC, as this provides many benefits.

Industrial Experience

One of the most important items in the questionnaire is the inquiry about the experience respondents had in the Petroleum industry. The reason for including this question is that it might help distinguish between employee responses at different seniority levels. According to Hong et al (2016), the more senior an employee is, the more specific the response about the industry would be, because he / she would have a broader perspective of the industry. A junior employee's response is also very important because according to Presslee, et al. (2013), junior employee's thinking about their industry is the true reflection of how the industry would appear to all the stakeholders. We know that stakeholders are not necessarily directly involved in the day to day operations of the industry, but the junior employees response typically reflect their views also.

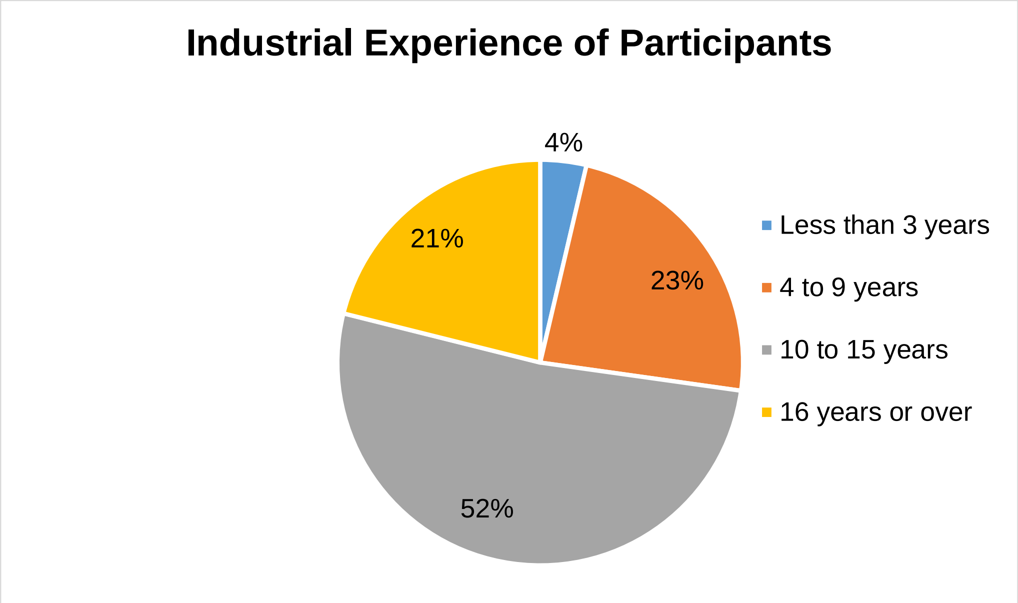

Figure 6.3: Industrial experience of participants

Figure 6.3 shows that nearly 2/3rd of participants have more than ten years' experience and only 4% less than three years, so the vast majority are knowledgeable enough to appreciate any problems and can form sound and rational judgements about them.

The significant number of senior employees in the survey improves the likelihood of finding ‘real’ problems in the industry, but hearing the responses from the junior and mid-level employees is also helpful as it provides a different dimension. Industries evolve with the passage of time and employees evolve with them, but some are more flexible than others in how they adapt to the change. It can be seen from the above data that a large number of employees stay within the industry for a considerable time, which implies most are able to adjust appropriately to modified working practices.

Respondent’s Operational Department:

There are many different departments working in the petroleum industry including production, maintenance, refining and administration. Some of these are core departments like production, maintenance and refining and some are 'soft' such as HR, administration and finance.

Participants were asked about the type of departments they are working in to give context to the answer (see Figure 6.4). More than 50% of participants belong to three core departments, Petroleum Production (25.7%), Maintenance (19.9%) and Oil Refining (15.6%). This is advantageous to the study as it allows the understanding of the issues from core petroleum departments. Furthermore, despite the fact that health, safety and environment departments have the lowest number of employees across the Libyan petroleum sector, the participants belong to these departments represent around 12.5%. This is considered high compared with the number of employees from other departments. This is deemed very beneficial with respect to the objectives of the study.

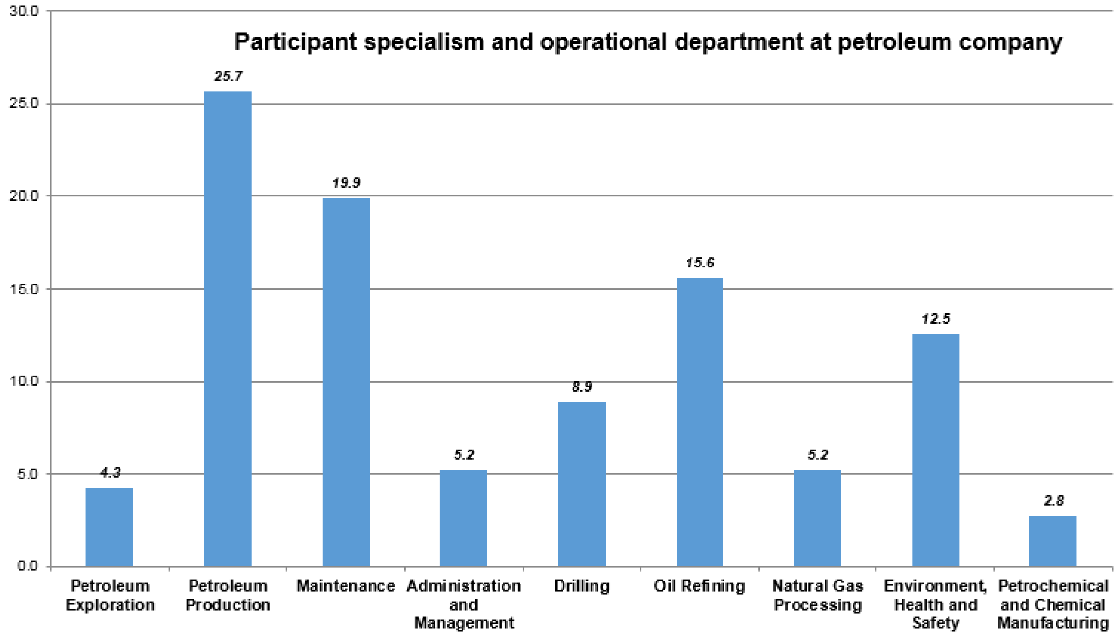

Figure 6.2: Participants' operational department

Employee's Position:

To understand the organisational hierarchy of participants, they were asked about their level within their companies. Figure (6.5) shows 52% of participants are normal employees which means they might be engage in manual labour and other working categories, 30% are Middle Managers and the remaining 18% are senior managers. It is clear that organisational hierarchy is therefore fairly distributed among participants with respect to their positions.

Different employee positions give rise to different perceptions about the organisation or industry, according to Shoss et al (2013). As employees go up in the organisational hierarchy, their perception about the organisation drastically changes and the things or issues which used to irritate them, no longer do. In fact, they often start to defend these issues. So, taking the responses from all the levels is important to have a 360 view.

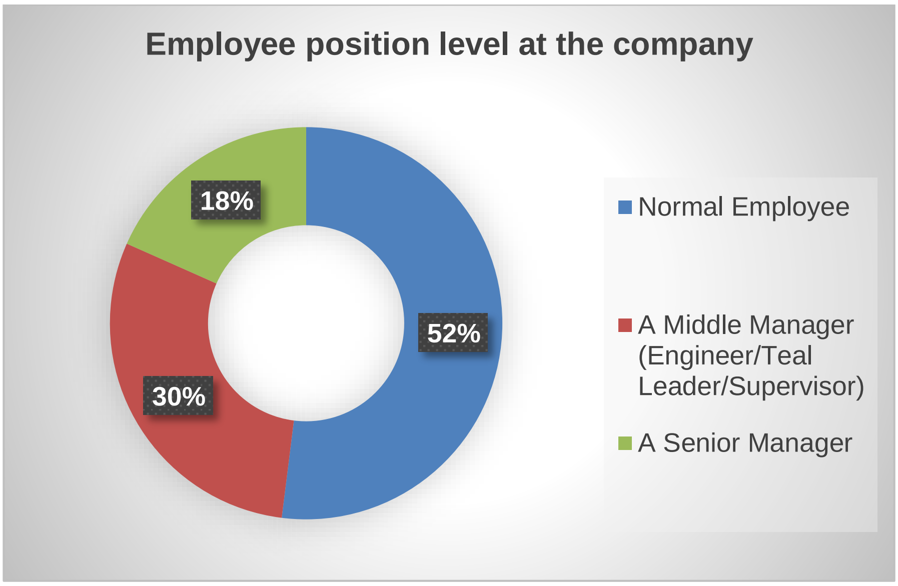

Figure 6.3: Employee positiion

Participants' Perception of Their Companies' Environment Performance

The participants were asked about how environment-friendly they think their company is and their responses are shown in Figure 6.6. Unsurprisingly, it can be inferred from the graph that 68% of the participants think their company is highly impacting the environment by emissions and wastes. Only 7% of participants thought their company is green. So if the employees think their company is not environment friendly, how will society judge them? These are concerning numbers and are a real worry for environmental decision makers.

According to Wayne et al (2013), many employees tend to speak positively about their company no matter what you ask them about. Even when the employees were asked about the negative impact of a petroleum company on the environment, 7% thought that the company is completely green.

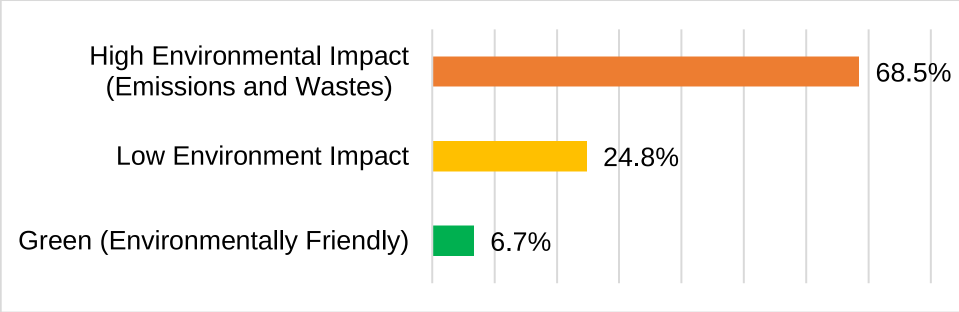

Figure 6.4: Partiicpants opinoion towards their company envrioemtal performamce

6.4 Descriptive Analysis and ANOVA

The second part of the questionnaire is items with a Likert Scale. There are two ways to do an analysis of Likert Scale questions; one method is descriptive and the other is ANOVA or regression analysis. This first part will be the descriptive method, in which the frequency of the responses will be taken into consideration and will be used to analyse the data and aid decisions.

Sustainability Practices followed by Libyan Petroleum Companies

In order to get a better understanding of the sustainability situation at the Libyan petroleum sector, all 327 participants were asked to rate their opinion on a five-point Likert scale regarding various sustainability practices. The participants' opinions are displayed in Table 6.1 below.

Table 6.1: Sustainability Practices

Sustainability Practice	Company using EMS or/ SMS	Company have sustainability policy	Company has designated team/manager for environmental issues	Accredited to ISO 4001: 14001	Addressing to ISO 4001:14001
Strongly Disagree	35.5%	12.2%	26.9%	35.2%	16.2%
Disagree	25.7%	6.7%	29.7%	31.2%	30.9%
Neither Agree nor Disagree	19.0%	9.5%	20.2%	10.7%	22.9%
Agree	17.1%	35.2%	17.7%	15.9%	20.2%
Strongly Agree	1.2%	32.1%	2.4%	1.2%	6.7%

A sustainability management system (SMS) is a technical means of integrating environmental, social and economic concerns into organisational management, so that it can become more effective in addressing its positive vision of a sustainable future. It is the starting point to moving towards sustainability. It can be inferred from Table 6.1 that more than 60% of participants disagree with the statement that the “Company is using EMS or SMS” with only 18% agreeing. This indicates that the majority of Libyan petroleum companies do not have any sustainability approaches in place or they are not being communicated effectively.

The results from the interviews (stage 1) imply it is the former case, that sustainability practices don't exist in the sector and this is the major reason for environmental deterioration in the area / country, so creating an SMS can only assist sustainability development.

Sustainability policy is a formal document that states the organisation’s intentions regarding its overall sustainability performance (Bueren and De Jong, 2007). The sustainability policy is the basis upon which the sustainability management system is to be built (Pojasek, 2008). It can be seen from Table 1 that nearly 2/3rd of participants agree with the statement about the “company having a sustainability policy”. This widely contrasts with the findings from the interviews at stage one of this research.

Interviews were conducted with 36 senior managers or consultants and most of them clearly stated that a sustainability policy does not exist in the sector. It is possible, however that there is some misunderstanding of what constitutes a company sustainability policy and the Libyan environmental law which is enforced by the NOC. When asked, one manager stated there was a huge difference between the two, so arguably, organisations have failed to communicate this effectively.

When the third statement in Table 6.1 was analysed regarding whether a “Team/Manager was responsible for environmental issues”, the results showed that only 1/5th of participants agreed this to be the case. Interviews findings showed similar results, which indicates that companies are not taking environmental issues seriously. In different countries of the world, where the petroleum and other industries give greater importance to the sustainability issue, they have a different department for sustainability, with their own governance. The employees of this department are responsible for managing sustainability, keeping an eye on changes and new laws, training employees about sustainability and taking actions to implement the laws.

ISO 4001 and its family of standards set out the criteria for an environmental management system. ISO4001 is a certification for evidenced EMS applied by the company. It maps out a framework that an organisation can follow to set up an effective environmental management system. Table 6.1 shows that more than 3/4th of participants disagree with the statement that the “company is accredited to ISO4001:14004” and only 1/4th of participants agree it. Thus, most companies do not have a proper EMS in practice.

With the use of the quantitative analysis software SPSS, a mean analysis was conducted. To give proper weight to the Likert scale, values were assigned to each rating point. 1 – Strongly disagree, 2- disagree, 3 – neither agree nor disagree, 4 – agree, and 5 – strongly disagree. Table 6.2 and Figure 6.5 shows the results.

Table 6.2: Sustainability Practices Means Score

Sustainability Practices	Mean	S.D
Company using SMS/EMS	2.2	1.15
Company have sustainability policy	3.7	1.34
Company has designated team/manager for environmental issues	2.3	1.10
Accredited to ISO 4001: 14001	2.1	1.16
Addressing to ISO 4001: 14004	2.7	1.20

It can be inferred from Table 6.2 that the mean score for all the statements are below 3, except the “company having sustainability policy” (3.7). A mean scores of less than three indicates that the participants are disagreeing or are neutral to the statement. The standard deviation is almost uniform for all the statements and hence we can conclude there is not much deviation in the responses among the participants. Thus, the only positive sustainability practice followed by Libyan petroleum companies as per the survey is to have a sustainability policy. As argued earlier, this aspect contradicts the interview findings and it is deemed that participants have confused the sustainability policy with the Libyan environmental law enforced by the NOC. This understanding was gained after further clarifications followed re-communicating with some participants. Basically, a policy without any management system or standard or team won’t be effective. Hence, a concerted effort should be made to improve the sustainability practices in Libyan the petroleum sector.

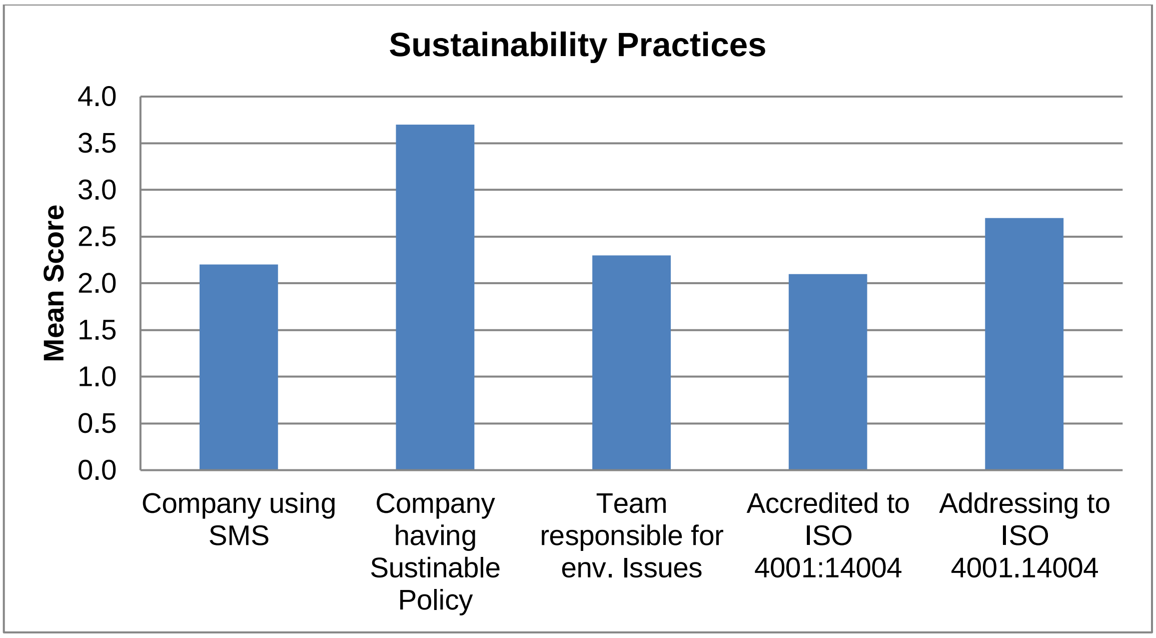

Figure 6.5: Sustinaiblity practices mean score

With a view to ascertain the variance in the sustainability practices among different company types, an ANOVA test has been used. Scores of all the five statements are added together to form the total sustainability score. The scores of each company on their sustainability practices are given in Table 6.3.

Table 6.3: Sustainability Practices Mean Score Vs. Company Type

Sustainability Practices Score	Freq.	Mean	Std. Deviation
State Owned (Owned by Libya's NOC)	136	11.21	4.10
Joint Venture with NOC	183	13.78	4.02
Exploration and Production Sharing Agreement	8	11.00	0.00
Total	**327**	**12.64**	**4.20**

It can be seen from Table 6.3 that the mean score of Joint Ventures with the NOC are higher than that of State Owned petroleum companies and those operating under exploration and production sharing agreements. Both NOC and exploration companies have low scores in sustainability practices when compared with JVs. To ascertain the statistical significance of this, ANOVA is used and the results are shown in Table 6.4.

Table 6.4: ANOVA Table

Null Hypothesis: There is no significant variance in the sustainability practice scores among different company types.

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	539.65	2.00	269.82	16.75	0.000
Within Groups	5219.49	324.00	16.11		
Total	**5759.14**	**326.00**			

It can be seen from the above ANOVA table, that there is significant variance in the sustainability practice scores among different company types. The F value is 16.75 (>1) and the Sig. value is 0.000 (<0.01), hence we can conclude with 99% confidence that our prediction of JVs having higher sustainability practices is statistically significant. This may be due to the fact that Join Ventures from advanced nations are following the sustainability practices of home countries. For instance, Eni is a North African oil company having Joint Venture with Libya's NOC. It is involved in various sustainability activities and operates an effective waste management system along with involvement in various community development programmes. It could be argued therefore that Libya's NOC still don't follow ISO 14001 EMS and that an effective EMS is not currently implemented in the Libyan Oil Industry.

Barriers to Introducing Sustainability

Most people understand the importance of sustainability and the need to follow environment management systems, but there are still many companies that don't follow sustainability practices. With the aim of understanding the main barriers to introducing sustainability, the participants are asked to rate their opinion on the 11 barrier highlighted in table 6.5 below.

Table 6.5: Barriers to Introducing Sustainability

Barriers to Sustainability	**Lack of Management Commitment**	**Lack of Awareness**	**Organisational Culture**	**Lack of Implementation framework**	**Insufficient Technology**	**Lack of Skilled Workers in Sustainability**	**Lack of Financial Incentives**	**Corruption and Lack of Transparency**	**Lack of Legislative framework and policies**	**Insufficient Drivers for Sustainability**	**Negative Attitude of Employees**
Strongly Disagree	10.4	12.2	22.6	16.2	23.9	22.6	16.2	23.9	4.0	22.6	16.2
Disagree	9.8	11.0	28.7	22.6	34.3	28.7	22.6	34.3	4.3	28.7	22.6

Neither Agree nor Disagree	5.7	7.3	10.1	11.9	17.1	10.1	11.9	17.1	3.7	10.1	11.9
Agree	35.2	33.6	24.5	36.4	18.7	24.5	36.4	18.7	55.7	24.5	36.4
Strongly Agree	38.8	35.8	12.5	11.3	1.8	12.5	11.3	1.8	32.4	12.5	11.3

It can be inferred from the table, that nearly 90% of the participants agree that lack of legislative framework and policies is the major barrier to introducing sustainability. Taylor (2007) says, voluntary approaches to environmental regulations are ineffective and won't work when the challenges outweigh the benefits. The study concludes legislation is the most important factor for most businesses to implement environmentally friendly practices as businesses will generally fulfil only the minimum requirements. Biltayib M. Biltayib (2006) point out that environmental laws are not influential in Libya. Hence Libyan environmental laws are to be reformed and properly administered to make the companies adhere to a strict sustainability management system and policy.

More than 80% of the participants agreed lack of management commitment is another key barrier to introducing sustainability. Research shows a strong relationship between management commitment and sustainability. Ikediashi et al. (2013) says, "The senior management personnel should be at the forefront to implement sustainability." The study found that the main barriers that were seen to prevent an organisation from effectively managing their sustainability responsibilities were lack of time, knowledge and senior management commitment.

According to Elmualim et al. (2012), the key to successful implementation of the sustainability agenda within organisations rests squarely in a positive perception by senior management that sustainability is an important issue to be addressed as a mainstream objective within that organisation's corporate plan. By implication, it is important to emphasise that the concept of sustainable practice can only make appreciable impact amongst the corporate world if sustainable principles are fully embedded in the strategic function of organisations. To improve sustainability practices, management commitment should be increased to the maximum, as this is the key to effective implementation of any regulation.

More than 2/3rd of participants agree that lack of awareness about sustainability practices and environmental laws is a major barrier. Tzschentke et al (2008) agree, stating that limited awareness among the business owners of their environmental footprint has been identified as a barrier to change.

To properly give weight to each rating, mean score analysis is used and presented in table 6.6.

Table 6.6: Mean Score of Barriers to Sustainability

Barriers to Sustainability	**Mean**	**S.D**
Lack of Management Commitment	3.9	1.4
Lack of Awareness	3.7	1.3
Organisational Culture	2.7	1.3
Lack of Implementation Framework	3.0	1.3
Insufficient Technology	2.4	1.1
Lack of Skilled Workers	2.8	1.4
Lack of Financial Incentives	3.0	1.3
Corruption and Lack of Transparency	2.4	1.5
Lack of Legislative Framework	4.1	0.9
Insufficient Drivers	2.7	1.4
Negative Attitude	3.0	1.3

The score is given as 5 – strongly agree, 4 – agree, 3 – neither agree nor disagree, 2 – disagree, 1 – strongly disagree. In mean score analysis, scores more than 3 are considered as agreed by the participants and less than 3 are considered as disagreed by the participants. It can be seen from table 6.6, that lack of legislative framework has a mean score of 4.1 and it has the lowest standard deviation 0.9, it is followed by lack of management commitment (3.9) and lack of awareness (3.7). Only these three barriers are having a score of more than 3. Hence, we can conclude that participants believe these three as the strongest barriers for sustainability. Appropriate action should be taken to remove or reduce these barriers.

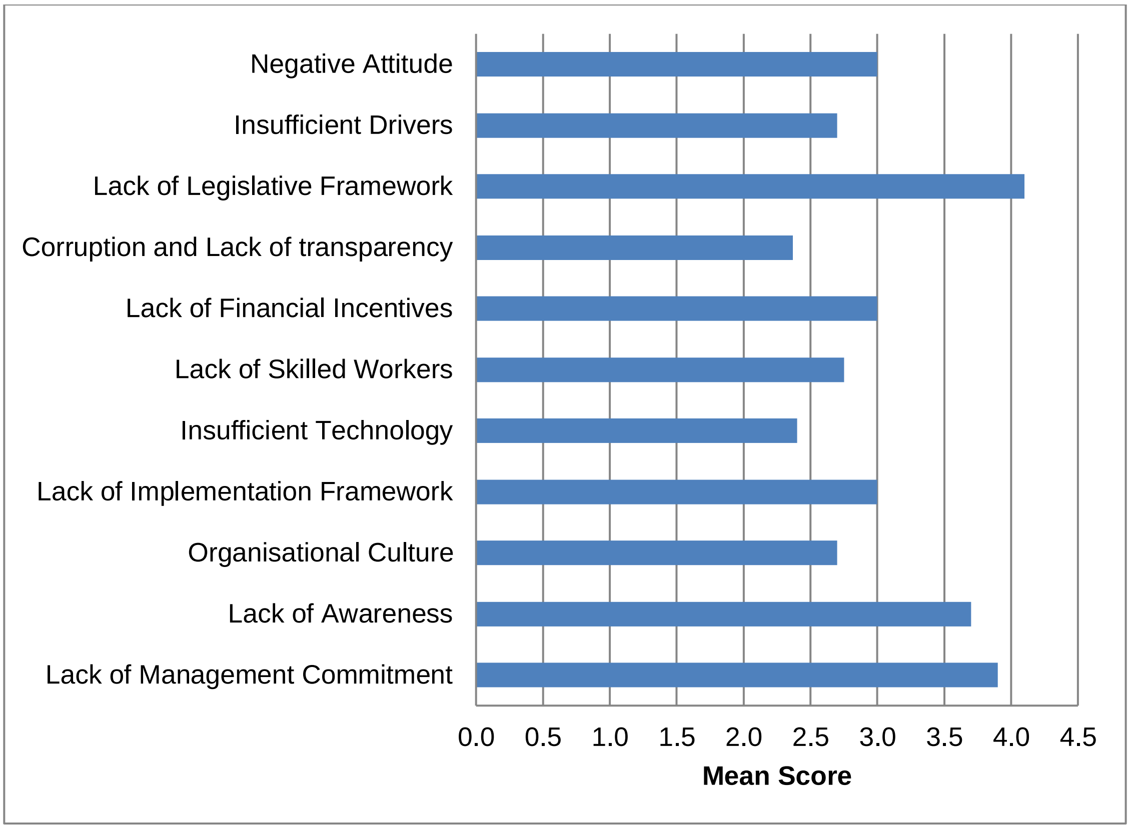

Figure 6.8: Barriers to sustainability

Factors Contributing to the Success of a Sustainability Management System

In the past decade, companies have increasingly realized that environmental sustainability is critical to their long term profitability. As global populations grow and demand for oil increases, companies are challenged to more efficiently use a finite base of natural resource. While some companies are successfully reducing their environmental impact, many others are still far behind. With the aim of ascertaining the factors contributing to the success of a sustainability management system, the participants were asked to rate their opinion against 9 contributory influences and their responses are given in Table 6.7.

Table 6.7: Factors Contributing to Success of Sustainability

Factors Contributing to Success of Sustainability	**Management Commitment**	**Regulations and Policies**	**Effective Management of Change**	**Raising Awareness of Sustainability**	**Training Programme**	**Use of Technological Advances**	**Effective Cultural Management**	**External Consultancy**
Strongly Disagree	12.2	16.5	35.5	11	35.5	12.2	26.9	16.5

Disagree	1 1.9	9.5	25.7	15	25.7	6.7	27.4	11.0
Neither Agree nor Disagree	7.0	4.9	19.0	7.5	19.0	9.5	12.2	6.1
Agree	32.7	41.6	17.1	32.4	17.1	35.2	17.7	29.4
Strongly Agree	36.1	32.5	1.2	35.0	1.2	32.1	10.0	37.0

It can be seen that nearly 3/4th of participants agree that regulations and policies significantly contribute to the success of a sustainability management system. Similar views are expressed by Herren et al (2010), "While some obstacle will be difficult to overcome, effective sustainability management can be enforced by Government regulations and Codes". Thus a Sustainability Management System must be made compulsory in Libya and proper codes and regulations should be framed to incorporate effective sustainability and environmental friendly practices.

More than 2/3rd of the participants agree that use of technological advancement will a major factor contributing to the success of sustainability. Dedicated sustainability software can play a pivotal role in addressing the sustainability services of an organisation. Bawazir (2006) states that sustainability development can be achieved through adoption of IT software and by using green technological innovations. Organisations can accomplish their sustainability goal by acquiring knowledge about the various technologies and components for creating sustainability services.

Management commitment is the third key factor rated by the participants. Nearly 2/3rd of the participants agree to the statement "management commitment is the key factor contributing to the success of a sustainability management system". Jim Fava (2014) says true commitment typically manifests itself in key ways. First, sustainability is embedded in the company's strategy rather than treated as an add-on item; second it is clearly tied to business value; it is part of the dialogue within the company in terms of agendas, performance reviews and KPIs and finally, is reflected in personal commitments to sustainability by company leadership. Paul Polman at Unilver is a good example of a CEO who has embedded sustainability into his vision for the company, the organisation and management of expectations.

It is noted that 66% of the participants consider raising sustainability awareness and using external sustainability consultants will also play a key role for creating a successful sustainability management system. In order to properly analyse which factor got the highest rating, mean analysis is used. The responses are given scores from 1 – 5, viz., 1 – strongly disagree, 2 – disagree, 3 – neither disagree nor agree, 4 – agree and 5 – strongly agree. The mean value of each factor is obtained and presented in Table 6.8.

Table 6.8: Means Score of Success Factors

Success Factors	Mean	S.D
Management Commitment	3.6	1.4
Regulations and Policies	3.8	1.3
Effective Management of Change	2.2	1.1
Raising Awareness	3.5	1.3
Training Programme	2.2	1.2
Use of Technological Advances	3.7	1.5
Effective Cultural Management	2.3	0.9
External Consultancy	3.5	1.6

Strict regulations and polices received the highest mean score (3.8), followed by use of technological advances (3.7), management commitment (3.6) and fourth place is shared by raising awareness (3.5) and external consultancy (3.5). However, the deviation is lower in raising awareness (1.3) when compared with external consultancy (1.6). Hence raising awareness about sustainability is considered by the participants as a more important factor than external consultancy.

Effective management of change (2.2), training programmes (2.2) and effective cultural management (2.3) are considered less important factors contributing to the success of a sustainability management system.

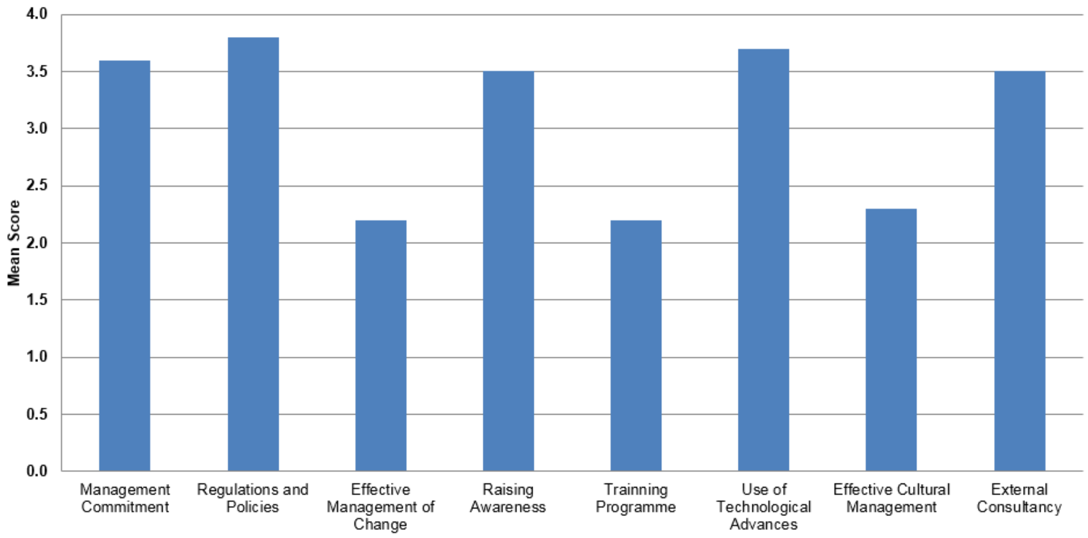

Figure 6.9: Mean score of success factors

It can be concluded from Figure 6.9, that for a successful sustainability management system, strict regulations and policies should be framed, companies should use green technologies and management must be committed to improve sustainability. Sustainability awareness among the companies, employees and public should be increased and the service of external consultants providing sustainability consultancy should be utilised.

Motivations for Implementing Sustainability

How effectively sustainability practices are implemented in an organisation depends on the motivations or reasons for such implementation. Motivation is crucial for decisions on how to operationalise corporate sustainability. In order to ascertain the main motives / drivers for implementing sustainability, the participants were asked to rate their opinion against 7 motivators and their responses are given in Table 6.9.

Table 6.9 Motivations for Implementing Sustainability

Motivations for Implementing Sustainability	**Reducing Env. Impact**	**Increase Efficiency**	**Cost Savings**	**Reduction of Waste**	**Reduce the Energy Consumption**	**Enhancing Corporate Image**	**Increase Employee Env. Awareness**
Strongly Disagree	25.7	25.7	15.6	12.2	12.5	34.9	25.7
Disagree	29.1	28.1	21.7	11.0	7.3	24.5	30.9
Neither Agree nor Disagree	19.6	19.3	11.9	7.3	5.8	18.3	19.6
Agree	19.3	19.9	37.9	33.6	47.1	18.3	18.3
Strongly Agree	4.0	4.6	11.9	35.8	27.2	3.1	4.3

It can be inferred from the above table that nearly 3/4th of the participants believe reducing energy consumption is the major motivation for implementing sustainability. Nearly 70% of the participants believe reduction of waste is the major motivator and more than half agree that cost saving is key.

In order to rank the motivators properly, scoring is given to responses from 1 – 5 viz., 1- strongly disagree, 2 – disagree, 3 – neither agree nor disagree, 4 – agree, and 5 – strongly agree and mean value of the statements are obtained and displayed in table 7.10. Mean value more than 3 means the statement is agreed by most of the participants and mean value less than 3 means the statement is disagreed by most of the participants.

Table 6.10: Mean Score of Motivations for Sustainability

Motivations for Sustainability	Mean	S.D
Reducing Environmental Impact	2.4	1.2
Cost Savings	3.2	1.3
Increase Efficiency	2.4	1.2
Reduction of Waste	3.6	1.4
Reduce the Energy Consumption	3.8	1.3
Increase Employee Awareness	2.4	1.1
Enhancing Corporate Image	2.2	1.1

It can be seen from the above table, that three motivators have mean value more than 3, viz., reduce the energy consumption (3.8), reduce the waste (3.6) and cost savings (3.2). When we look into these three motivators, they can be collectively called 'internal improvements'. Hence the majority of the participants believe that internal improvements will be main motivator for sustainability practices to be implemented.

Internal improvement refers to the optimization of process, reduction of waste and increased cost savings. Miles and Covin (2000) point out that costs can be driven down by sustainable process improvements, more complete utilization of inputs, reduction in energy and water consumption and reductions in waste handling and storage. There is strong support that being a good environmental steward helps create a reputational advantage that lead to enhanced marketing and financial performance as well.

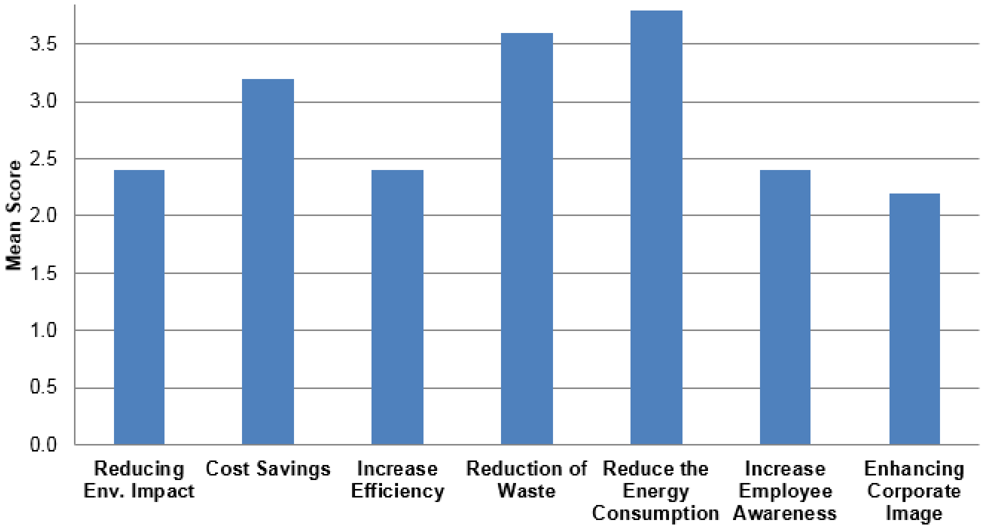

Figure 6.10: Mean score of Motivations for sustainability

If the Libyan government wants to motivate oil companies to adopt sustainability practices, it should convince them that a sustainability management system can lead to internal improvement thereby the companies will gain marketing and financial advantage.

Solution to Negative Environmental Impact

The oil industry can rightly be considered a mixed blessing. On the one hand, oil plays a vital role in our society but on the other, it holds a major risk of creating a hazard for the environment and all living beings on our planet. In order to address the problem of the negative environmental impact created by oil industry, the participants were asked to rate their opinion against 7 factors of relevance and their responses are given in Table 6.11.

Table 6.11: Solution for Negative Environmental Impact

Solution for Negative Environmental Impact	**Continuous Improvement Culture**	**Sustainability System**	**Management Commitment**	**Raising Awareness**	**Training**	**Establishing Regulations and Policies**	**Government Support**
Strongly Disagree	16.8	14.4	21.4	18.0	20.5	26.3	13.5
Disagree	11.6	13.5	30.6	19.9	36.7	23.5	34.6
Neither Agree nor Disagree	7.6	7.3	33.3	10.7	21.1	26.0	24.8
Agree	31.5	30.3	8.3	24.5	16.5	18.7	19.0
Strongly Agree	32.4	34.6	4.6	26.9	3.1	3.4	7.0

As can be seen from the above table, nearly 2/3rd of participants feel that having a sustainability system is the potential solution to counteract negative environmental impact. Sustainable systems are a set of engineered and ecological processes that can economically meet the needs of society while maintaining the integrity of ecosystems in the long term. PNNL (Pacific Northwest National Laboratory) express in its mission statement that we need sustainable systems to reduce our negative environmental footprint.

63% of participants agree that a continuous improvement culture will be the optimal solution against negative environmental impact. Continuous Improvement Culture consist of incremental initiatives and innovations to achieve best results. Daily and Huang (2001) suggest that sustainability can be achieved by developing a continuous improvement culture. According to their study, top management should support EMS by employee empowerment and by developing a culture of continuous improvement.

More than half of the participants consider raising awareness will also be a good solution for negative environmental impact. To properly analyse the rating given to each statement, scores has been assigned from 1 – 5 viz., 1 – strongly disagree, 2 – disagree, 3 – neither disagree nor agree, 4 – agree, and 5 – strongly disagree. The mean value for each statement is obtained and given in table 11.2. Statements having mean score of more than 3 are considered to be agreed by the participants and statements having mean score of less than 3 are considered to be disagreed by the participants.

Table 6.12: Mean Score of Solutions for Negative Environmental Impact

Solution for Negative Environmental Impact	Mean	S.D
Continuous Improvement Culture	3.3	1.4
Sustainability System	3.5	1.5
Management Commitment	2.4	1.1
Raising Awareness	3.2	1.5
Training	2.4	1.2
Establishing Regulations & Policies	2.5	1.3
Government Support	2.7	1.1

It can be inferred from Table 6.12, that a sustainability system implementation has the highest mean score of 3.5, followed by continuous improvement culture (3.3) and raising awareness (3.2). Hence the solution for negative environmental impact is to have a sustainability system in an organisation and the organisation should follow a culture of continuous improvement. Efforts should be taken to raise awareness about sustainability practices.

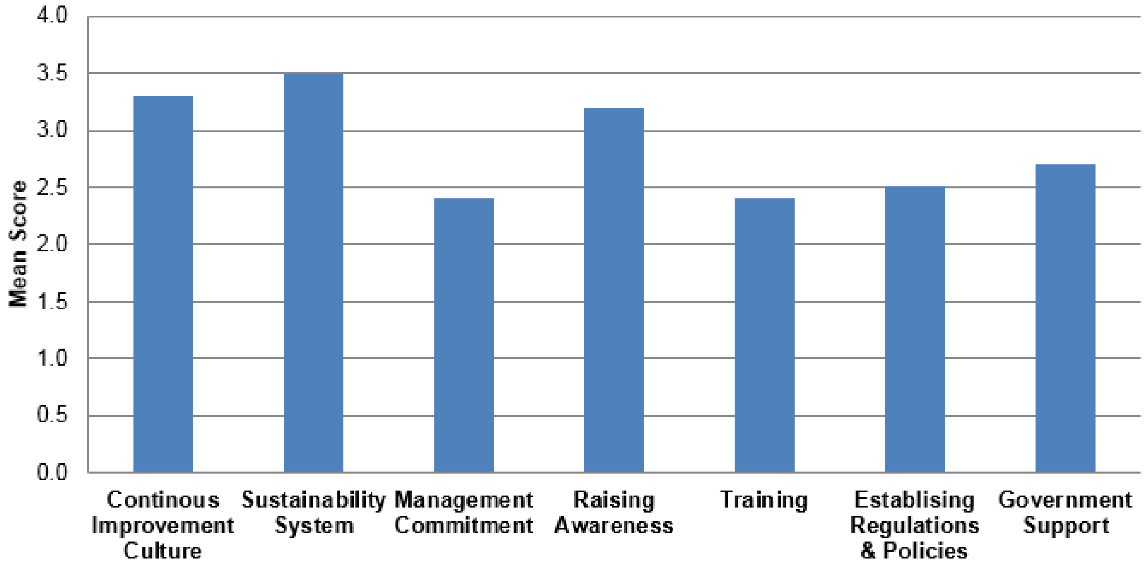

Figure 6.11: Mean score for solutions for negative environmental impact

Employee Opinion Toward Systainability Practices

It is noted that implementation of any practices and polices depends on the positive attitude of the employees and only through their whole hearted support can management attain the desired results. In order to find out the employee opinion towards sustainabilty practices, the participants were asked to rate their opinion about 16 statements concerning sustainability and their responses are given in graph 6.13.

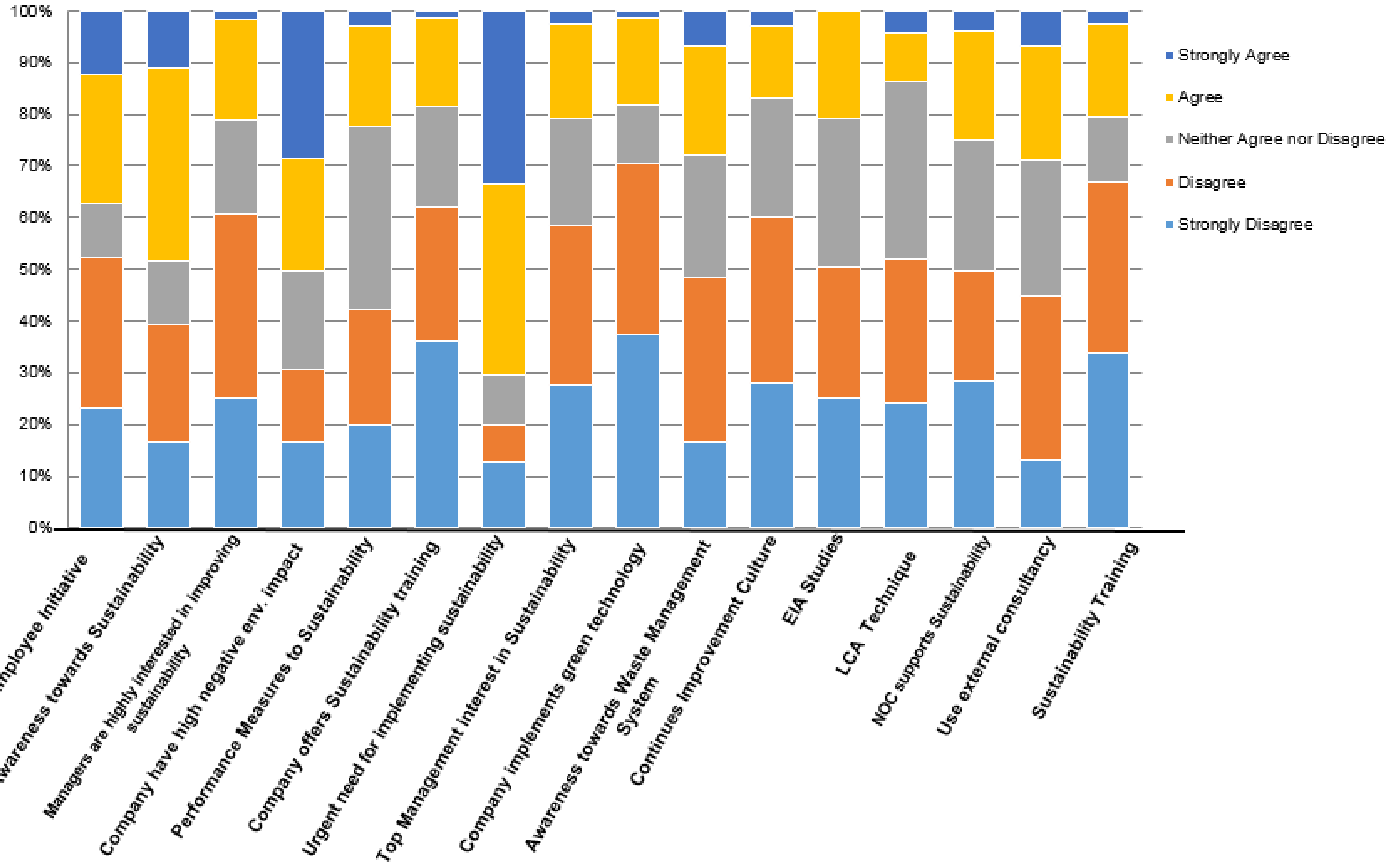

Figure 6.13: Employee opionions towards sustainaiblity

It can be seen that the employees believe that their companies have a low level of sustainability. More than 2/3rd agree to the statements that their companies have high negative environmental impact and there is an urgent need for implementing a sustainability system.

To properly analyse the rating given to each statement, scores has been assigned from 1 – 5 viz., 1 – strongly disagree, 2 – disagree, 3 – neither disagree nor agree, 4 – agree, and 5 – strongly disagree. The mean value for each statement is obtained and given in table 6.12. Statements having mean scores of more than 3 are considered to be agreed by the participants and statements have mean score of less than 3 are considered to be disagreed by the participants.

Table 6.12: Mean Score of Employee Opinion towards Sustainability

Employee Opinion Towards Sustainability	Mean	S.D
Employees are encouraged to take initiative	2.7	1.38
Aware of sustainability system	3.03	1.31
Managers are highly interest in improving sustainability	2.36	1.11
Company have high negative environmental impact	3.3	1.4
Performance measured in terms of sustainability	2.6	1.09
Company offers sustainability training	2.21	1.15
Urgent need for implementing sustainability	3.7	1.34
Top management shows interest in sustainability	2.4	1.14
Company implements green technology	2.1	1.12
Employees are aware of environmental impact and waste management techniques	2.7	1.17
Company focuses on continuous improvement culture	2.3	1.11
Company conducts EIA studies	2.5	1.08
Company Implements LCA techniques	2.4	1.07
NOC and Oil ministry supports sustainability	2.5	1.3
Company uses external consultancy	2.7	1.13
Sustainability training programmes offered	2.22	1.17

It can be inferred from the above table that the majority of the participants disagree with the statements concerning sustainability practices such as implementation of green technology (mean score 2.1), offering sustainability training (2.21), conducting Environmental Impact Assessment (EIA) studies (2.5), implementing Life Cycle Analysis (LCA) techniques (2.4), interest in improving sustainability (2.36), performance measurement in terms of sustainability (2.6), encouragement of employees to take initiatives (2.7) and using external consultancy. On the other hand, the majority agree there is an urgent need for implementing sustainability

(3.7), the company is having high negative environmental impact (3.3) and employees are aware of sustainability (3.03). This show that sustainability practices are in their nascent stages in Libyan petroleum industries. The majority of the petroleum companies are not even accredited to the ISO 14004 environmental management system and most of the environmental laws are not properly followed. It is also noted that employees are well aware of the negative environmental impact of oil companies and are interested in following a sustainability management system.

In order to find out, if there is any significant difference among the employees opinion towards sustainability practices and their relative position in their organisation, an ANOVA test is used. The total score of all the 16 statement are established and the ANOVA test applied between employee position and opinions towards sustainability. The result is shown in Table 6.13.1.

Table 6.13.1: Employee Position vs. Opinion towards Sustainability

Employee Position	**Frequency**	**Mean**
Normal Employee	170	41.3
A Middle Manager	97	42.2
A Senior Manager	60	36.1
Total	327	40.6

It can be seen that senior managers are displaying more negative opinion towards sustainability practices compared to middle managers and normal employees. The senior managers are in a strong position to have an accurate knowledge about the company's practices and policies and their negative opinion provides proof that sustainability is very low in Libyan oil companies. The statistical significance of this finding is shows in table 6.13.2.

Table 6.13.2: ANOVA Table

Null Hypothesis: There is no significant difference in the mean employee opinion score among different levels of employees.

	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	1542.93	2	771.46	5.80	0.00
Within Groups	43040.33	324	132.84		
Total	44583.26	326			

As the F value is 5.8 (>1) and sig. is 0.003 (<0.01) we can say with 99% confidence that there is significant variance in employee opinion towards sustainability and employee position. The senior managers have a low opinion of oil companies' sustainability practices when compared to middle managers and normal employees.

6.5 Discussion

This stage of the study has highlighted significant findings which are in alignment with the findings of the qualitative study. The quantitative stage involved the distribution of a questionnaire survey to participants working in the petroleum sector in which 327 completed questionnaires that were fit for analysis were analysed. It was indicated in the findings of the quantitative stage that employees believe their companies have a low level of sustainability practices in which they affirmed that their companies are in need of developing and implementing sustainability systems. It was clearly highlighted by the participates that the level of the environmental impact from their company's practices is significantly high which requires a robust system to be in place to ensure such impacts are minimised. More importantly, the participants believe that the first step to minimising these impacts is by having a sustainability system in place.

Furthermore, the participants raised several concerns about the factors that hinder the successful implementation of sustainability systems. For example, they believe that there is a low level of commitment from the top management and a lack of culture of continuous improvement in the workplace. For this reason, 63% of the participants state that continuous improvement culture is considered as one of the optimal solutions to minimising negative environmental impact. Continuous improvement culture relies on having a system that supports the reporting of near misses, accidents and improper practices so that investigations can be carried out to identify the root causes that might hinder improvement.

As highlighted in the literature review, top management has a major role to play in the process of developing and implementing environmental management systems by empowering and involving employees at all levels as well as by encouraging a culture of continuous learning and improvement.

The participants believe that without a strict regulatory framework, sustainability adoption will be very difficult. This was highlighted by the survey findings as 'strict regulations and policies' received the highest mean score against other barriers in ensuring that all petroleum operations are being monitored. Management commitment was also seen as significant in ensuring that sustainability systems are implemented successfully and efficiently.

Furthermore, the need to increase awareness about the importance of sustainability amongst the public as well as the petroleum companies was also seen as vital. It was highlighted by the participants that raising awareness is more important than acquiring external consultancy, which could imply that raising awareness would be a more sustainable option that will help shift the focus towards sustainability in the long-term whereas obtaining external consultancy might only help to develop systems that might not achieve the long term goals of the organisation. Hence, raising awareness about sustainability should be seen as a priority for policy which can be achieved through a series of programmes such as educational and training initiatives, workshops, conferences and through in house-advertising and training.

The findings of the survey study indicate that both internal and external factors play a significant role in implementing sustainability systems in the petroleum sector in Libya. Amongst the internal factors is the need to have a strong top management support and commitment towards sustainability as well as creating a culture of continuous improvement. The study also found that having a strict regulatory framework and raising awareness about sustainability are very important external factors. There should be a cultural shift towards the significance and value of sustainability in the petroleum sector to help counteract the negative impact this sector suffers from.

6.6 Chapter Summary

The purpose of this chapter was to present and discuss the results of the quantitative stage in which a questionnaire survey was used to collect primary data from participants associated with the petroleum sector in Libya. The chapter started by presenting some demographic details about the participants in the study followed by further statistical analysis. The results support the findings of the qualitative study which showed that sustainability is not a priority for the petroleum sector in Libya, as the participants indicated their poor awareness about the benefits and how sustainability can be implemented within the sector. Managers and leaders who participated in the quantitative survey presented poor awareness or interest about sustainability as highlighted by the ANOVA results, which are very alarming as sustainability requires a top-down approach in which strong management commitment is critical to the success of any sustainability initiatives.

It was noted that employees are well aware of the negative environmental impact of oil companies and are interested in following sustainability practices. This suggests that education is needed to raise the awareness of sustainability and all its benefits to stakeholders. The findings so far suggest that an integrated approach is needed. To further understand the current status of environmental management within the petroleum sector, the following chapter presents the findings of the Environmental Impact Assessment that was carried in Libya as part of this PhD study.

Chapter 7
Environmental Impact Assessment Study (EIA)

This chapter is concerned with analysing the 3rd stage of this research (case studies). Three case studies were conducted through pilot fieldwork trips in Libyan petroleum sector. The case study has similar goals to the interviews, but focuses on empirical investigations of the selected cases.

7.1 Environmental Impact Assessment

EIA is one of the major tools used to assist environmental analysis of a project of this nature. It evaluates the degradation that human activities can cause to the environment (Toro et al., 2013) and yields results that assist the decision making process (Wathern, 1994). Wood, (2003) and Toro et al., (2009) state that EIA is the technical key to incorporating environmental protection approaches and to avoiding the loss of natural resources (Wood, 2003). EIA is widely implemented by various industries around the world, but (Ali and Harvie, 2013) and Goodland, (2013) claim that the Libyan petroleum sector lacks such studies.

In order to assess the environmental situation at the upstream phase, EIA was conducted in the Libyan petroleum companies specific to the Murzuq basin project area (Southwest region- El Feel Oil field) and in compliance with the requirements of Libyan Law No 15 of 1371 (2003), NOC guidelines and best industry practice. This study is very significant in terms of originality as it is the first of its kind conducted in the sector in Libya. The EIA followed the UNEP methodology (Abaza, et al., 2004) as well as taking account of the results of the fieldwork and reviews of unpublished reports from the upstream oil companies summarising the physical, biological, and socio-cultural/economic aspects of the oil field sites and surroundings.

The assessment methodology as adopted from (Modak and Biswas, 1999; Eidinov, 2004; Green Oil and Akakus, 2008) is illustrated for quantifying the environmental impacts. The EIA assessment procedure uses the following formulas and calculations to rate the environmental risk. The environmental risk is the combination of the probability of a certain event occurring and the magnitude of its consequences (severity rate). For this procedure, the Rate of Environmental Risk (RER) is calculated as follows:

$$RER = P \times S \quad (1)$$

Where P is the probability rate and S is the severity rate. Both P and S require additional calculations to establish the environmental risk. The quantification of the Probability Rate (P) is dependent on two factors, (1) the degree of control on the aspect (Co) and (2) the frequency of the impact or the aspect (Fr), hence:

$$P = Co + Fr \quad (2)$$

To determine the degree of control, consideration is given to the existence or absence of: (a) written procedures and technical instructions; (b) contingency plans and training in case of contingency; (c) protection or physical barriers; (d) environmental objectives and targets related to the aspect; (e) competence (personnel developing the activities); (f) monitoring; and (g) a maintenance programme. Considering the above, the degree of control is scored according to the table below:

Table 7.1 Degree of control (*Co*)

Degree of control	*Value*
Not controlled aspect	5
Partially controlled aspect	3
Controlled aspect	1

Frequency values of an environmental impact are shown in Table 7.2.

Table 7.2 Frequency (*Fr*) of Impact

Frequency	*Value*
Very Frequent	4
Frequent	3
Not Frequent	2
Rare	1

The assessment of the Severity Rate (S) as shown in equation (1) requires the analysis of three issues which are: (1) the environment where the impact is affected

(Environment, Env); (2) the nature of the substance and its hazards (Nature, Na); and (3) the magnitude of the impact (Magnitude, Ma).

$$S = Env + Na + Ma \qquad (3)$$

The Environment affected considers the sensitivity of the area impacted.
The following table shows the rating:

Table 7.3: The Environment (*Env*)

Environment affected	*Value*
Ground water, ground or underground sweet water, agricultural land and human settlements	10
Protected areas and cultural heritage	8
Land for livestock activities	7
air, flora and fauna in a direct way	6
Land with no agricultural or livestock use, saline water	3
Land used for installations	1

The nature and hazards of a certain pollutant (*Na*) considers the physical and chemical characteristics of the pollutant. The ratings are illustrated below.

Table 7.4 Nature (*Na*) of the impact

Nature	*Value*
Dangerous	5
Not very dangerous	3
Not dangerous / there is no pollutant	0

In order to establish the magnitude of the impact (*Ma*), it is necessary to measure the amount of resources consumed, the amount of wastes produced and the amount and concentration of the pollutant:

Table 7.5 Magnitude (*Ma*) of the impact

Magnitude	*Value*
Very High	10
High	7
Medium	5
Low	3
Negligible	1

Each impact is assessed using formulas (1), (2) and (3). The Rate of Environmental Risk (*RES*) calculated will show the amount of risk based on the evaluation of risk categories shown in Table 7.6. The risk categories are colour coded and hatched. This methodology was adopted from the general methodology of EIA and as used in EIA studies (Kharaka and Otton, 2003; Eidinov, 2004)

Table 7.6 Risk Categories

Risk Categories		
Probability Rate (P) × Severity Rate (S)	*RES Value*	*Sign*
Low risk	<75	
Minor risk	75 to 84	
Moderate risk	85 to 99	
High risk	>100	

The results of the EIA are shown in Table 7.7. The table includes the activity, the aspect and the rate of the environmental impact calculated using the above formulas. In addition, mitigation recommendations are given for each impact. The RER results are colour coded hatched based on the risk categories in Table 7.6.

Table 7.7 EIA results and recommendations

Activity	*Aspects*	*Impacts*	*Probability Rate (P) P= Co+ Fr*			*Severity Rate (S) S= Env + Na + Ma*				*(RER) = P × S*
			Degree of Control (Co)	*Frequency (Fr)*	*P*	*Environment (En)*	*Nature (Na)*	*Magnitude (Ma)*	*S*	
Operations Transportation	Soil	Oil and chemical spillages from vehicle accident or during fuelling may impact soils/water resources. Minor risk of leaks and small-scale spillages from engines and during refuelling. **Mitigation/Controls** (1) Spill Contingency Plan should be prepared; (2) clean up materials and equipment to be available on site; (3) on-going environmental training to all associated with the project.	5	2	**7**	6	3	3	**12**	**84**

	Water	Minor oil spillage and leakage. Grease/oil may accumulate in ground water at low levels. **Mitigation/Controls** (1) Spill Contingency Plan should be prepared; (2) clean up materials and equipment to be available on site; (3) on-going environmental training to all associated with the project.	5	2	**7**	3	5	3	**1** **1**	77
	Air	Atmospheric emissions from diesel engines used in transport. Emissions mainly from diesel engine exhausts and some dust. **Mitigation/Controls** (1) Short transient.	5	2	**7**	6	3	3	**1** **2**	84
	Solid Wastes	Industrial inorganic wastes, hazardous materials will be generated but in small quantities. **Mitigation/Controls** (1) A detailed Waste Management Plan (WMP) must be implemented; (2) the WMP will take into account the existing reduction processes for treating or eliminating, partly or fully, all waste generated.	5	2	**7**	3	5	3	**1** **1**	77
	Spillages	Oil spillages from accident or during gas oil tank refuelling may impact soils/water resources. **Mitigation/Controls** (1) Spill Contingency Plan should be prepared; (2) clean up materials and equipment to be available on site.	5	2	**7**	3	5	3	**1** **1**	77

Production and processing of crude oil and facilities	Soil	Oil and chemical spillages from vehicle accident or during fuelling may impact soils/water resources. Minor risk of leaks and small-scale spillages from engines and during refuelling. **Mitigation/Controls** (1) Spill Contingency Plan; (2) clean up materials/ equipment to be available on site; (3) on-going environmental training to all associated with the project.	5	2	**7**	6	3	4	**12**	84
	Biological Resources	Impact on terrestrial habitat. Possible damage to flora fauna and habitat. **Mitigation/Controls** (1) avoid destruction of vegetation; (2) restrict unnecessary vehicle movement in any sensitive vegetation areas; (3) each site must be scouted from an environmental perspective; (4) avoid locations with endangered species and habitats; (5) no intentional killing of local fauna (birds, mammals, reptiles, insects and spiders) unless there is threat to life; (6) decommissioning concept – all operations and facilities are designed to be easily dismantled. Renovation of tracks on completion; (7) Contractors and personnel used in the operation should receive environmental awareness training; (8) on-going environmental training to all associated with the project	5	4	**9**	3	3	3	**9**	81
		Noise and light may cause disturbance to life	5	4	**9**	5	2	3	**10**	90

	Air	Atmospheric emissions from power generation, flaring, venting and diesel engines used in transport. **Mitigation/Controls** (1) require comprehensive monitoring programme; (2) reduce SO_2, H_2S and other harmful emissions; (3) increase energy efficiency.	5	4	**9**	6	3	4	**13**	117
	Solid Wastes	Industrial inorganic and organic wastes, hazardous materials generated in small quantities from maintenance, short term, infrequent and transient in nature. **Mitigation/Controls** (1) a detailed Waste Management Plan (WMP) must be implemented; (2) the WMP will take into account the existing reduction processes for treating or eliminating, partly or fully, all waste generated by the project.	5	4	**9**	3	5	3	**11**	99
	Noise and light	1. High transient noise and extraneous light levels close to the process plant could cause disturbance to people 2. Site is close to communities, little or no wildlife **Mitigation/Controls** (1) use adequate noise attenuation on engines and plant; (2) isolated location; (3) implement noise monitoring programme.	5	4	**9**	6	0	3	**9**	81
	Oil Spillages	Large scale catastrophic events may accumulate in soils water. **Mitigation/Controls** (1) detailed study for the site hydrology is recommended.	5	1	**6**	3	5	10	**18**	108

	Chemical Usage/Spillages	As with oil spillages, may accumulate in ground water **Mitigation/Controls** (1) chemical spill contingency plan to be implemented.	5	1	**6**	6	5	10	**21**	126
Emergency conditions	Air	Minor H_2S leak, Atmospheric emissions from burning hydrocarbons during fire. **Mitigation** (1) proper maintenance programme, personnel gas detector and escape masks	5	1	**6**	10	5	3	**18**	108
	Water	Fire water escapes to ground water with low level of contamination	5	1	**6**	6	5	3	**14**	84

Table 7.7 shows the calculations conducted for each impact using equations (1), (2) and (3). The table also offers concise mitigation recommendations for each impact. These results reveal that water contamination with hydrocarbons is mainly due to leaks at the field facilities. Thorough evaluation of the extent and source of the pollution is recommended along with a review of the best technologies for soil and water remediation. The air analysis results were gained from unpublished studies at the company carried out to determine the extent of H_2S, VOC, SO_2, NO, NO_2, CO and O_3 pollutants. It was noted that these results are based on instantaneous measurements, which are not comparable with international standards. A conclusion of the significance of these data can only be drawn following long term continuous measurements (six months to a year).

This data is only indicative of the extent of the pollution; permanent monitoring stations are recommended. The water and air samples results will be used as a referenced for future monitoring. The EIA results show the level of risk of the environmental impacts identified. The high risk impacts were mainly air emissions (GHGs and hazardous H_2S) and oil spillages. The extreme amount of gases exhausted from the heavy duty machinery and flaring were significant. Comprehensive monitoring programs are essential as are reduction of SO_2 and H2S emissions.

The use of standardised environmental protection procedures is necessary to minimise spillages and the use of chemical spill contingency plans. Surprisingly, levels of noise and light were rated as a moderate risk along with industrial inorganic and organic wastes and hazardous materials. Although these represent small quantities from maintenance departments, consideration is still important. The remaining impacts were rated as minor risk and low risk.

7.4 Discussion

The results of the Environmental Impact Assessment above highlight that there is an urgent need for a systematic and integrated approach to environmental management in the petroleum sector in Libya. EIA can be used to evaluate the negative impacts of upstream and downstream activities in the petroleum industry. The petroleum industry has significant impact upon the environment which due to the nature of its operations hence such operations may as well have negative impacts on the resources downstream as well as on air quality.

As discussed in the literature review chapters, Environmental Impact Assessment is one of the key methodologies and tools that is widely used in large scale planning applications as it helps policy makers to understand the impacts of major and minor development proposal on the environment. Such a tool as indicated in the case-studies showed that the Libyan petroleum sector poses significant environmental impacts that include air emissions such as GHGs and Hazardous H_2S along with oil spillages which affects the land use on the long-term. The EIA also showed that heavy duty machinery exhausts extreme amounts of gases as well as flaring in which gas pose significant environmental risk. In this regard, strict rules and regulations are needed to be in place to ensure that reductions of SO_2 and H_2S emissions are achieved. However, this requires a comprehensive monitoring system in place where all stakeholders who are involved in the study are taking corrective and preventive actions to minimise the environmental impact of such operations.

EIA results show the high risk of environmental impacts are those related to air emissions (combustion and flaring) and those that impact land and soil such as spillages of chemical wastes. Other organic and inorganic waste was considered moderate risk, with noise and other terrestrial impacts minor rise. Underground water, noise and other Socio-economic and socio-cultural impacts were ranked as low, but not insignificant risk; studies should be conducted to evaluate reduction options.

A major issue witnessed with all the upstream companies visited is the lack of environmental reporting and data-storing. This is clearly expected in an environment where there are no government monitoring procedures to force the companies to initiate environmental recording and reporting procedures. EIA recommends a spill contingency plan to be established with clean up materials and equipment being available on site along with on-going environmental training to all associated with the project. In addition, studies into soil remediation technologies along with the use of oil sludge disposal and recovery technologies for treatment purposes as advised by Hu et al., (2013) should be adopted.

To minimise emissions, flaring gas recovery systems (GRS) are required at all field flaring stations. Companies should invest in carbon storage technologies and conduct a set of energy saving feasibility studies. These studies will allow simple and effective energy savings throughout the processes. Industrial inorganic wastes and hazardous materials were ranked as high risk; therefore a detailed waste management plan (WMP) must be developed and implemented.

A comprehensive monitoring programme is recommended to improve air emissions along with technologies to minimise SO_2, H_2S, NOX. Further, increasing the energy efficiency of diesel engines and heavy duty machines is essential, which could be assisted by replacement of old machines with more advanced and environmental-friendly options. Leaks, spillage and other wastes were ranked as a minor risk.

Thus, it could be assumed that stakeholder involvement is vital in ensuring a successful EIA process. Hence, greater attention should be given to stakeholder involvement so that better environmental assessment results can be achieved which will also lead to more sustainable projects that lead to financial benefits, greater economic development and also fewer environmental impacts. In this regard, local community groups, suppliers, petroleum companies, regulators, non-governmental organisations, multinational companies, employees and customers all have a role to play in monitoring the environmental assessment process. Their involvement is also vital in the screening procedures as those stakeholders will provide greater insight about the issues that face each of them in terms of complying with the local and international standards as well as issues related to infrastructure, resources and continuous support from the top management.

Unfortunately, there is not much available data about the environmental impacts of the petroleum operations in Libya due to the absence of regulations and laws that put pressure on companies to carry out such assessments and report upon their activities. This is because of the fact that efficient and good environmental assessment requires sufficient and good data that can help in understanding the different variables that might influence the EIA process. Thus, for petroleum companies in Libya, it could be argued that due to the absence and limited data available, it is vital for these companies to put more emphasis on the monitoring stage of the EIA to ensure that practices are adjusted based on the performance. This will help in understanding the environmental impacts of all operations by ensuring that performance and measurement indicators are used to assess the environmental impact based on each project or operation phase.

More importantly, in Libya EIA should be seen as a tool that helps petroleum companies to achieve better standards of practices as it will lead to medium and long-term benefits for sustainability in this sector. The case-studies that were carried out as part of this PhD show that more emphasis needs to be shifted towards such methodologies to ensure better practices are adopted based on empirical evidence. For Libyan petroleum companies, and in particular because of the limited capacity and resources available to carry out EIA, it is important to identify ways of reducing eventual negative consequences when introducing a new activity as the impacts will inevitably occur.

There are several mitigation measures that can be taken to minimise the impacts which could include changes to design or practices, changes to certain management practices or measures as well as obtaining feedback from different stakeholders through the involvement of these stakeholders. It can be concluded that in the petroleum sector in Libya public participation in EIA is very limited due to the absence of regulatory frameworks that support such activities. Along with the technical impacts that might incur as a result of the petroleum operations, there are others impacts that impact the wider public and community. For example, the emissions will lead to significant negative impacts on the environment in particular to the air quality which will result in pollution that will affect the public. Not just external stakeholders are affected but also internal stakeholders including employees at all levels.

There is a need to have a regulatory framework along with strong public participation and involvement of all stakeholders to ensure that EIA is carried out periodically to assess any changes in the operations and also to evaluate the environmental impact so that measures can be taken to reduce these impacts. This requires an educational element which is also equally important as the regulatory element. This is because of the fact that raising awareness about such negative practices will help increase the stakeholders' knowledge about the consequences of such impacts on the long-term.

7.5 Chapter Summary

The purpose of this chapter was to present the results of the Environmental Impact Assessment that was carried out in Libya in the southwest region. The results of this EIA show that there is a high level of risk of the environmental impacts caused by the oil and gas companies' operations. The high risk impacts were mainly air emissions (GHGs and hazardous H_2S) and oil spillages. The extreme amount of gases exhausted from the heavy duty machinery and flaring were significant. Comprehensive monitoring programs are essential as are reduction of SO_2 and H_2S emissions.

The use of standardised environmental protection procedures is necessary to minimise spillages and the use of chemical spill contingency plans. It can also show that such tools provide an insightful evidence to help policy makers and practitioners in the field make informed decisions about the existing risks. Hence, the findings of the EIA are of high significance to the overall study as it affirms that the current practices are imposing high environmental impacts. The following chapter presents the findings of the Life Cycle Assessment study that was also carried out in Libya.

Chapter 8
Life Cycle Assessment Study (LCA)

8.1. Introduction

The principle aim of this chapter is to deliver a transparent and reproducible study of crude oil in Libya, compliant with the ISO 14040 and 14044 series. The following aspects will be covered:

- **Methodological issues** that strongly affect the LCA results, such as the definition of the functional unit, system boundaries, multi-functionality and data quality requirements.
- **Data collection**, i.e. what kinds of data are necessary to the study and how data was collected; what major issues were encountered in the data collection procedures, etc.;
- **Reporting of the results**, i.e. types of results to be included in the LCA interpretation phase to support the critical analysis and evaluation of environmental impact.

All the suggestions made in this chapter aim to facilitate data collection and the subsequent LCA study. Following a description of the methodological approach utilised, the LCA study investigates and analyses the systems used.

8.1.1. Objectives

This LCA study has been designed in order to identify the best actions to undertake in order to minimise the environmental footprint of the crude oil extraction process. The study acknowledges and builds upon the contributions of previous scientific and field research. This LCA study is a small but important step for Libyan Oil producers in the global sustainability effort. The study is carried out according to the following international standards and guidelines:

- ISO 14040:2006 Environmental management - Life cycle assessment – Principles and framework (ISO 2006a);
- ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines (ISO 2006b);

- ILCD, International Reference Life Cycle Data System, Handbook. General guidance for life cycle assessment. Detailed Guidance (EC-JRC 2010).

The overall objectives of the LCA study are to benefit Libyan Oil producers in the following ways:

- To support Libyan Oil Companies by providing them with relevant information to help select the most effective and environmentally friendly crude oil extraction technologies;
- To increase knowledge among public and private stakeholders about the most important environmental issues which result from the crude oil extraction process;
- To enhance general know-how in the field of Crude Oil extraction and to improve understanding of potential environmental impacts.

Many factors, particularly in the political and economic arenas, make it difficult to realize this LCA study in the Libyan Maghreb region today, specifically:

- Factors connected to geographic and cultural aspects and the scientific situation in Mediterranean Sea region.
- Factors connected to the political stability of the area following many years of conflict.
- Factors connected to the knowledge gap of the most important decision makers and missing datasets.

8.1.2. Crude oil extraction plant and life cycle assessment

Crude oil extraction plants (COEP) are complex systems from a technological and environmental point of view. In fact, COEP are typically multi-output systems, with the subsoil also involved in the analysis during COEP installations. An LCA study identifies all the components of the inputs and outputs of the product system under study, i.e. energy, materials and waste flows and their impact on the environment from an holistic perspective, starting from the raw material extraction and proceeding on to the end of life phase (disposal/recovery/recycling), in a so-called “cradle to grave” approach. However, this LCA study focuses only on well-to-refinery gate (WTRG) analysis. This is due to the fact that after the refinery processes are downstream activities which are influenced by the market rather policy makers in the oil and gas sector. Another reason is the complexity of data estimation at this stage.

Recent research (EC-JRC, 2013) has described the combination of steps necessary to turn a resource into a fuel and subsequently bring that fuel to a vehicle as a Well-to-Tank pathway (WTT). For a COEP, this means taking into account all the input and output flows attributable to:

- the extraction of the materials used in the plant
- the manufacturing of all components used in the product system under study
- the installation process of extraction machinery (including the digging process)
- the refinery process of crude oil
- all transport processes to the end phase (to refinery plant gate)

Moreover, for every phase of the life cycle mentioned above, all transportation of materials, components and waste should be included.

Because the technology is complex, detailed and robust information on how to dismantle these systems and how to deal with waste and valuable materials (i.e. through recycling) is not yet available, as only a few installations have reached their end of life stage. The end of life stages of the components of COEPs are beyond the scope of this LCA study, as is the assessment of impacts generated by the groundwater system and on the subsoil structure. Different tools, scientific approaches and analyses would need to be used in order to achieve this significant but separate goal.

8.2. Methodological Approach

8.2.1. Life Cycle Assessment (Type of Study)

ISO defines LCA, or life cycle assessment, as a scientifically standardised methodology by which flows, such as energy and mass that are associated with a specified service, manufacturing process, technology or product life cycle can be systematically analysed (ISO, 2006a). Essentially, the goal of this approach is to comprehensively and holistically analyse the above elements, including manufacturing and use as well as raw materials and EoL (end-of-life) management. In accordance with the philosophy of the LCA approach, it is important to note that LCA results of the environmental impacts associated with each modelled system are estimates of the potential impacts, rather than direct measurements of real impacts.

According to the International Organisation for Standardization (ISO) 14040/44 standards, an LCA study must consist of four phases:

1. Goal and scope (framework and objective of the study);
2. Life cycle inventory (input/output analysis of mass and energy flows from operations along the product's value chain);
3. Life cycle impact assessment (evaluation of environmental relevance, e.g. global warming potential);
4. Interpretation (e.g. conclusions and recommendations) (ISO, 2006a; ISO, 2006b).

This LCA study was carried out for Libyan crude oil (well-to-refinery gate). A LCA software-based tool (SimaPro PHD version) was used for the assessment. Figure 8.1 shows the Life Cycle Assessment framework and direct applications of LCA results.

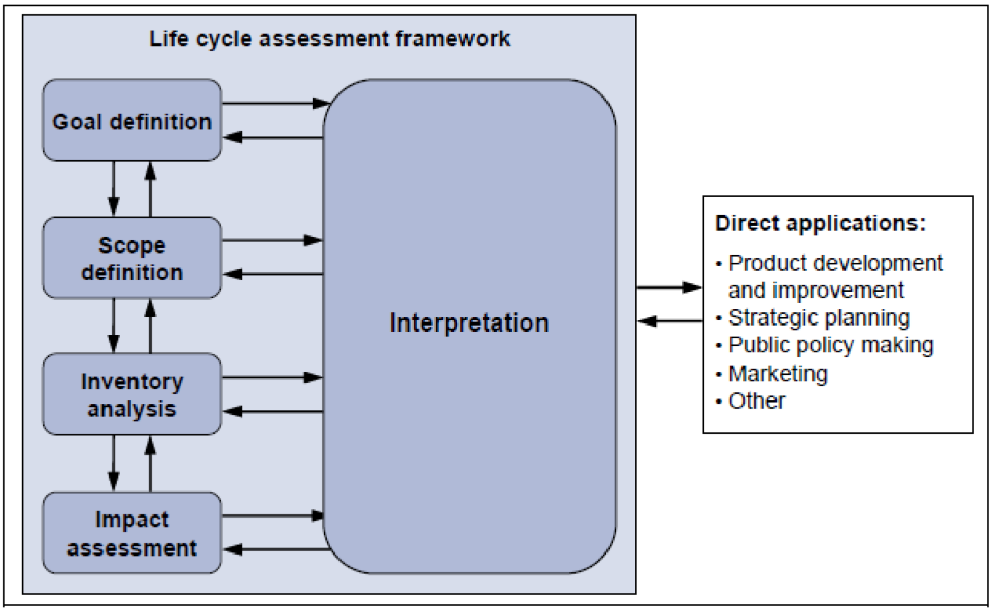

Figure 8.1: Framework for life cycle assessment (from ISO 14040:2006; modified)

Within the initial scope and goal stage are outlined the study's technical specifications, including study rationale, anticipated applications of its results, data requirements, boundary conditions, assumptions to be made in order to analyse the product system being considered, and similar. The study aims primarily to answer any questions the project stakeholders and target audience have specifically raised, while also considering other possible uses for the results of the study. The boundary of the system is defined by the study's scope, in terms of its temporal, geographical and technological coverage, the product system's attributes and the study's level of complexity and detail.

The LCI or life cycle inventory phase analyses the energy and materials used, both quantitatively and qualitatively, and also the by-products and products the system generates, as well as any environmental emissions, particularly in terms of emissions that are not retained, and any wastes (outputs) to be treated for the system under investigation. Data from the LCI can be utilised in order to understand total wastes, resource usage and emissions that can be associated with the product or material under investigation; to improve product performance or production, or indeed to be interpreted and analysed further in order to offer greater insight into the system's potential impacts on the environment (LCIA, or life cycle impact assessment and interpretation).

The following sections present the goal and scope of the conducted LCA, Life Cycle Inventory analysis, Life Cycle Impact Assessment and the Interpretation phase.

8.3. Goal of the Study

Definition of the goal and scope is the first step in an LCA study. The purpose of clearly defining the goals and the scope of the study is to ensure that the analytical aims, results and intended applications are optimally aligned and that a shared vision is in place to guide the participants in the study (JRC, 2010).

The goal of this LCA study is:

- To analyse the potential environmental impact of a crude oil extraction plant installed in Libya, so as to identify strengths and weaknesses of the system from an environmental point of view. This means investigating the potential environmental impact of crude oil production in Libya from well to refinery gate. Specifically, the well in question is from the El-Sharara Oil field, pumping oil to the Azzawiya Oil refinery, where it is refined into multiple products, including diesel fuel, with several different technologies.

8.3.1. Reasons for carrying out the study

Research studies can target improvement and optimisation possibilities more effectively, since LCA provides a detailed breakdown of the main contributors (materials, energy sources, phase of the life cycle, etc.) which are linked to key environmental impacts. The resultant data can suggest which choice would lead to better environmental performance of the studied system. Also, a LCA study could increase knowledge amongst public and private stakeholders as to the most important environmental issues and impacts which can result from the crude oil extraction process.

8.3.2. Intended Applications

LCA analyses of the COEP plant were precisely conducted and optimised with respect to the intended applications, the most important of which was the assessment of the environmental impacts of using crude oil for production of several products. LCA can contribute to lower overall environmental impacts through more efficient use of resources or energy, or by identifying alternative processes that support these possible actions.

This study is intended for researchers, policymakers and stakeholders in the Libyan petroleum sector in order to assist in the establishment of new environmental protection policies and to promote protection measures to reduce emissions.

The results of this study could be used for several purposes:

- Inform Libyan Oil Producers involved in decision making processes about potential environmental impacts;
- Identify optimisation and improvement areas for Crude Oil Extraction technologies;
- Support the proposed step of replacing the old system with new COEP technology.

8.4. Scope of the Study

8.4.1. Function and Functional Unit

LCA experts (e.g. Notarnicola, et al. 2015) described a functional unit as defining a product's performance characteristics, or identified function, through quantification. The functional unit primarily exists in order to offer a reference point to which the outputs and inputs are all connected. LCA results require this reference in order to be comparable.

Considering the different outputs of the complex technical and technological system, the functional unit for this LCA study is **1 kg of produced crude oil**. This means that all impact generated during the life cycle of the COEP plant (80 years) should be divided by the quantity of mass of produced crude oil during the 80 years the system is designed to work for. The life span of the COEP system is based on assumption.

The supply chain of the petroleum sector in Libya is divided between upstream and midstream parts in which the point of separation is the refinery. The exploration, production and logistics management of crude oil from remotely located wells to the refinery is all part of the upstream supply chain. The traditional industrial supply chain comprises of the retailing, distribution and the product use phase are part of the downstream part (Schwartz, 2000 cited in Schwartz, 2006).

In the context of a realised LCA study, the two major components mentioned above have been described as follows:

Upstream processes: including the raw material extraction, the fuel production, the process fluids production, the electricity production and the manufacturing of all the components needed in the system. In this subsection of the life cycle, the use of secondary data referring to the quantity of the material and energy consumed and the waste produced were obtained from other sources, e.g. primarily from the Ecoinvent database and scientific literature.

Core processes: including the digging and drilling operations (energy and fuel consumption), the installation process of the whole COEP system and the use phase (energy consumption), as well as the maintenance operations (such as the substitution of the components, refilling of the operation fluids if needed). The treatment of the waste produced during the digging or drilling operations, the assembling operations and the maintenance operations are included in the analysis. In this subsection of the life cycle, the use of primary data referring to the quantity of the material and energy consumed and the waste produced were obtained. Primary data have been collected from persons responsible for creating the main technical documentation and supervision of onsite work in Azzawiya Oil Refinery Company Ltd.

8.4.2 System Boundary

This LCA study follows a Well to Refinery (WTR) approach, assessing the potential environmental impacts associated with the COEP system. Production and maintenance of infrastructure and capital goods have been excluded from the scope of this study unless specifically noted.

The goal and scope of this study is to identify and estimate the critical environmental impacts at various stages of the Well to Refinery (WTR) cycle as shown schematically in Figure 8.2, namely:

1. Crude exploration and production at the oil well (A);
2. Crude transportation to the refinery (T1);
3. Crude conversion to petroleum products at the refinery (B);
4. Crude transportation within the refinery (T2).

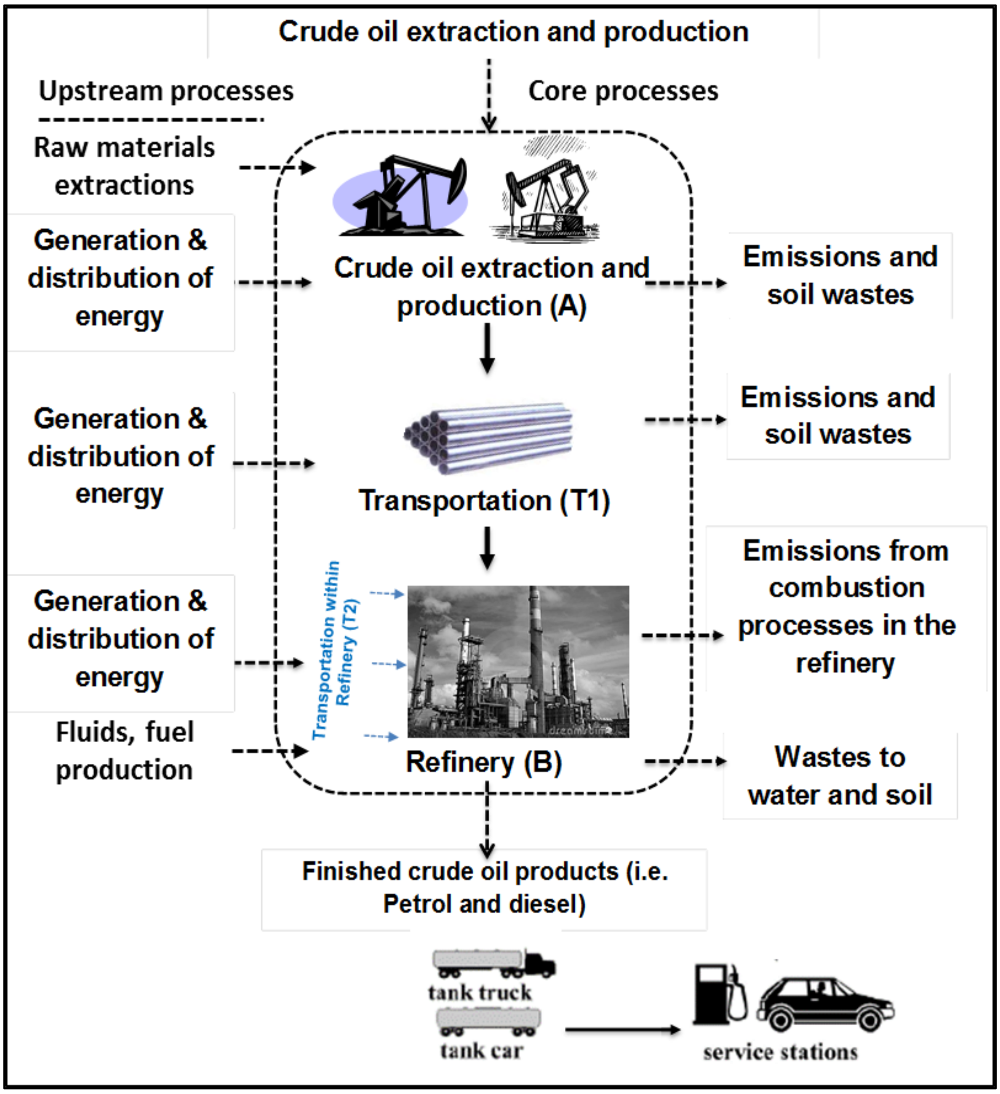

Figure 8.2: Description of system boundary

Azzawya Oil Refinery located on the coastal side of western Libya receives crude oil from the El-Sharara Oil Field in which multiple products are refined including diesel fuel. For the purpose of this analysis, material uses, environmental impacts, emissions and energy consumption data that is generated in the life cycle are presented in terms of the functional unit (1 kg of produced crude oil). The LCA study represents the situation in the 1990s, and assumes that the situation has not changed much. This is due to the fact that the Azzawya Oil refinery was built in the 1970s and the technology used is very outdated, therefore the situation of the 1990s in SimaPro fits well and can be used to gain more accurate estimated data.

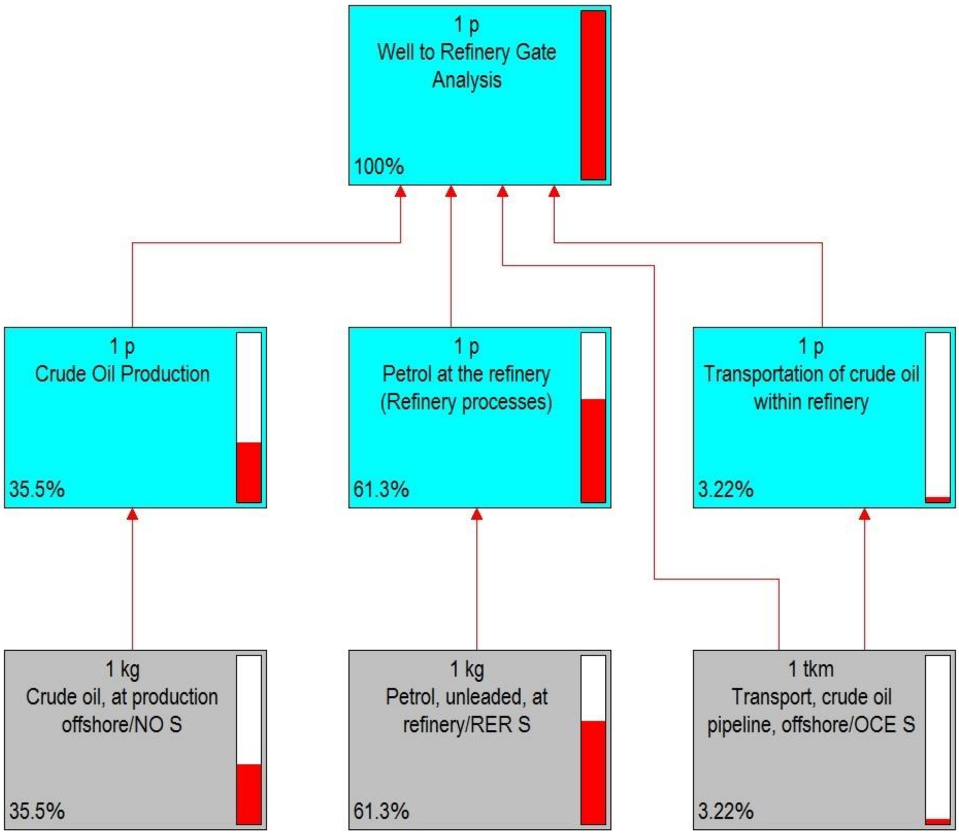

Figure 8.3: Network Diagram, (Source: SimaPro) P: piece (Unit), tkm: ton-kilometre.

Table 8.1 Oil refining technologies – Azzawiya (AORC, 2015)

Technology	**Process**	
FCC Technology	Deep Catalytic Cracking Technology(DCC)	
	A FCC Technology for Maximizing Iso-paraffin(MIP)	
	A FCC Technology for Producing Clean Gasoline and More Propylene(CGP)	
	Feed of Paraffinic Vacuum Residue FCC Technology(VRFCC)	
	Catalytic Cracking Technology for Maximum liquefied Gas and High-Octane Gasoline(MGG ARGG)	
	Maximizing Iso-Olefins Catalytic Cracking Technology(MIO)	
	Maximizing Gas and Diesel FCC Technology(MGD)	
	Flexible Dual-riser Fluid Catalytic Cracking Process FDFCC-III	
Hydrocracking Technology	High Pressure Hydrocracking Technology	Single-Stage Hydrocracking Technology(SHC)
		Single-Stage in Series Hydrocracking Technology(FMD_1)
		Two-stage Hydrocracking Technology for maximum production of middle distillates(FMD_2)
		Single-Stage, Double-Catalysts Hydrocracking technology for Producing More Middle Distillates (FDC)

		Hydrocracking technology for Maximum Production fo Catalytic Reforming Feed (FMN)
		Single-stage in Series and Once-through Hydrocracking Technology for Producing More Chemical feeds (FMC_1)
		Two-stage Hydrocracking Technology for Producing More Chemical feeds (FMC_2)
		Hydrocracking Technology for Flexibly Producing Middle-Distillates and Petrochemical Materials (FHC)
	Medium Pressure Hydrocracking Technology(RMC)	
Hydrotreating Technology	High space velocity reformer feed hydrofining technology	
	Selective Hydrodesulphurization of FCC Gasoline（RSDS-II, OCT—M）	
	Coker Naphtha Hydro treating technology	
	Mercaptans Removal Technology from Jet Fuel in Hydrogen Atmosphere (RHSS)	
	Ultra Deep Hydrodesulphurization Technology for Diesel (UDS)	
	Technology for Maximally Improving FCC Diesel Cetane Number(RICH)	
	Inferior Diesel Hydro-Upgrading Technology	
	Diesel Hydroupgrading-Isodewaxing Technology	
	Medium-Pressure Hydro-Upgrading Technology (MHUG)	
	Full Range Coker Distillate Hydrotreating Technology	
	FCC Feed Pretreating Technology(RVHT)	
	Technology for Fix-bed Residue Hydrotreating(S-RHT)	
	Lube Medium Pressure Hydrotreating Technology	

The LCA study is focused solely on the production phase of crude oil, from oil well to the refinery gate (Figure 3 shows the network diagram of LCA study). Therefore the system boundaries are set to cover all activities within these boundaries. The crude oil production and distillation is analysed to produce multiple products including petrol, diesel, fuel oil, etc. The analysis considers 1 kg of crude oil for the upstream operations (exploration and production) from the ground, transported from the Murzueq (Figure 8.4) basin in the south of Libya to the Azzawiya Oil refinery, which is around 900 km. The analysis considers the distillation processes in the refinery. The system boundary for the LCA study is very basic, clear and simple. It excludes tank to wheel analysis (TTW) and wheel to pump (WTP) analysis.

The reason for excluding these two stages is principally that all activities and processes after the refinery gate are influenced by the markets, sales and other indirect factors. In addition to that, this LCA study focuses solely on optimising the environmental sustainability performance for the petroleum operations, which fall under the upstream production processes. Another reason for excluding the later stages is the difficulty and complexity of obtaining relevant data after the refinery gate.

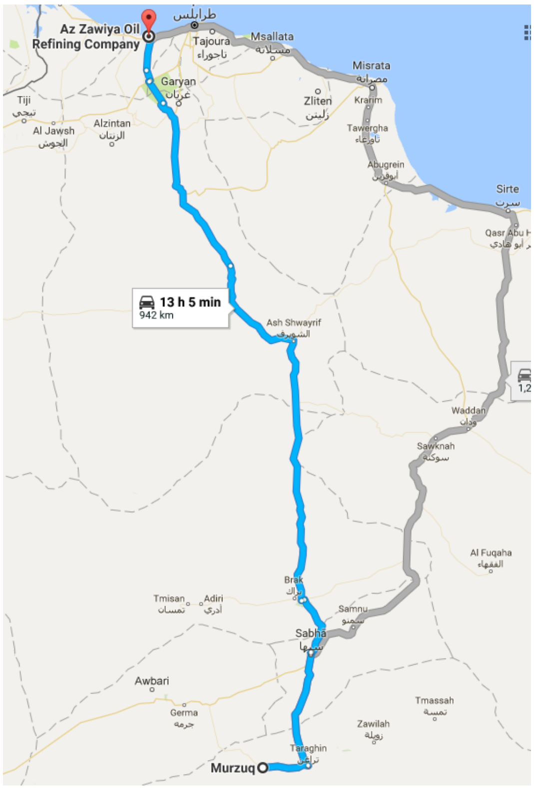

Figure 8.4: Route taken by oil between Oil field and Oil refinery (Google Maps, 2017)

8.4.3. Cut-Off Criteria for Initial Inclusion of Inputs and Outputs

Recent research (Milankovic, 2014) shows that the following cut-off criteria should be used to ensure that all relevant environmental impacts were represented in the study, according to:

- Mass – any flow that makes up less than 1% of the LCI model's total outputs and inputs (dependent on flow type) can be excluded, providing that its environmental impact is not a relevant concern.
- Energy – where a flow represents smaller than 1% of the LCI model's cumulative output and input energy (dependent on flow type) then it too can be excluded, again providing that its impact on the environment is not a relevant concern.
- Environmental relevance – where a flow can be excluded under the above criteria, except that it is thought to possibly have significant impact on the environment, then it will be taken into account. Any emissions with an impact on the environment greater than 1% of the total impact of a category being considered must be included in the assessment.
- The total sum of all material flows neglected must not be greater than 5% of the total energy, environmental relevance or mass.

8.5. Life Cycle Inventory (LCI Phase)

According to ISO 14044, the Life Cycle Inventory Analysis result is the "outcome of a life cycle inventory analysis that catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment" (ISO 14044, 2006). Because the total inventory is made up of several hundred flows, the table below only displays a selection of flows based on their relevance to the subsequent impact assessment in order to provide a transparent link between the inventory and impact assessment results. The data quality refers to the characteristics of data that relate to their ability to satisfy stated requirements (ISO 14040, 2006).

In order to perform a robust and scientifically valid LCA study, the secondary data used for the different processes in the study must come from the same LCI database, so as to ensure that the same assumptions are adopted for modelling the background system. The Ecoinvent database is used, due to its background documentation and availability worldwide.

8.5.1. Data Collection Procedures

Primary data have been collected from Azzawiya company engineers as well as from the project engineer and his associates responsible for technical documentation. These primary data were collected via data lists and technical drawings and from supplier declarations. Instances where primary data have been used in this study include:

- Energy consumption of the COEP system in the use phase;
- Drilling operations which include energy and fuel consumption needed for the crude oil extraction process;
- Transport of the heavy machinery needed for the whole operation;
- Transport of pipes and other infrastructure equipment needed for the other life cycle phases.

Where primary data have not been readily available from the sources mentioned above, secondary data have been used to fill these gaps. Secondary data have also been used to account for background processes that are upstream and downstream in the supply chain of COEP system.

Instances where secondary data have been used in this study include:

- Power grid mix information;

- Production of primary materials e.g. steel, aluminium and copper, plastic granulates;
- Transport processes
- Material composition of smaller standard purchased items e.g. valves, screws and bolts.

Most secondary datasets have been obtained from the Ecoinvent database. Other sources of secondary datasets include scientific literature e.g. scientific journals and books, as well as industry associates. Secondary datasets have also been obtained from product specification datasheets or by contacting the manufacturer directly via telephone or the contact forms on their official websites.

The inventory data have been modified using SimaPro to incorporate changes to the original data. These changes have been made to reflect as realistically as possible the current situation of the Libyan crude oil industry and its production stages and processes. One of the key changes is the energy sources. In the Ecoinvent database, a combination of energy sources including coal, diesel, solar, wind and heavy oil are assigned in the input data; however, in Libya, the production and refinery processes are fuelled by heavy oil from crude oil. Other changes include the exclusion of renewable energy sources such as wind and solar in the energy sources, as the Libyan petroleum sector does not use any renewable energy sources for its energy.

8.5.2 Qualitative and Quantitative Description of Unit Processes

This section details the data (inputs from nature, techno-sphere, generated wastes and emissions) and assumptions used to conduct a life cycle inventory phase. In the following tables, data collected for the crude oil extraction and production system (COEP) life cycle are presented. The Table was adjusted by the specifications and technical/technological characteristics of the modelled system.

Crude exploration and production at the oil well (A)

Nature	Sub-compartment	Amount	Unit
Oil, crude	in ground	1	kg
Gas, natural	in ground	0.0013071	m3
Water, salt, sole	in water	0.00035536	m3

Table 8.2 Know inputs from techno-sphere used in LCI modelling (A)

Know inputs from techno-sphere (materials/fuels)	Amount	Unit

Platform, crude oil, offshore	4.109E-11	piece
Chemicals organic, at plant	9.12E-07	kg
Ethylene glycol, at plant	0.0000176	kg
Methanol, at regional storage	2.81E-05	kg
Chemicals inorganic, at plant	1.60E-06	kg
Sweet gas, burned in gas turbine, production	0.005322	m3
Diesel, burned in diesel-electric generating set	0.0095153	MJ
Electricity, medium voltage, at grid	0.013876	kWh
Transport, lorry >16t, fleet average	6.99E-06	tkm
Well for exploration and production, offshore	8.33E-06	m

Table 8.3 Emissions to air (A)

Emissions to air	Amount	Unit
Methane, fossil	0.00022624	Kg
Carbon dioxide, fossil	0.0021142	Kg
Carbon monoxide, fossil	3.81E-05	Kg
Nitrogen oxides	6.85E-07	Kg
Hydrocarbons, aliphatic, alkanes	5.33E-05	Kg
Hydrocarbons, aromatic	2.78E-05	kg
Sulphur dioxide	1.30E-06	kg
Mercury	1.78E-10	kg
Radon-222	6.23E-05	kBq
Methane, chlorodifluoro-, HCFC-22	9.51E-08	kg
Methane, dichlorodifluoro-, CFC-12	9.51E-10	kg
Heat, waste	8.90E-02	MJ

Table 8.4 Emissions to water (A)

Emissions to water	Amount	Unit
Oils, unspecified	5.96E-06	Kg
Lead	2.47E-07	Kg
Cadmium, ion	3.66E-09	Kg
Nitrogen	4.60E-09	Kg
Nickel, ion	2.75E-08	Kg
Zinc, ion	8.39E-07	Kg
BOD5, Biological Oxygen Demand	8.73E-04	Kg
COD, Chemical Oxygen Demand	7.98E-04	Kg
DOC, Dissolved Organic Carbon	2.48E-04	Kg
TOC, Total Organic Carbon	2.49E-04	Kg
AOX, Adsorbable Organic Halogen as Cl	6.11E-11	Kg
Sulphur	1.59E-08	Kg

Table 8.5 Wastes and emissions (A)

Waste and emissions to treatment	Amount	Unit
Low active radioactive waste	2.0E-7	kg
Disposal, used mineral oil, 10% water	3.72E-5	kg
Disposal, municipal waste, 30 % water	3.31E-5	kg
Disposal, hazardous waste, 0 % water	4.48E-5	kg
Disposal, antifreeze liquid, 52 % water	1.01E-7	kg
Disposal, emulsion paint remains	4.47E-7	kg

Crude transportation to the refinery (T1)

Table 8.6 Known inputs from techno-sphere used in second phase (T1)

Known inputs from techno-sphere (materials/fuels)	Amount	Unit
Diesel, burned in diesel-electric generating set	0.45	MJ
Pipeline, crude oil, offshore	9E-9	km

Table 8.7 Emissions to water (T1)

Emissions to water	Amount	Unit
Oils, unspecified	1.07E-05	kg
Nitrogen	8.24E-09	kg
BOD5, Biological Oxygen Demand	3.36E-05	kg
COD, Chemical Oxygen Demand	3.2E-04	kg
DOC, Dissolved Organic Carbon	9.23E-06	kg
TOC, Total Organic Carbon	9.23E-06	kg
AOX, Adsorbable Organic Halogen as Cl	1.1E-10	kg
Sulphur	2.86E-08	kg

Crude conversion to petroleum products at the refinery (B)

Table 8.8 Known inputs from nature used in LCI modelling (B)

Nature	Sub-compartment	Amount	Unit
Rhenium, in crude oil	in ground	3.15E-9	kg
Water	in water	0.00066809	m3
Water, cooling, unspecified	in water	0.00038177	m3

Table 8.9 Known inputs from techno-sphere used in LCI modelling (B)

Known inputs from techno-sphere (materials/fuels)	Amount	Unit
Methyl tert-butyl ether, at plant	0.02493	kg
Tap water	0.014507	Kg
Calcium chloride, CaCl2, at plant	1.54E-5	Kg
Hydrochloric acid, 30 % in H_2O, at plant	8.494E-5	Kg

Iron sulphate	4.77E-5	Kg
Lubricating oil, at plant	2.36E-5	Kg
Nitrogen, liquid, at plant	0.00078644	kg
Soap, at plant	2.55E-5	kg
Sodium hypochlorite, 15 % in H20	4.77E-5	kg
Heavy fuel oil, burned in refinery furnace	1.218	MJ
Refinery gas, burned in flare	0.14962	MJ
Refinery	5E-11	piece
Ammonia, liquid, at regional storage	1.918E-6	kg
Naphtha, at regional storage	0.038171	kg
Chlorine, liquid	0.00013059	kg
Chemicals organic	0.00018223	kg
Propylene glycol, liquid	1.9716E-5	kg
Molybdenum, at regional storage	7.87E-8	kg
Nickel	1.22E-8	kg
Palladium, at regional storage	7.95E-8	kg
Platinum, at regional storage	2.52E-9	kg
Zeolite, powder, at plant	1.79E-5	kg
Zinc, primary	1.89E-7	kg
Transport, lorry >16t, fleet average	6.99E-06	tkm

Table 8.10 Emissions to air (B)

Emissions to air	Amount	Unit
Ammonia	7.01E-8	kg
Dinitrogen monoxide	1.68E-6	kg
Nitrogen oxides	3.95E-5	kg
Benzene	5.14E-6	kg
Benzene, ethyl-	1.28E-6	kg
Butane	1.28E-6	kg
Butene	2.57E-6	kg
Ethane	1.28E-6	kg
Ethene	2.57E-6	kg
Heptane	1.27E-5	kg
Hexane	2.56E-5	kg
Hydrocarbons, aliphatic alkanes, unspecified	4.29E-11	kg
Hydrocarbons, aliphatic, unsaturated	2.35E-12	kg
Hydrocarbons, aromatic	6.44E-13	kg
Methane, fossil	3.83E-5	kg
Particulates, > 10 µm	9.59E-6	kg
Pentane	6.42E-5	kg
Propane	5.14E-6	kg
Propene	2.57E-6	kg
Toluene	7.71E-6	kg
Xylene	5.14E-6	kg
Heat, waste	0.092	MJ
Sulphur dioxide	0.0003001	kg

Table 8.11 Emissions to water (B)

Emissions to water	Amount	Unit
t-Butyl methyl ether	3.76E-7	kg
TOC, Total Organic Carbon	5.16E-5	kg
Aluminium	1.26E-8	kg
Barium	2.44E-8	kg
Boron	9.73E-8	kg
Chloride	1.93E-5	kg
Cyanide	4.22E-8	kg
Fluoride	1.08E-6	kg
Hydrocarbons, aromatic	1.75E-7	kg
Iron, ion	1.20E-7	kg
Magnesium	6.08E-6	kg
Manganese	4.87E-8	kg
Mercury	2.44E-11	kg
Molybdenum	2.43E-9	kg
Nitrate	2.01E-6	kg
Phosphorus	9.44E-8	kg
Potassium, ion	2.44E-6	kg
Selenium	3.65E-9	kg
Silver, ion	1.22E-8	kg
Sodium, ion	7.35E-5	kg
Sulfide	2.44E-8	kg
Suspended solids, unspecified	2.33E-6	kg
Toluene	2.43E-7	kg
Xylene	2.36E-8	kg
Aluminium	2.11E-8	kg
Barium	4.23E-8	kg
Boron	1.69E-7	kg
Calcium, ion	2.11E-5	kg
BOD5, Biological Oxygen Demand	2.98E-6	kg
COD, Chemical Oxygen Demand	3.06E-5	kg

Crude transportation within the refinery (T2)

Table 8.12 Known inputs from techno-sphere used in second phase (T2)

Known inputs from techno-sphere (materials/fuels)	Amount	Unit
Diesel, burned in diesel-electric generating set	0.23	MJ
Pipeline	2.3E-18	km

Table 8.13 Emissions to water (T2)

Emissions to water	Amount	Unit
Oils, unspecified	1.07E-8	kg

Nitrogen	4.12E-10	kg
BOD5, Biological Oxygen Demand	1.36E-10	kg
COD, Chemical Oxygen Demand	1.2E-10	kg
DOC, Dissolved Organic Carbon	4.23E-10	kg
TOC, Total Organic Carbon	4.11E-10	kg
AOX, Adsorbable Organic Halogen as Cl	0.1E-10	kg
Sulphur	1..46E-08	kg

8.6. Life Cycle Impact Assessment Analysis

The purpose of the LCIA (Life Cycle Impact Assessment) section of the LCA study is to estimate possible impacts on the environment and human health of the releases and environmental resources that have been identified throughout the life cycle inventory section. Impact assessment must address both human health and ecological effects; it must also address depletion of resources. An LCIA seeks to establish connections between processes or products and any possible impacts upon the environment.

8.6.1. The LCIA Procedures and Factors

In accordance with the ILCD guidelines, all the recommended impact categories shall be taken into account in the LCIA phase (ILCD, 2010). This LCA study utilised the Impact 2002+, damage oriented method for Life Cycle Impact Assessment. This methodology was first devised in Switzerland at the Swiss Federal Institute of Technology Lausanne (EPFL). Now, it is further developed and maintained by the IMPACT Modelling Team. IMPACT 2002+ is a combination of IMPACT 2002 (Pennington et al. 2005), Eco-indicator 99 (Goedkoop and Spriensma, 2000), CML (Guinée et al. 2002) and IPCC. The life cycle impact assessment methodology IMPACT 2002+ proposes a feasible implementation of a combined midpoint/damage approach, linking all types of life cycle inventory results (elementary flows and other interventions) via several midpoint categories (Quantis User Guide, 2015).

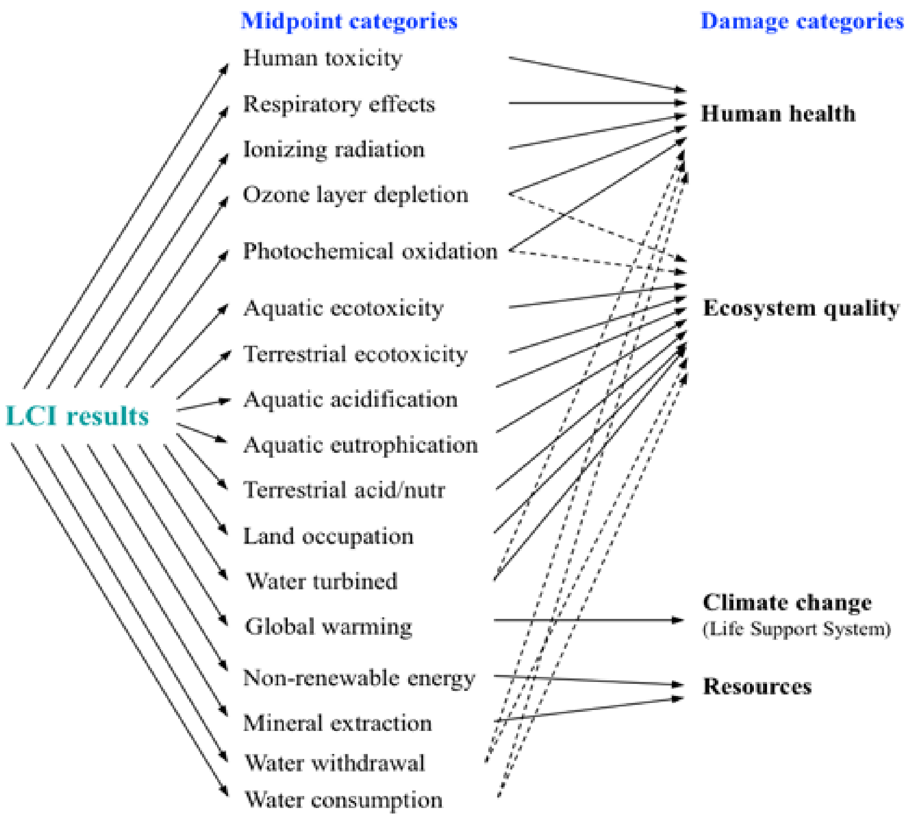

Figure 8.5 Scheme connecting LCI results to damage categories via midpoint categories, according to the IMPACT 2002+ framework, based upon Jolliet et al. (2003a).

Figure 8.5 shows how the IMPACT 2002+ vQ2.2 framework functions, connecting the results of the LCI through a number of midpoint categories. These include human toxicity effects, both carcinogenic and non-carcinogenic, grouped sometimes into a single category; ionising radiation, respiratory effects, depletion of the ozone layer, photochemical oxidation, terrestrial ecotoxicity, aquatic ecotoxicity, aquatic eutrophication, aquatic acidification, terrestrial nutrification/acidification, water turbines, land occupation, non-renewable energy consumption, global warming, mineral extraction, water consumption and water withdrawal. These are connected to four categories of damage: ecosystem quality, resources, climate change and human health (Quantis, 2015).

8.6.2. Reference for All Characterisation Models, Characterisation Factors, Reference Substances, and Damage Units Used In IMPACT 2002+

This section provides a reference for all characterisation and normalisation factors of the LCIA methods applied in the LCA study. Table 8.14 provides the environmental impact categories, indicators and characterisation models of the IMPACT 2002+ impact assessment method. Further details on the characterisation factors to be implemented for each elementary flow are available at http://www.quantis-intl.com.

Table 8.14 Main sources for characterisation factors, reference substances, and damage units

[source]	Midpoint category	Midpoint reference substance	Damage category	Damage unit	Normalized damage unit
[a]	Human toxicity (carcinogens + non-carcinogens)	kg Chloroethylene into air$_{-eq}$	Human health	DALY	point
[b]	Respiratory (inorganics)	kg PM2.5 into air$_{-eq}$	Human health		
[b]	Ionizing radiations	Bq Carbon-14 into air$_{-eq}$	Human health		
[USEPA and b]	Ozone layer depletion	kg CFC-11 into air$_{-eq}$	Human health		
[b]	Photochemical oxidation	kg Ethylene into air$_{-eq}$	Human health		
			Ecosystem quality	n/a	n/a
[a]	Aquatic ecotoxicity	kg Triethylene glycol into water$_{-eq}$	Ecosystem quality	PDF·m^2·y	point
[a]	Terrestrial ecotoxicity	kg Triethylene glycol into soil$_{-eq}$	Ecosystem quality		
[b]	Terrestrial acidification/nutrification	kg SO_2 into air$_{-eq}$	Ecosystem quality		
[c]	Aquatic acidification	kg SO_2 into air$_{-eq}$	Ecosystem quality		
[c]	Aquatic eutrophication	kg PO_4^{3-}into water$_{-eq}$	Ecosystem quality		
[b]	Land occupation	m^2 Organic arable land$_{-eq}$ · y	Ecosystem quality		
	Water turbines	inventory in m^3	Ecosystem quality		
[IPCC]	Global warming	kg CO_2 into air$_{-eq}$	Climate change (life support system)	kg CO_2 into air$_{-eq}$	point
[d]	Non-renewable energy	MJ or kg Crude oil$_{eq}$ (860 kg/m^3)	Resources	MJ	point
[b]	Mineral extraction	MJ or kg Iron$_{-eq}$ (in ore)	Resources		

Sources: [a] IMPACT 2002 (Pennington et al. 2005, 2006), [b] Ecoindicator 99 (Goedkoop and Spriensma 2000), [c] CML 2002 (Guinée et al. 2002), [d] ecoinvent (Frischknecht et al. 2003), [IPCC] (IPCC 2001), and [USEPA] (EPA). DALY= Disability-Adjusted Life Years; PDF= Potentially Disappeared Fraction of species; -eq= equivalents; y= year.

8.6.3. Limitations and the Relationship of the LCIA Results Relative to the Defined Goal and Scope of the LCA

Global Warming measures an increase in such emissions as methane and carbon dioxide, the so-called greenhouse gases. Due to this increase, gases in the atmosphere are absorbing more of the radiation the earth emits, intensifying the greenhouse effect. Global Warming Potential is relevant both to energy efficiency and climate change. Both these things are of high institutional and public interest, are interlinked, and are a significant and pressing current issue. Characterisation factors can be expressed as kg CO_2 into air$_{-eq}$.

Aquatic Eutrophication: this is the result of bodies of water being overloaded with such nutrients as phosphorus and nitrogen. Eutrophication in freshwater is precipitated mostly by phosphorus, and in saltwater, mostly by nitrate. Substances that can potentially cause nitrification can be aggregated through the use of nitrification potentials, which measure the ability of something to form biomass as compared to phosphate (PO_4). Characterisation factors can be expressed as kg PO_4^{3-} into water $_{-\,eq}$.

Acidification is the production of acid substances deposits because of air pollution comprising mainly nitrogen oxides, ammonia and sulphur dioxide. "Acid rain" causes damage to lakes and forests. Acidification can also affect coastal and freshwater ecosystems, historical monuments and soils. These acids facilitate the release of heavy metals into groundwater. Gases that contribute to the acidification of air can be aggregated by potential for acidification. These potentials are developed based on the number of hydrogen ions every substance can produce per mole, where SO_2 is the reference substance. Characterisation factors can be expressed as kg SO_2 into air$_{-eq}$.

Human toxicity: chemical compounds can be released anthropogenically into the environment, which is a huge environmental concern because of the potential harm this could cause to the natural environment and to humans. As such, scientists have developed methods for estimating the potential harm to the environment that could result from the emissions of certain chemical compounds. The method of impact assessment used for this is based upon human toxicity potentials that have been pre-calculated, rather than being related to the actual impact. The Human Toxicity Potentials, or HTPs, represent an index of calculated potentials showing the harm one unit of a chemical could cause to the environment. Characterisation factors for each substance, detailing the potential effects of the toxic substances across an infinite time, can be expressed as kg Chloroethylene into air$_{-eq}$ emissions.

Eco-toxicity is the potential for toxic effects to be exerted on natural organisms by substances released due to human activities. Characterisation factors are expressed as Triethylene glycol equivalents/ kg emission.

Eutrophication, Acidification, Photochemical oxidation, Ozone layer depletion and other impact categories were chosen because they are closely connected to air, soil, and water quality and capture the environmental burden of regulated emissions such as NO_x, SO_2, VOC, and others commonly associated with life cycle phases of crude oil extraction plants (COEP). Ozone depletion potential was chosen because of its high political relevance, which eventually led to the worldwide ban of ozone-depleting substances.

Therefore, the characterisation factors were used within this study to identify key contributors within COEP which influence that system's toxicity potential. The results would indicate which of the analysed phases shows up as the ‘phase of high concern’. When using this methodology, indicators are placed into four principal damage categories: damage to resources, damage to ecosystems, damage to human health and climate change. These categories are balanced against a number of factors: number of years of human lives lost or damaged (health of humans), number of animal species depleted in a certain place over a certain period (ecosystem) and amount of energy necessary for extraction of fossil and mineral fuels in the future (resources).

Impact categories have been selected to capture a complete picture of the environmental effects of the life cycle of the Crude Oil Extraction Plant.

8.7. Life Cycle Interpretation

This section will discuss the outcomes of the impact assessment. The interpretation phase involves studying the results of the goal and scope, inventory analysis and impact assessment, in order to draw conclusions and make recommendations as to the final phase of conducted research. The baseline characterisation results without uncertainty ranges are presented in this chapter. Normalisation results will not be further discussed as they do not provide new insights compared to the insights based on the characterisation results. Interpretation must be conducted to ensure that the results are consistent with the defined goal and scope of the study.

In this LCA study, the life cycle stages included are crude oil extraction, production, transportation, processing and distillation which are considered from well to refinery gate. GTW and WTP phases are excluded. The exclusion is due to the fact that impacts generated outside the refinery are out of the policy makers' control and, therefore, study of these elements cannot assist in environmental impact minimisation specifically targeted for aiding the policy makers. Study of these elements would not contribute towards the objectives of this research. The LCA results are obtained using characterisation, normalisation and single score features of SimaPro and IMPACT 2002+ method.

8.7.1. The results

Based on the IMPACT 2002+ conducted damage oriented midpoint/endpoint LCIA method, figure 8.6 shows the characterisation of the impacts. The graph shows the crude oil production (red colour), petrol refinery technologies processes (green colour), transportation within the refinery (yellow colour) and crude oil transportation to the refinery (blue colour).

Table 8.15 Characterisation results for analysed COEP system with distribution system included. Results are specified per functional unit of 1 kg.

Impact category	Unit	Total	Crude Oil Production	Petrol at the refinery	Transportation within refinery	Transport, crude oil pipeline
Carcinogens	kg C2H3Cl eq	0.009305	0.000126	0.008603	0.000575	2.13E-07
Non-carcinogens	kg C2H3Cl eq	0.00813	0.000115	0.007509	0.000506	1.87E-07
Respiratory inorganics	kg PM2.5 eq	0.001131	6.24E-05	0.000887	0.000181	6.7E-08
Ionizing radiation	Bq C-14 eq	8.352368	0.103563	8.007121	0.241594	8.94E-05
Ozone layer depletion	kg CFC-11 eq	4.82E-07	5.91E-09	4.71E-07	6.03E-09	2.23E-12
Respiratory organics	kg C2H4 eq	0.001715	0.0008	0.000875	4E-05	1.48E-08
Aquatic ecotoxicity	kg TEG water	147.0259	0.617969	143.7754	2.631556	0.000974
Terrestrial ecotoxicity	kg TEG soil	31.8706	0.157219	31.0974	0.615752	0.000228

Terrestrial acid/nutri	kg SO_2 eq	0.022016	0.001746	0.016374	0.003894	1.44E-06
Land occupation	m2org.arable	0.003597	5.27E-05	0.003404	0.00014	5.19E-08
Aquatic acidification	kg SO_2 eq	0.007827	0.000257	0.006984	0.000586	2.17E-07
Aquatic eutrophication	kg PO_4 P-lim	0.00036	8.15E-06	0.000347	5.09E-06	1.88E-09
Global warming	kg CO_2 eq	0.752688	0.060767	0.642469	0.049433	1.83E-05
Non-renewable energy	MJ primary	104.406	46.77902	56.8504	0.77625	0.000287
Mineral extraction	MJ surplus	0.004236	0.000196	0.003042	0.000999	3.7E-07

Sources: Ecoinvent database and SimaPro 7 exported files. MJ surplus energy per year per captia'. *m2org.arable* m^2 equivalent organic arable Land. *TEG triethylene glycol. P-lim in P-limited water*

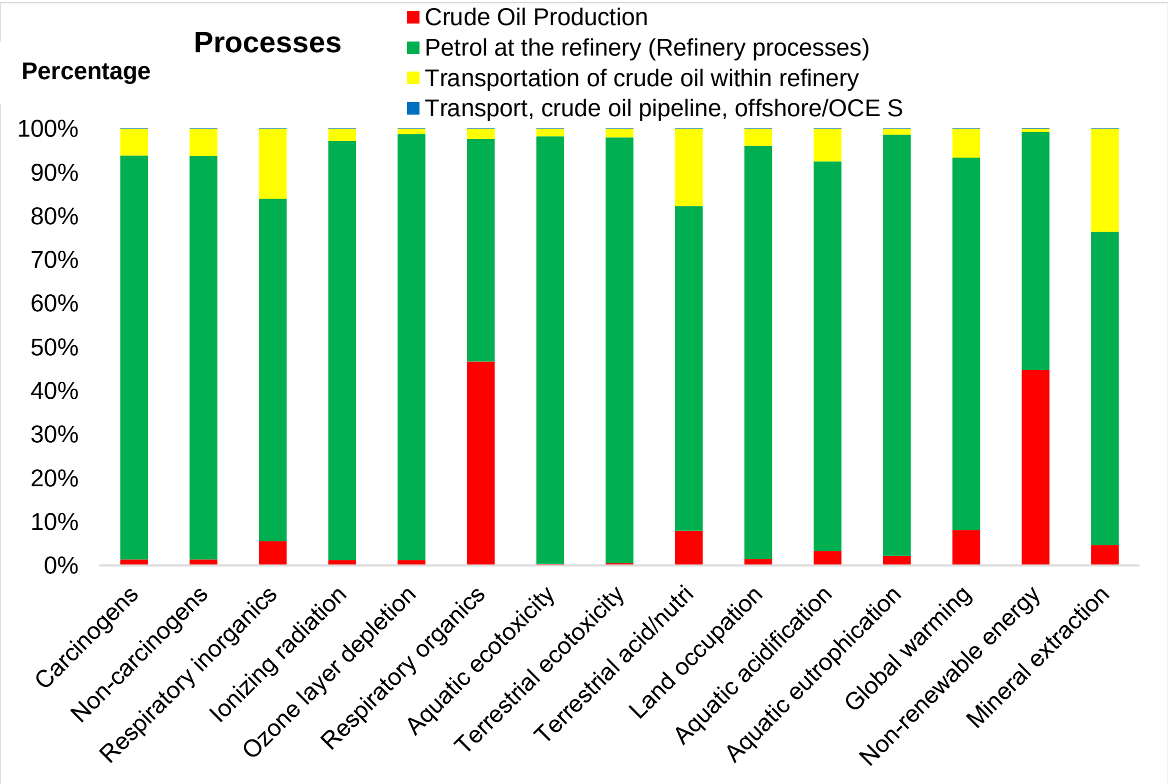

Figure 8.6: Characterisation results for analysed COEP system with distribution system included. Results are specified per functional unit of 1 kg of produced crude oil

Table 8.16 Normalisation results for analysed COEP system with distribution system included. Results are specified per functional unit of 1 kg produced crude oil

Impact category	Crude Oil Production	Petrol at the refinery (Refinery processes)	Transportation of crude oil within refinery	Transport, crude oil pipeline, offshore
Carcinogens	4.98E-08	3.4E-06	2.27E-07	8.41E-11
Non-carcinogens	4.53E-08	2.96E-06	2E-07	7.4E-11

Respiratory inorganics	6.16E-06	8.76E-05	1.79E-05	6.61E-09
Ionizing radiation	3.07E-09	2.37E-07	7.15E-09	2.65E-12
Ozone layer depletion	8.76E-10	6.97E-08	8.93E-10	3.3E-13
Respiratory organics	2.4E-07	2.63E-07	1.2E-08	4.45E-12
Aquatic ecotoxicity	2.26E-09	5.27E-07	9.64E-09	3.57E-12
Terrestrial ecotoxicity	9.08E-08	1.8E-05	3.56E-07	1.32E-10
Terrestrial acid/nutri	1.33E-07	1.24E-06	2.96E-07	1.09E-10
Land occupation	4.19E-09	2.71E-07	1.12E-08	4.13E-12
Global warming	6.14E-06	6.49E-05	4.99E-06	1.85E-09
Non-renewable energy	0.000308	0.000374	5.11E-06	1.89E-09
Mineral extraction	1.29E-09	2E-08	6.57E-09	2.43E-12

Sources: Ecoinvent database and SimaPro 7 exported files

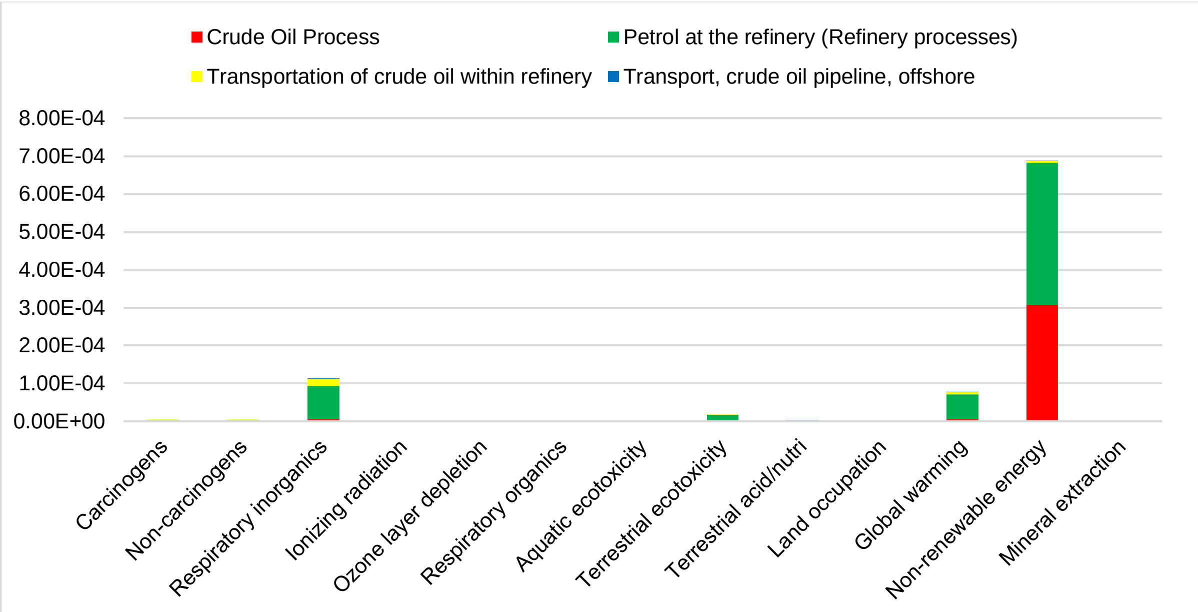

Figure 8.7: Normalisation results for analysed COEP system with distribution system included. Results are specified per functional unit of 1 kg produced crude oil

Table 8.17 Normalisation results for analysed COEP system with distribution system included – endpoint level

Damage category	Crude Oil Production	Petrol at the refinery (Refinery processes)	Transportation of crude oil within refine`ry	Transport, crude oil pipeline, offshore
Human health	6.5E-06	9.45E-05	1.83E-05	6.78E-09
Ecosystem quality	2.3E-07	2E-05	6.72E-07	2.49E-10
Climate change	6.14E-06	6.49E-05	4.99E-06	1.85E-09
Resources	0.000308	0.000374	5.11E-06	1.89E-09

Sources: Ecoinvent database and SimaPro 7 exported files

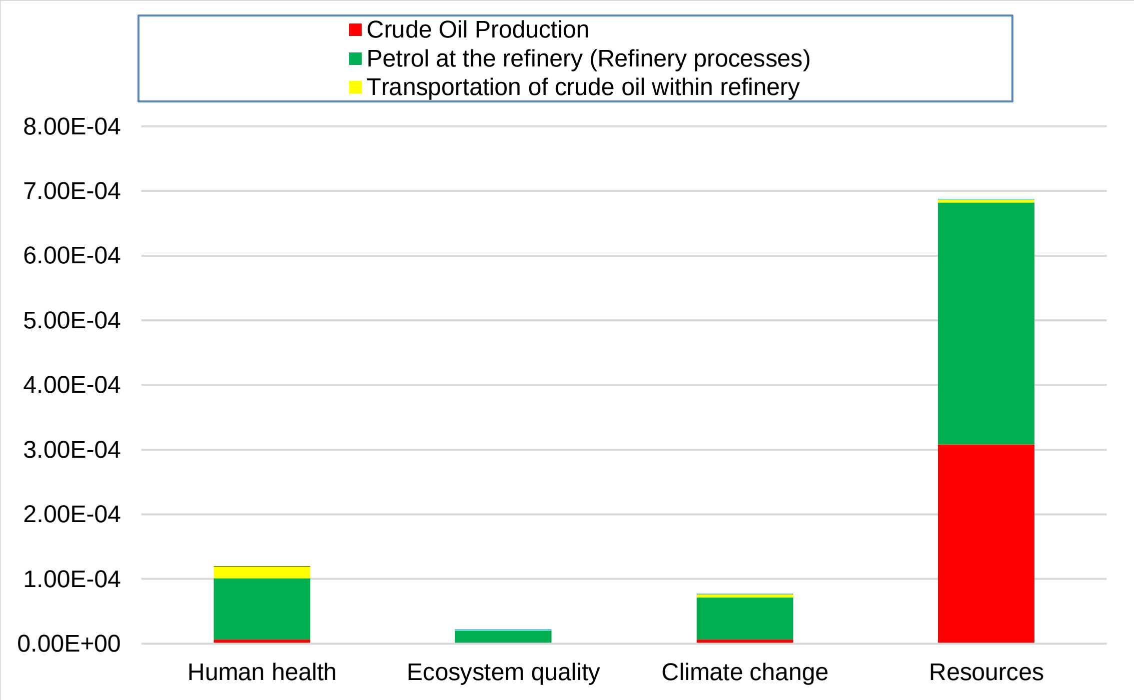

Figure 8.8: Normalisation results for analysed COEP system with distribution system included – endpoint level

Table 8.18 Single score results - midpoint level

Impact category	Total	Crude Oil Production	Petrol at the refinery (Refinery processes)	Transportation of crude oil within refinery	Transport, crude oil pipeline, offshore
Total	0.000903	0.000321	0.000554	2.91E-05	1.08E-08
Carcinogens	3.67E-06	4.98E-08	3.4E-06	2.27E-07	8.41E-11
Non-carcinogens	3.21E-06	4.53E-08	2.96E-06	2E-07	7.4E-11
Respiratory inorganics	0.000112	6.16E-06	8.76E-05	1.79E-05	6.61E-09
Ionizing radiation	2.47E-07	3.07E-09	2.37E-07	7.15E-09	2.65E-12
Ozone layer depletion	7.14E-08	8.76E-10	6.97E-08	8.93E-10	3.3E-13
Respiratory organics	5.15E-07	2.4E-07	2.63E-07	1.2E-08	4.45E-12
Aquatic ecotoxicity	5.39E-07	2.26E-09	5.27E-07	9.64E-09	3.57E-12
Terrestrial ecotoxicity	1.84E-05	9.08E-08	1.8E-05	3.56E-07	1.32E-10
Terrestrial acid/nutri	1.67E-06	1.33E-07	1.24E-06	2.96E-07	1.09E-10
Land occupation	2.86E-07	4.19E-09	2.71E-07	1.12E-08	4.13E-12
Global warming	7.6E-05	6.14E-06	6.49E-05	4.99E-06	1.85E-09
Non-renewable energy	0.000687	0.000308	0.000374	5.11E-06	1.89E-09
Mineral extraction	2.79E-08	1.29E-09	2E-08	6.57E-09	2.43E-12

Sources: Ecoinvent database and SimaPro 7 exported files

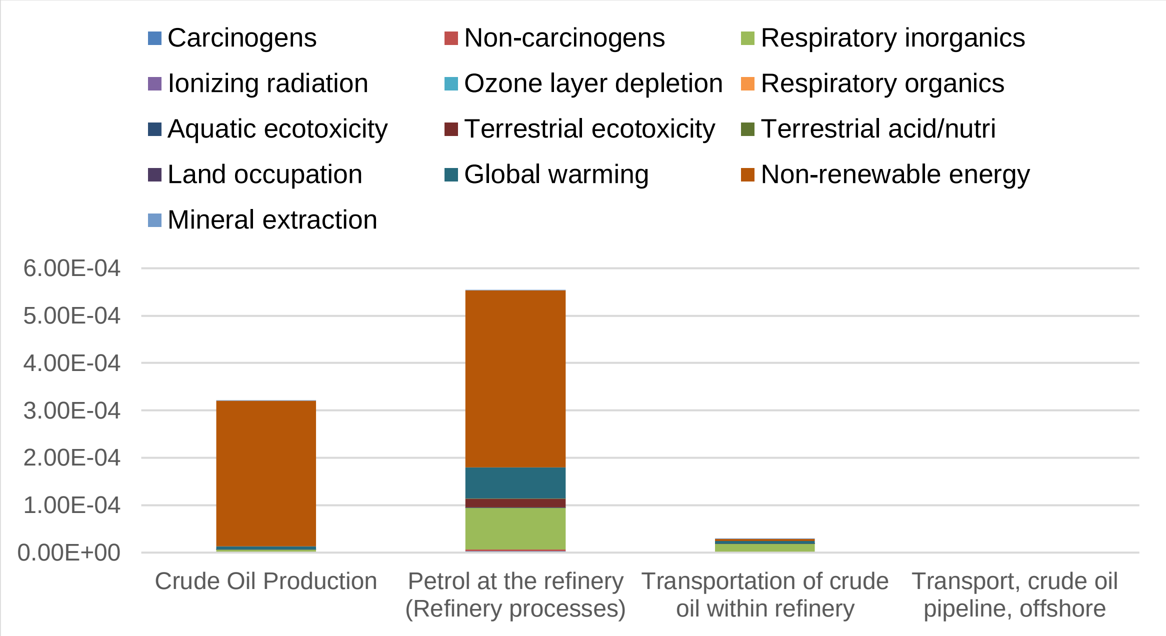

Figure 8.9: Single score results - midpoint level

Table 8.19 Single score results - end point level

Damage category	Unit	Total	Crude Oil Production	Petrol at the refinery (Refinery processes)	Transportation of crude oil within refinery	Transport, crude oil pipeline, offshore
Total	Pt	0.000903	0.000321	0.000554	2.91E-05	1.08E-08
Human health	Pt	0.000119	6.5E-06	9.45E-05	1.83E-05	6.78E-09
Ecosystem quality	Pt	2.09E-05	2.3E-07	2E-05	6.72E-07	2.49E-10
Climate change	Pt	7.6E-05	6.14E-06	6.49E-05	4.99E-06	1.85E-09
Resources	Pt	0.000687	0.000308	0.000374	5.11E-06	1.89E-09

Sources: Ecoinvent database and SimaPro 7 exported files

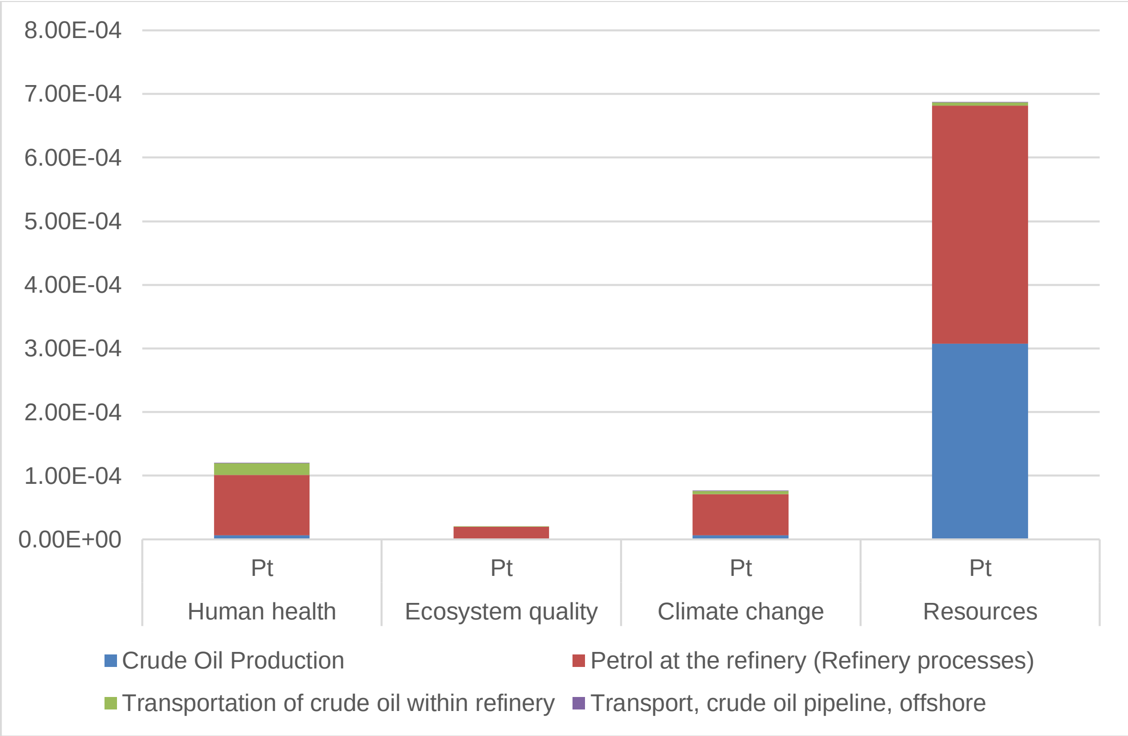

Figure 8.10: Single score results - end point level

8.7.2 Better Understanding of Impact Assessment Units

Humbert, et al., (2012) explains different types of units which are used in IMPACT 2002+:

At the midpoint level: ("kg equivalent of a reference substance s") "kg substance s-eq" is an expression showing how much of reference substance s is equivalent to the impact of a selected pollutant within studies in the midpoint category. For example, on a 100-y scale, the Global Warming Potential of fossil-based methane is higher than that of CO_2 by 27.75 times, therefore its CF = 27.75 kg CO_2-eq.

At the damage level:

- "Disability-Adjusted Life Years" or DALY is a characterisation of the severity of diseases, taking into account both morbidity (amount of life spent with poor quality because of illness) and mortality (years of life lost to early death). Most non-carcinogenic and carcinogenic effects adopt default values of 1.3 and 13 (years/incidence) on the DALY scale (Keller, 2005). These values replace the earlier calculations of Crettaz et al (2002) which were used in earlier versions of IMpact 2002+ (v1.0, v1.1 and v2.0). If a product has a human health score of 3 on the DALY scale, this suggests that three years' life would be lost across the total population.

- "PDF·m2·y" ("Potentially Disappeared Fraction of species over a certain amount of m^2 during a certain amount of year") is a unit of measurement for impact upon ecosystems. The unit to "measure" the impacts on ecosystems. PDF·m^2·y is a representation of how much of a species, as a fraction, has vanished across 1 m^2 of earth surface in one year. If a product has an ecosystem quality scoring of 0.2 PDF·m^2·y, 20% of species on 1 m^2 of earth surface would be lost over the course of a year.
- MJ ("Mega Joules") is a measurement either of the amount of energy needed to extract a resource, or the amount of energy that is extracted.

At normalised damage level:

- "points" are equal to "pers.y". The average impact in a specific category caused by a person during one year in Europe is represented by a "point". It also represents the average impact on a person during one year for human health, in a first approximation (i.e., an impact of 3 points in the ecosystem quality represents the average annual impact of 3 Europeans. This could also be applicable to interpreting climate change and resources data). The calculations are based on the total year damage score as a result of emissions and extractions in Europe then divided by the total population of Europe.

Figure 8.11 shows the cause-effect chain (also referred to as the environmental mechanism) for an emission category. At the top are emissions, sometimes referred to as stressors, so called because they are triggers for potential impacts (the 'causes' in the cause-effect chain).

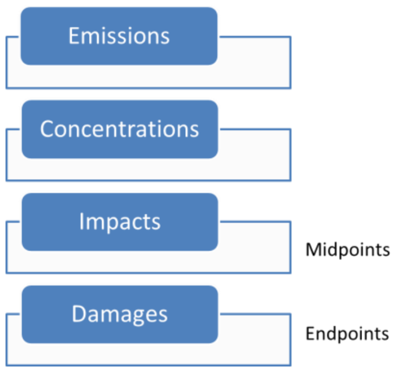

Figure 8.11: General cause-effect chain for environmental impacts (adopted version from Finnveden 1992)

8.8. Discussion

After the completion of the LCIA step, the results have been obtained to describe potential environmental impacts of the Crude Oil Extraction Plant (COEP) system. These results provide insight in quantitative expression of generated environmental impacts throughout the considered life cycle phases of the system in scope.
After applying the IMPACT 2002+ methodology, it can be observed that the largest environmental impact of the COEP system is within the non-renewable energy impact category and is followed by Respiratory Inorganics, Global Warming and Terrestrial ecotoxicity. These impacts represent the characterisation results (Table 16). Also, it can be observed that impact on the Non-renewable impact category significantly dominates other impact categories, which show almost negligible impact by comparison (Figure 8.6).

Normalisation and single score calculation steps follow the same pattern (as with characterisation step) when considering the environmental impact among impact categories and the situation is not changed (Table 17, Table 19). When observing the scenario of the COEP system divided amongst each phase of the life cycle, it can be concluded that the largest impact is associated with the petrol at the refinery (Refinery processes) and all other phases have almost negligible impact when compared to this.

More in-depth analysis of the main contributing impact categories reveals the main processes responsible for generating these impacts. The main contributing unit processes within the Non-renewable energy impact category are: *crude oil, in ground; natural gas, in ground; uranium, in ground; coal, hard, in ground* (figure 8.11). These unit processes are in the background of the system boundaries.

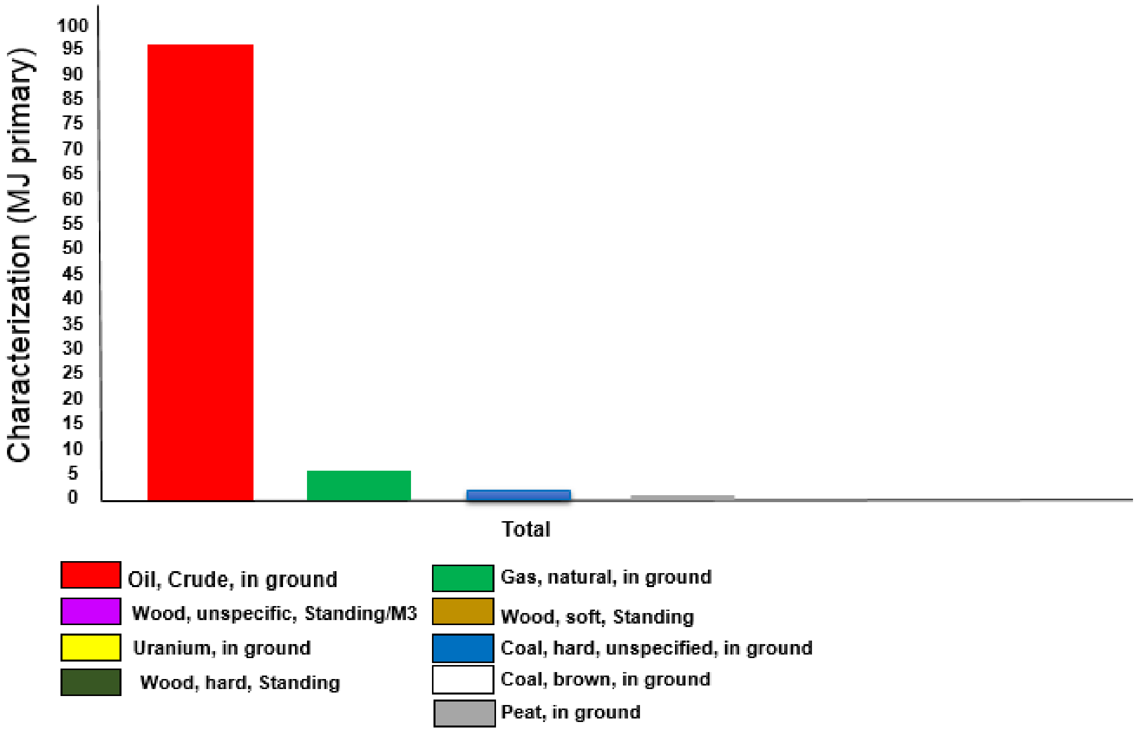

Figure 8.12: In depth analysis - characterisation results (main unit processes)

More in-depth analysis of the main contributing substances in impact categories reveals the main substances responsible for generating these impacts. The main contributing substances within the Non-renewable energy impact category are: *Sulphur dioxide, Nitrogen oxides; Particulates < 2.5µm, Hydrocarbons aromatic, Beryllium and others* (Figure 8.12).

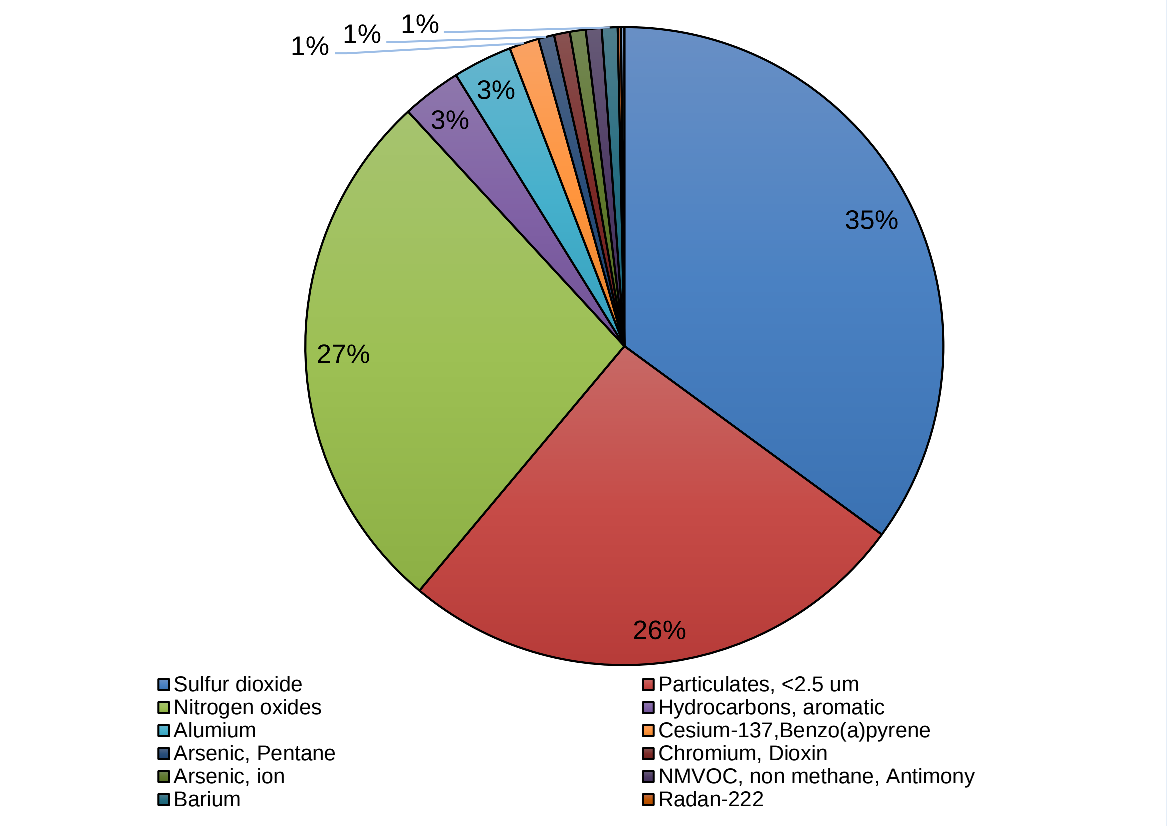

Figure 8.13: The most contributing substances to the Non-renewable impact category

It is evident from the LCA results that the most significant impacts are caused by fossil fuels across all the stages of crude oil production in Libya, which is no surprise. These impacts are mainly due to the continuous flaring and venting of gases and the operation of various heavy duty machines, turbines, engines and pumps which produce, transport and generate energy for production facilities, oil field and the refinery. The amount of emissions from these processes is significant and almost equal in terms of upstream and midstream stages.

8.8.1. Assumptions and Limitations Associated With the Interpretation of Results, Both Methodology and Data Related

This LCA reports using a Well to Refinery (WTR) approach, assessing the potential environmental impacts associated with the COEP system. It is not suitable for comparative assertions, defined as an environmental claim regarding the superiority or equivalence of one product or system versus a competing system that performs the same function. In order to assess the consequential impacts of the installed COEP system, additional analysis is required.

The LCA results presented here are limited to the objectives, goal and scope defined beforehand. This study is based on available primary data combined with generic data from preliminary literature research and existing commercial databases. There are some limitations to the outcomes of this study. Overall, the quality of the information is sufficient to meet the goals of the study and the consistency of collecting data among the system studied is good.

8.8.2. Full Transparency In Terms Of Value-Choices and Rationales

This study was performed in accordance with the ISO 14040 and 14044 requirements. This report was compiled and revised in accordance with the ISO 14044 Compliance Checklist. It is important to state that LCIA results are relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins or risks.

8.9 Conclusion

This chapter concludes the main findings based on the case study and data collection conducted in a Well to Refinery (WTR) analysis of a Crude Oil Extraction Plant. Additional work has been done to ensure the completeness of the study, to analyse the sensitivity of key aspects and to check that the consistency in data and results is in line with the defined Goal and Scope of the study. Hence, it could be argued that the results of the LCA study provides an insight about the current practices in the petroleum sector in Libya and these results can further provide evidence for the need to have an integrated system to manage and minimise environmental impacts.

As indicated in chapter four, Libya’s wealth and main revenues are highly dependent on the petroleum sector. Despite this fact, no previous investigations of the environmental impacts have been carried out. This study provides a well to refinery gate LCA analysis. Based on the environmental impacts of the considered phases of the life cycle, crude oil refinery processes dominate the whole of the life cycle's impacts, which can be attributed to the activities associated with this process that include the preparation, production, transportation, processing and handling of the crude oil. Based on case studies, it can be concluded that the use of energy and fossil fuels dominates emissions and environmental impacts over the life cycle of the COEP system. The results of the assessment show (Table 8.16 and 8.17) significant impacts are caused by the crude oil production and distillation. Therefore, the following conclusions have been reached based on the analysis of the crude oil life cycle and its transportation.

It is evident from the analysis that the level of environmental impact at the refinery stage is marginally higher than the impact at the oil field, whereas transportation impacts are the lowest and are almost negligible. The most significant impact is fossil fuels at both stages and the second major set of impacts are the respiratory inorganic impacts. Despite the limitation of a lack of sufficient actual industrial data, the results of this LCA demonstrate that this analysis could help recommend measures which need to be taken to reduce environmental impacts and the use of fossil fuels. A set of recommendations are provided for the Libyan petroleum companies to consider minimising fossil fuel consumption. LCA results show that there is a high environmental impact caused by the Libyan petroleum industry, which requires the implementation of a Sustainability Management System to minimise these impacts. Furthermore, future discussions must be undertaken concerning: the sensitivity analysis of change in the total life span of the COEP system, optimum parameters with the Libyan conditions and underground impacts.

Energy optimisation for the COEP technologies in the petrol at the refinery (Refinery processes) phase is advisable. Further research and development should be undertaken in the field of systematic controlled energy reduction and power demand for crude oil extraction technologies.

The central role of energy use underlines the need for continuous efforts to further improve energy efficiency in the use phase of the life cycle of the COEP system in order to decrease its environmental impact. Thus, it could be argued that the following recommendations can improve performance in the oil industry in Libya:

- **Introduction of Life Cycle Thinking concept and Life Cycle Assessment as a management/engineering tool for environmental assessment in the Libyan Crude Oil industry**

Conducting an LCA for a private company means compiling all inputs and outputs into a transparent inventory which considers all relevant environmental concerns. LCA and LCIA results may seem detailed and to some extent they are, but they fail to represent additional detail that exists within the models – i.e., the specific processes and sectors at the various tiers that lead to these emissions. Because of that, it is very important to include all phases of the considered product system.

In process-based results, such as the SimaPro computing algorithm, multiple processes may contribute to the CO_2 emissions from coal-fired electricity or diesel fuel, but the aggregated totals provided do not show which of these underlying processes cause most damage. It may be important to know whether most of the emissions are from final production or from a specific upstream product or process. Full life cycle assessment provides the company with an excellent overview of areas where improvements can be made both economic and environment. Integrating LCA and LCC research in future Crude Oil Industry projects is an interesting idea for finding sustainable solutions. Including the life cycle perspective of all processes makes it possible to get an overview of whether inputs could be substituted by less polluting technologies, production processes or alternative materials.

Calculating the LCI results and understanding impact scores will determine how the pollution affects humans and the environment and provides a comparable impact value that may be used in the R&D and Marketing company sectors. Some globally recognised organisations (e.g. UNEP, EPA, IUCN and WNO) are putting pressure on Crude Oil producers to demand cleaner production and to invest in scientific projects involving renewable energy sources and technologies. Generally, integrated environmental improvements often prove to lessen expenses in the long term and thus provide direct/indirect economic incentives on top of the competitive advantages.

The LCA study conducted is small but an important step for the Libyan Crude Oil industry. Implementation of the Life Cycle thinking concept, Life Cycle Engineering procedures, Life Cycle Assessment methodology, Life Cycle Cost analysis and eco-design strategies in the decision-making process, ensures that a company can continuously develop in the direction of sustainable development. All these concepts, tools and strategies are necessary in the competitive business world. It is hard to achieve a balance between an oil company’s economic and environmental objectives without an integrated environmental management system. Putting eco-design strategies into practice is a very important step for future generations. It is necessary to consider manufacturing decisions from an environmental point of view and to find solutions for the following issues:

- optimisation of crude oil production techniques (alternative production, fewer production steps, lower/cleaner energy consumption)
- optimization of the distribution system (energy efficient transport mode, cleaner/reusable packaging of final products, energy-efficient logistics)
- reduction of impact during the use phase of final products (less energy consumption, cleaner energy sources, cleaner consumables)
- optimisation of the Crude Oil Production Plant's initial lifetime (easier maintenance and repair)
- optimization of an end-of-life system (find the best solution for EOL scenarios)

➢ **Libyan government incentives for implementation of cleaner technology in the Oil industry**

Incentives should be available to encourage companies that operate in this industry to adopt cleaner technologies and invest in such technological changes. These incentives should be collaborated and facilitated by the Libyan government as well as industry representatives.

How dependent is our society on oil products? This complex issue needs to be investigated from a number of angles (individual, social, scientific, philosophical and political). Science and industry together need to find new ways to transform environmental knowledge into business practice. The scientific community must work towards solutions for all industries that are indirectly and directly dependent on crude oil. The Crude Oil supply chain is enormously complex. Changes in the supply chain have significant consequences in modern society. Knowledge, political power, global economy, standard of living and development are all interconnected with Oil products. The price of Crude Oil represents more than economic information. Every aspect of our life is in some way connected with Crude Oil (food, clothes, medicines, energy, transport, etc.). If we can find an environmentally friendly solution in the Crude Oil sector, then we can change the world in a sustainable way. Raising awareness among the public through campaigns is vital so that their knowledge about international standards and indictors used in monitoring environmental performance is enhanced which will further trigger them putting more pressure on companies to adopt cleaner technologies to reduce the environmental impacts of their operations. The energy required to refine crude oils depends on the crude oil properties and the refining intensity.

- **Crude Oil Production GHG Emissions—Significant Uncertainty**

There is considerable variation in the carbon intensities of crude oil typically refined in North Africa. GHG emissions from producing the Study crude oil refined in Libya are based on modelling—not field checked. Energy consumption and GHG emissions was estimated through the use of engineering models from the study crude oils that were refined in North Africa but the results were not possible to verify with the field data.

- **Future research - collection of Libyan LCI datasets, LCA standards and preparation of characterization and normalization factors**

In order to be able to carry out precise LCAs in Libya in the future, it is important to collect, develop and improve the availability of life cycle related input-output data. The above matters should be addressed by a panel of local experts with the aim of preparing Libyan normalisation and weighting standards. In order to create Libyan normalisation standards, a large scale inventory must be created for Libya, including industries, households, transportation and public / governmental / commercial institutions, to map out the full environmental impact of the country. It is also important that government put pressure on industries to record and make available their input-output inventories.

Decisions based on Well-to-gate LCA analysis of Crude Oil Production Plants must use more detailed and relevant information from the production field. Better information should be made available so that in countries that do not measure the greenhouse gas emissions associated with production of crude oil (such as Libya), better definitions of crude production energy can be made. More importantly, it is vital that data is measured and collected from sites rather than using country-wide estimates that are based on the collection of data through satellites. It is also important that carbon losses from soil and land reclamation are determined in the process of crude oil production. All of these efforts will minimise the level of uncertainty in data. In future environmental assessment, it is necessary to include all phases of the Crude Oil life cycle.

Hence, following these findings along with the findings presented in the previous chapters, the following chapter presents the proposed Sustainability Management System for the Libyan petroleum sector.

Chapter 9
Sustainability Management System

9.1 Introduction

This chapter presents the Sustainability Management System that was developed as part of this research. The chapter presents and discusses in detail the process that was adopted to develop the proposed system and also elaborates on the different system components. Sustainability management in the oil and gas industry requires a systematic approach that aims to integrate policy-making, technology, organisational and individual factors. This chapter further provides a detailed explanation of the benefits of the developed system and its application in the Libyan context taking into consideration the barriers and challenges presented above. Therefore, the sub-objectives of this chapter are:

- To present the proposed Sustainability Management System as per the findings from the previous chapters
- To present the different components of the proposed SMS and discuss their applicability
- To discuss the limitations associated with using the developed SMS in practice by oil and gas companies

9.2 Brief Restatement of the Research Problem

In the recent years, there has been accumulating pressure from different international organisations including the United Nations on petroleum companies to improve and enhance their operational environmental performance as well as their sustainable development strategies as a result of the increasing concerns regarding the climate change and the impact of the greenhouse gas emissions. Many countries have developed national strategies that aim to enhance their environmental performance and sustainability performance.

However, developing countries and countries in transition are not yet doing enough to meet these increasing pressures. Libya is one of the countries that is facing great challenges when it comes to managing key environmental sustainability issues. Thus, this research study aimed to investigate these issues so that a sustainability management system for the Libyan petroleum sector can be developed taking into account the lessons learnt from developed nations and based on secondary and primary data from different sources. A Sustainability Management System that is Libyan oriented requires an extensive examination and collection of data from multiple sources. That is why this study adopted a triangulation approach to enhance its validity and applicability to the Libya's petroleum sector.

The proposed system requires a deep understanding of the current issues in relation to sustainability management in the oil and gas sector which was achieved through a comprehensive literature review that looked at the challenges and barriers that hinder oil companies' efforts to integrate sustainability management into their operational policies. This was vital to ensure existing literature is embedded within the developed system along with the primary data that was collected through the triangulation approach.

Field visits, semi-structured interviews, survey questionnaires, life cycle assessment and environmental impact assessment were all carried out. The overall aim and outcomes of this study can be expressed in a research question: how can petroleum companies in Libya improve their sustainability management practices in order for them to provide high quality services at an acceptable level and meet the expectations of their stakeholders nationally and internationally?

9.3 SMS Development Stages

As outlined in the methodology chapter, framework and system development requires the collection of different types of data using both a qualitative and quantitative methods. Hence, this developed system was based on the use of semi-structured interviews, questionnaire survey, direct observation, documentation and technical procedures including EIA and LCA. More importantly, it was realised that developing a system is a process in which the researcher theorises and systematises on data that is generated from existing resources and different literature foundations and enhanced by the collection of relevant empirical data. In other words, it could be argued that data that is gathered from different sources of evidence gives the researcher the ability to build a robust qualitative and quantitative understandings of the various issues, problems and success factors in relation to sustainability management. The researcher also believes that developing a system that is well-articulated and supported by multiple sources of evidence enables all stakeholders in the petroleum sector to better identify, understand, integrate, assess, implement and monitor the vital issues associated with environmental and sustainability management.

The researcher believes that any developed system must be based on the awareness, understanding, identification and assessment of sustainability factors, barriers and success factor as well as understanding the role of different stakeholders' involvement and the adoption of technology and technical assessment methodologies to ensure that a comprehensive system results. A systematic approach was used that followed a well-defined and integrated plan to develop the sustainability management system through a review of the relevant literature on the subject matter and identifying the drivers / factors / issues / barriers and challenges associated with sustainability management.

As shown in Figure 9.1, the process to develop the integrated sustainability management system emerged by carrying out a comprehensive literature review followed by the collection and analysis of empirical data.

The stages in which the SMS was developed are summarised here.

- ***Comprehensive literature review***

Developing a sustainability management system for petroleum companies requires the understanding of the current theoretical context. This was one of the core and vital aspects that contributed to the development of the management system as a detailed understanding of the existing environmental sustainability issues was carried out along with examining the current organisational structure of petroleum companies in Libya. The literature review involved detailed examination of the published peer-reviewed work that was obtained from multiple sources.

- **Semi Structured Interviews**

Understanding the current environmental management and sustainability issues in Libya requires direct communication with policy makers and stakeholders in the Libyan petroleum sector. As explained by Kvale (1996), qualitative research interviews aim to describe both factual information and the meaning level. Moreover, the key strength of the qualitative strategy is gained from its inductive reasoning approach as it focuses on people or situations. The qualitative inductive approach is investigative and explorative in nature concerning the attitudes and behaviours of the participants and the issues. This study focuses on a specific problem within the oil industry (i.e. environmental sustainability management).

- **Semi-structured Questionnaire**

As part of the triangulation approach, understanding the current environmental concerns and issues in the Libyan petroleum sector requires the collection of primary data. A survey strategy was adopted as part of this study to collect primary data from petroleum companies that operate in Libya. The consideration of using an analytical survey tool for this research is to collect the bulk of the data from the wider population (Libyan petroleum sector) and to test general hypotheses generated from the interviews and case studies findings such as level of awareness about sustainability and environmental issues and the key current management problems. The survey aims to examine the importance of linking the findings of the qualitative methods (i.e. interviews and case studies) to the results of the questionnaire.

- **Fieldwork visits**

The fieldwork trips included the collection of data through distributing questionnaires, conducting interviews, observations and visits to the sites, petroleum refineries and plants. The 3rd field work included an Environmental Impact Assessment study. Furthermore, throughout the field work, the author collected other company reports and unpublished documents.

- **Environmental Impact assessment (EIA)**

EIA can be described as a procedure that aims to examine, analyse and inform all possible effects which any new project, process or development has on the environment. To further explore the issues associated with environmental management and sustainability in Libya, EIA was carried out to assess various impacts in Libya so that sources of these impacts can be identified and mitigation measures are proposed.

- **Life Cycle Assessment (LCA)**

The researcher conducted LCA studies to assess and evaluate impacts associated with crude oil production and processes which could help develop the sustainability management system. LCA follows the ISO framework and methodology. The study acknowledges and builds upon the contributions of previous scientific research and field research in the area of crude oil extraction. LCA can help petroleum companies make improvements such as in the treatment and disposal of oily sludge and other waste generated from different operations.

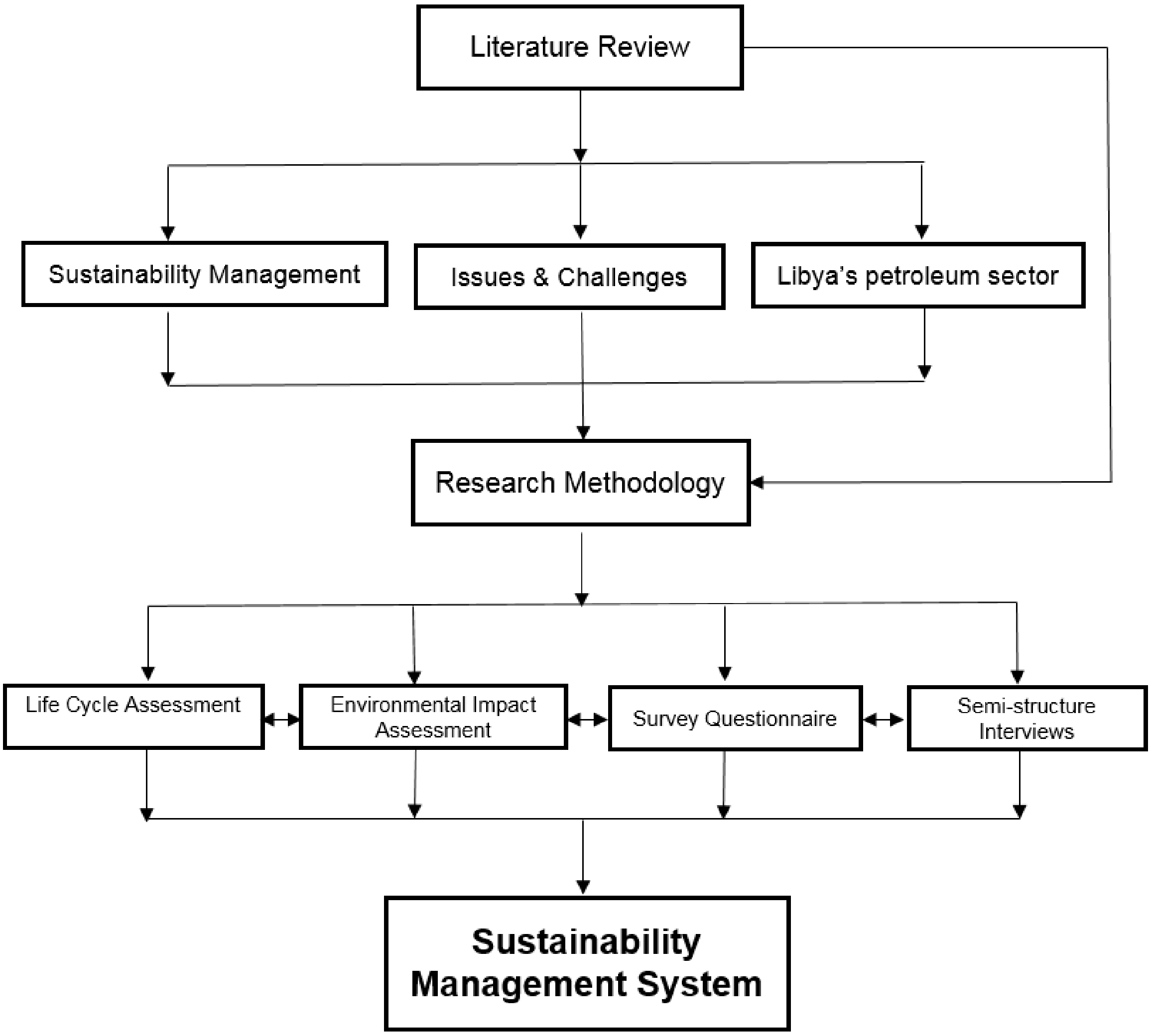

Figure 9.1: SMS development process

9.4 Aim of the SMS

The aim of the developed SMS is to provide a systematic, well-evidenced methodology which can be adopted by petroleum companies, policy makers and governmental organisations in Libya to improve their sustainability management practices and environmental performance. In other words, the SMS can be used as a tool to help policy makers make informed decisions in relation to improving environmental management in Libya and in developing countries.

The SMS also provides a systematic process that can be followed by policy makers in order for them to propose standards, laws or guidelines. The researcher believes that this system promotes an effective and efficient process in enhancing environmental management and sustainability performance as it integrates different variables and elements that are interrelated. Adopting sustainability thinking in the petroleum sector in Libya is a priority which can be achieved through the implementation of this SMS.

9.5 Sustainability Management System (SMS)

Figure 9.2 shows the design of the proposed SMS as per the findings of the empirical studies that were carried out. The researcher believes that this SMS provides a dynamic process that diagnoses, identifies, explains and gives a comprehensive view of sustainability management in the petroleum sectors as the SMS incorporates the main components, activities, consequences, barriers, success factors and outcomes along with the different power structures and taking account of internal and external factors.

The SMS will help petroleum companies to be responsive to the needs of regulatory bodies at national and international level. This system contains some of the components that are available in the existing frameworks but builds upon the findings of this study and provides an overall conceptual system which reflects, illustrates and interprets the current situation in the petroleum sector in Libya. It could be argued that this system could be widely utilised in other Arab countries and in developing countries in general as it provides an integrated approach to sustainability management. Before discussing the benefits and limitations of this SMS, the following section explains the different components and how they work.

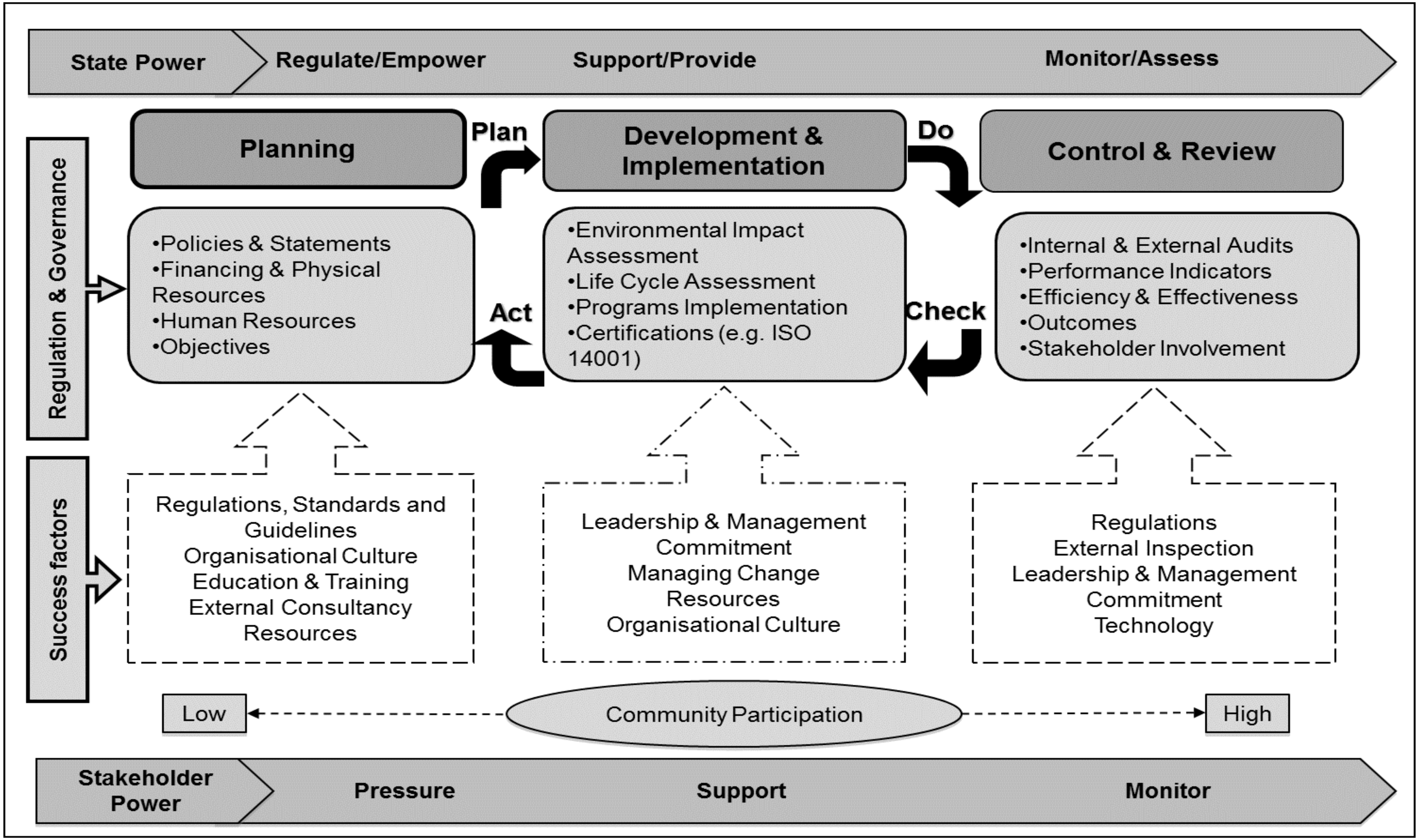

Figure 9.2: Proposed Sustainability Management System for Libyan Petroleum Sector

9.6 The Components of the SMS

The diagram above (Figure 9.2) presented the integrated SMS that is proposed by the petroleum sector in Libya. The proposed SMS consists of interrelated elements that will be explained below. The integrated SMS provides a systematic approach to managing environmental issues and enhancing sustainability performance in Libya. Before explaining each component, the following table (Table 9.1) provides descriptions of the terms used in this system.

Table 9.1: Descriptions of the terms used in the SMS

• **State power:** the government should be the central force that takes on the primary responsibility of protecting the environment. The state's role should be about providing the relevant legislations, resources, policy development, monitoring, evaluation as well as assurances. • **Stakeholder power**: these are all stakeholders involved in the petroleum industry in Libya including the government, people, companies, communities, non-governmental organisations, media and all others. Their role is to put pressure on petroleum companies to implement sustainability practices and provide services that environmentally-friendly. They also have a role in monitoring and providing feedback to relevant authorities. • **Planning**: this is an integral element of all environmental management systems as it involves the process of establishing the organisation's environmental policy which is the foundation of any management system. It also involves the process of identifying the environmental aspects of the different operations such as hazardous waste etc.., which might have negative impact on the environment or people. It also involves ensuring that the required resources are available to implement environmental management systems. • **Development and Implementation:** at this stage, the organisation develops action plans and strategies to reduce the environmental impact of its operations. At this stage, the necessary resources either human or financial should be allocated. Documentation is part of the implementation stage as well as setting up communication processes with different stakeholders • **Control and Review:** organisations should monitor their operations, programmes and strategies to ensure that targets are being met. If these targets are not met, then corrective actions should be taken. This feeds back to the implantation and planning phase.

9.6.1 Planning Phase

The core component of the proposed SMS is the Planning Phase. Based on the proposed system, the planning stage should be the starting point for any organisation that operates in the petroleum sector in Libya. It identifies the organisation's sustainability interests, responsibilities and also defines the goals and objectives of the sustainability strategy, so that a positive view of the future is projected. Organisations must be aware that there is no quick fix to becoming sustainable or socially responsible. In other words, the planning phase should define the sustainability footprint of an organisation and the objectives to be achieved. The organisation should also identify the legal requirements associated with its sustainability programme.

- **Policies & Statements**

As required by existing ISO and other environmental management systems, organisations should develop a policy for sustainability management. This policy should reflect the nature and value of the organisation and its commitment to sustainability. In other words, the policy should be aligned with the organisation's values, mission statement and vision. The sustainability policy should be considered as a formal document that requires approval from the organisation's top management and should be devised in collaboration with all stakeholders in the organisation. It should be considered as a formal document that describes the organisation's commitment towards sustainability. This policy should also be regularly revised and reviewed to be meaningful to all internal and external stakeholders.

- **Financing & Physical Resources**

The organisation should ensure that its vision towards sustainability requires financial commitment from the organisation. The financial and physical resources are vital to the successful implementation of sustainability management systems. For the provision of awareness programs that involve training, the organisation needs to allocate budgets and equipment. Spending on sustainability should be perceived by the organisation as a core success factor in which the top management and regulatory agencies should ensure that such budgets are allocated. For Libya, the country and the petroleum industry in particular is a well-resourced and has high income. The petroleum sector should utilise its revenues in a way that encourages the adoption of sustainability practices. This cannot be achieved without the presence of relevant regulations and standards.

- **Human Resources**

Along with the financial and physical resources, organisations need to ensure that they have enough human resources capable of developing and implementing sustainability management systems. The availability of human and physical resources are very important as they directly influence the SMS's components and outcomes. Therefore, organisations need competent staff who are capable of implementing sustainability management systems. This also relates to the point about the financial element, as organisations need to allocate financial resources for the education and training of its human capital as well as appointing external consultants to provide training. A culture of continuous learning should be encouraged within organisations for knowledge to be transferred among employees at all levels.

- **Objectives**

As part of the planning phase, the organisation should ensure that clear objectives are set with specified targets. These objectives should be SMART (specific, measurable, achievable, realistic and timely). The objectives should describe the organisation's mission statement towards sustainability and should be assigned with clear deadlines so that the organisation can evaluate its progress against these objectives.

- **Regulations, Standards and Guidelines**

As highlighted in the SMS diagram above, in order for organisations to be successful in implementing sustainability systems, there should be regulations, standards and guidelines available to them so that they can follow and implement such systems. The regulatory element of any management system is vital as highlighted in the literature review along with the findings of the empirical study. The regulations, standards and guidelines are external to the organisation which means that the state power as well as international organisations should ensure that such regulation, laws and rules that monitor the petroleum operations in developing countries are available to encourage petroleum companies implement sustainability systems. There are current international standards which organisations are encouraged to adopt which will help improve performance.

- **Organisational Culture**

For any management intervention to be successful it is vital to be supported by all of the stakeholders in the organisation. As a part of the planning stage and amongst the success factors, organisational culture should be considered as a vital element as it shapes the beliefs, attitudes and values of the members of the organisation. In other words, the organisational structure, policies and procedures should reflect the organisation's commitment towards adopting sustainability as a management concept. The top management should steer the organisational culture of the company towards sustainability management by the provision of education and training programs to raise their awareness about the need to improve the environmental performance at all levels. Organisational culture is seen as one of the barriers when it comes to proposing new interventions. Therefore, it was important to include this element as part of the success factors that will help in carrying out efficient planning.

- **Education & Training**

Organisations must ensure that training and education programs are provided to their staff. It was noted in the literature that raising awareness about sustainability and environmental management is vital for the successful implementation of EMS and other organisational interventions. Furthermore, based on the findings of empirical studies, education and training were deemed very critical to the success of any SMS as it helps the organisation improve the knowledge and skills of its members who will be responsible for the delivery and implementation of such systems. More importantly, organisations should provide training to employees who need to deal with advanced technologies as part of their operations. The lack of training and education opportunities can also be considered as a barrier to the successful implementation of EMS.

- **External Consultancy**

As per the findings of the literature review and the empirical studies, getting external help and support should be seen as an encouraging factor for companies to be successful in implementing EMS. In other words, as part of the planning process, the organisation should specify its needs in terms of expertise, technology and physical resources as that will help the organisation improve its operational effectiveness. Furthermore, external consultancy will simplify the process of developing and implementing management systems as the organisation will benefit from the existing expertise and knowledge that was applied in other organisations. Hence, external consultancy is seen as one of the success factors that contribute positively to the successful implementation of sustainability management systems.

- **Resources**

The organisation must clearly identify its needs in terms of resources i.e. human, physical, financial or technological. The availability of resources was highlighted as important from the findings of the empirical studies. Organisations will not be able to improve their performance without the provision of the required resources by the top management. Thus, this shows that identifying the resources in the planning stage is vital.

9.6.2 Development and Implementation Phase

This phase involves the actual execution of the plans and programmes. As part of this phase, there are a number of actions that organisations should take when include the use of technical tools such as the LCA and EIA along with obtaining certifications from regulatory agencies.

- **Environmental Impact Assessment**

Among the most important and integral elements of the SMS is the application of EIA which is a procedure that aims to assess, analyse and inform all the negative impacts that are associated with a new development, process or project. EIA was introduced by the US National Environmental Protection Act in 1969 and is currently being adopted by many organisations worldwide as a tool to help them mitigate environmental harm. As part of the EIA, organisations should ensure that all stakeholders are involved in the process including local authorities, communities and regulatory agencies, since this helps the organisation to assess the environmental impact of different products and projects. One of the advantages of using the EIA is the fact that it is site-specific. There should be a legal requirement imposed on petroleum companies to carry out the EIA and communicate the outcomes of their assessment.

- **Life Cycle Assessment**

The usefulness and benefits of LCA has been identified by the ISO and UNEP in many publications and is supported by evidence from the literature as highlighted in chapter three. LCA has been widely used in many industrial applications for different purposes such as product development and performance improvement, environmental management and planning as well as cleaner technology development. LCA should be considered as an integral element of petroleum companies' sustainability framework. This is because LCA can help organisations determine the most significant environmental impacts and identify new sustainable options. It will help petroleum companies and policy makers to make informed decisions which will lead to more sustainable development.

- **Programmes Implementation**

This element of the SMS describes the organisation's ability to execute its programs such as waste management as per the requirements of the regulations, standards and guidelines. As part of development and implementation phase, programmes should be developed that are site-specific and should be documented to prove the organisation is committed towards improving its environmental performance. The documentation process is an integral part of the programmes implementation stage.

- **Certifications (e.g. ISO 14001)**

Following the planning stage, the organisation should have identified its needs and objectives, and also developed plans and strategies that can help the company achieve its objectives and targets. Existing EMS systems such as ISO 14001 can help achieve this. Organisations should ensure that the required resources are available to help them accomplish and achieve certifications. These certifications should be based on identified objectives from the planning phase.

- **Leadership & Management Commitment**

Leadership and management commitment has been proven to be one of the internal elements in the successful implementation of environmental management systems and sustainability interventions. This was supported by the findings of the empirical studies that were carried out in Libya. For this purpose, these elements plays a vital role in the implementation of the proposed SMS and commitment should start from the top including the regulatory agencies, policy makers, senior managers and down to the shop floor staff. It is necessary and expedient for the implementation of all the processes, activities and elements of the SMS. In other words, without the commitment of the top management, it would be very difficult for the organisation to implement the SMS. The findings of the literature also suggested that clear lack of leadership commitment leads to failures in the implementation of management and organisational systems. This factor plays a significant role in terms of policy, structure, regulation, monitoring and supervision.

- **Managing Change**

Organisations need to have the required strategies and plans in place to manage change. As highlighted, organisational culture and structure are vital when it comes to proposing new interventions and programmes. Therefore, change could have significant negative outcomes if the organisation does not have the right policies and procedures in place to manage the consequences of the change proposed. Introducing sustainability to organisations requires a number of changes at the organisational and individual level which should be identified and managed to avoid any negative consequences that will lead to losses in the human or physical capital of the organisation.

- **Resources**

This element is also vital in the development and implementation stage and is seen as one of the success factors. All types of resources should be present and available to the organisation to ensure that the SMS is successfully implemented.

- **Organisational Culture**

As stated, managing change and organisational culture is key, which should be taken into consideration when developing and implementing environmental management and sustainability programmes. Such programmes need to be implemented over a long period of time which means that continuous support, commitment and communication between all the relevant parties and stakeholders is a must. Therefore, the organisation should ensure that all stakeholders are motivated and supportive of the process of developing and implementing sustainability programmes.

9.6.3 Control and Review Stage

The third phase of the proposed SMS is the control and review stage in which organisations need to reflect upon their performance by carrying out evaluations and assessments. This can be done by different ways as explained below.

- **Internal & External Audits**

Internal and external audits are integral in the successful implementation of sustainability management programmes as they provide the opportunity for companies to monitor their performance against the targets set in the planning stage. External audits are also vital as they provide independent assessment of the organisation's performance, which will also be helpful for organisations that aim to obtain external accreditation. Internal and external audits are significant elements of the proposed SMS as they help the organisation take corrective actions if the objectives and goals are not met.

- **Performance Indicators**

As highlighted in the literature review, performance indicators that are associated with sustainability and environmental management should be adopted by organisations. These indicators will help focus on weaknesses and also improve an organisation's strengths. For Libyan petroleum companies, there is a need for organisations to ensure that performance indicators that are associated with sustainability as proposed by many international organisations are used in the control and review stage.

- **Efficiency & Effectiveness**

There is a clear difference between effectiveness and efficiency and these are vital for the petroleum sector in Libya. Thus, companies need to ensure that they utilise their resources efficiently. This should be based on the clear measures.

- **Outcomes**

Another important element proposed is the need for petroleum companies to perform outcomes that can be measured. Comparison of past to current performance is necessary if new interventions are to have a positive impact on overall performance. The overall aim of the proposed SMS is to improve the environmental performance of petroleum companies as a result of the increasing concerns about waste and pollution generated from petroleum operations.

- **Stakeholder Involvement**

Organisations should also consider the need for stakeholder involvement in the process of control and review, as that will help the organisation identify any lapses or weaknesses in their programmes. The organisation may want to consult with its employees, suppliers and agents to ensure that its current programs are providing significant improvements. This element is also vital as it can be considered as one of the external validation tools which can be used by the organisation to assess its performance.

- **Regulations**

As indicated in the above phases, regulations and laws need imposing to monitor and report organisation’s performance to regulatory agencies so that they can be seen to comply with the legal requirements. Therefore, petroleum companies should ensure that their review process is based on the requirements of the law and that any conditions set by the law such as reducing levels of greenhouse gas emissions.

- **External Inspection**

Among the vital success factors which are important when it comes to the review of the management systems is having independent external inspection from local or international agencies. This would help organisations identify any lapses or weaknesses which can be acted upon as part of the PDCA cycle.

- **Leadership & Management Commitment**

For every aspect of this proposed SMS, leadership and management commitment is critical in the provision of resources and support to the different system elements and hence to the management system implementation as a whole.

- **Technology**

Technology should be considered by petroleum companies when it comes to sustainability management and improving performance. It was reflected in the literature review and in the empirical studies that companies need to use advanced technologies in the process of monitoring their environmental impacts. Therefore, as part of the control and review stage, organisation should rely on technology in the process of monitoring their performance against the set targets and objectives.

- **State Power**

As outlined in table 9.1, state power reflects the need for a strong governance and a regulatory framework that is imposed on petroleum companies that operate in Libya. Without strict regulation and law, petroleum companies will not be committed towards adopting sustainability practices. As it can be seen in the SMS diagram, state power imposes regulations in the planning stage, provides resources and support to companies in the implementation and development phase and also monitors and assesses petroleum companies in the control and review phase.

- **Stakeholder Power**

All stakeholders have a role to play in the process of integrating sustainability practices within the petroleum sector. This role varies from one phase to another as highlighted in the SMS diagram. For example stakeholder power plays an important role in putting pressure on petroleum companies and regulatory agencies to adopt sustainability in the planning phase. In the development and implementation phase, the stakeholders should support petroleum companies in their efforts to implementing sustainability interventions. In the control and review stage, the stakeholders should assess and monitor the work of these companies to help them improve their performance.

- **Community Participation**

Community participation has also been integrated within the proposed SMS as communities are part of the external stakeholders. The level of involvement with each stage of the different phases has been highlighted by “high” and “low”. This means that the community has a role to play in the monitoring and evaluation of the practices of these companies and should help regulatory agencies to monitor these companies. In other words, community participation will play a vital role in improving the performance of organisations, as they act as external monitors.

- **Regulation and Governance**

As explained above, for sustainability to be adopted by Libyan petroleum companies, there is a need for a strong and strict governance and regulatory system which should regulator the work of petroleum companies. Regulation and governance elements are the starting point for the sustainability journey. It was noted in the literature that without a strict regulatory framework, companies will not be encouraged to embrace sustainability. The same points were raised in the empirical studies which suggest that for Libyan oil companies, governance and regulations (which are the role of the state power) are essential for the integration of sustainability practices.

- **Success Factors**

This element of the proposed SMS describes the elements that are necessary for the successful implementation of the sustainability interventions, programs and plans. Each success factor has been described and has been linked with each phase. The absence of these factors means that failures or delays can be expected in terms of the successful implementation of the SMS. These success factors are based on the findings of the literature review and from the empirical studies.

- **PDCA Cycle**

The PDCA cycle is integrated in the proposed SMS. It shows that the SMS' different activities should be carried out in a repetitive manner to bring about continual improvement. Following the identification of the key sustainability interests and goals in the planning stage, comes the "doing" stage in which the organisation translates its written goals into actual programmes. The checking stages involve that collection of information about the actions and programmes so that reviewing can determine whether the goals were achieved or not. If the goals are not achieved, further adjustments are needed as shown in the proposed SMS. All other elements should be considered when the cycle begins again.

9.7 Framework Validation Process

A significant and important element of this study was the validation process of the developed SMS model. It was highlighted by Rykiel (1996) that validation is important in affirming that any proposed guideline or framework is good enough for the its proposed use. In other words, validation helps in further understanding the practicability of the proposed framework. It was also pointed out by Rykiel (1996) that validation is not a required action of every framework development nor it is a method for testing a precise premise. The proposed SMS mode that is presented above was based on a triangulation methodology that involved the collection of data through different sources.

For the purposes of validation of the proposed SMS model, it was decided that semi-structured interviews be carried out with policy makers in the oil and gas sector in Libya. Guest et al (2006) and Yin (1994) indicated that when a point of saturation is reached, interviews should be stopped. Thus, and based on the lessons learnt from the qualitative stage in this study, nine interviews were carried out with stakeholders that were involved in the early stages of this research to examine their suitability and usefulness as well as the practicality of the proposed SMS model.

To ensure a consistent approach is used in the validation process, the same set of questions were put to the interviewees to explore their perceptions and views about the proposed SMS and its content. This included the process of presenting the developed SMS along with the different elements as well as using a list of questions. The interviews were carried out through online-communication channels and phone calls and the process involved asking the participants to answer a set of questions using a Likert Scale along with giving them the opportunity to provide comments for improvement to the proposed model. As argued by many scholars such as Balci and Sargent (1982); Rykiel (1996); Law and Kelton (1991), operational framework validation aims to ensure that the proposed framework is fit for purpose from the perspective of the users. In other words, the proposed SMS model of this study aims to improve the sustainability practices in the oil and gas industry in Libya in which all stakeholders in this sector need to be heard. This affirms that the validation of the proposed SMS should only be done in the context of the research frame and purpose to ensure its validity and reliability (Rao et al., 1998).

It was highlighted by Shannon (1975) that no framework based on one-to-one communication will be correct and that theories and findings in the context of the study should be used to enhance the practicability of the proposal. Thus as argued by Schlesinger et al (1979), validation aims to ensure that any framework or model provides a reasonable range of reliability and precision. The developed model was based on the theoretical underpinnings in the field as well as on the empirical findings of different studies that were carried as part of this research which involved quantitative and qualitative approaches, along with LCA and EIA assessments. The overall purpose of the validation process is to evaluate the acceptability and soundness of the proposed SMS in conjunction with the perceptions of the system users in Libya who are the experts of the current situation and can influence the design of the proposed SMS model.

Hence, a questionnaire survey instrument was used in the semi-structured interviews with the validation process participants. It was decided that a qualitative approach using a pre-designed survey instrument is the most suitable and convenient tool to validate the framework due to the issue of acceptability and limited resources to carry out in-depth application of the model. Moreover, the development of the SMS model was also based on substantial human intrusion as rich and valuable data was gathered through interviews and surveys in different stages of this study. The validation process involved nine participants from the petroleum sector in Libya. Each interviewee was given the opportunity to answer the survey instrument and also comment upon the overall model. The selected participants were chosen based on the fact that they have participated in previous stages. The following table presents the sample profile in the validation phase of this study:

Table 9.2: Sample profile in the validation process

Interviewee Code	Job Title	Years of Experience	Time and Location	Duration of Interview
X01	Line Manager	23	1 July 2016 Skype	52 minutes
X02	Supervisor	20	13 July 2016 Skype	45 minutes
X03	Senior Engineer	16	23 July 2016 Viber	47 minutes
X04	Supervisor	15	2 August 2016 Skype	50 minutes
X05	Head Manager	10	10th August 2011 Phone Call	58 minutes
X06	Middle Manager	16	17 August 2016	1 hour
X07	Safety Manager	24	21 August 2016	45 minutes
X08	Environmentalist	22	27 August 2016	1 hour
X09	Senior Engineer	24	30 August 2016	51 minutes

The participants were selected based on their rich experience in the field as well as showing their interest in the early stages of the study for further involvement in the research process. They also had a wide experience of working in the petroleum sector in Libya which makes them very unique in understanding the context of the study. Furthermore, the participants were very interested in providing their feedback and insights about the developed SMS, as they believe that such an important area of research requires support from all stakeholders and their participation is the least they could do to improve the overall situation in Libya. The questions which were used in the survey instrument that was shared with the participants in the interviews is based on a five point Likert Scale as shown in the following table 9.3. Six themes were used in the survey instrument that were adopted from Kwasnicki (1999) which were:

- Contents

- Context
- Completeness
- Clarity
- Usefulness
- Universality/Applicability

Table 9.3: Validation Survey Tool

Theme/item	Strongly Agree (5)	Agree (4)	Not Sure (3)	Disagree (2)	Strongly Disagree(1)
To what extent do you agree with the contents of the SMS model					
To what extent do you agree the SMS model fits within the Libyan context					
To what extent do you agree with the completeness of the SMS					
To what extent to do you agree that the SMS model is clear					
To what extent to do you agree that the SMS is useful					
To what extent do you agree with the Applicability and Universality of the SMS					
Please comment on possible improvements of the proposed SMS					

9.7.1 Validation Findings

Following the interviews, the findings of the validation process were analysed. It could be argued that the validation process indicated that the developed SMS model is fit and reliable within the study context and that possible positive outcomes can be achieved as a result of adopting the SMS model. As highlighted in the following findings, most of the participants in the validation process were very supportive and in agreement that the proposed SMS model is of high usefulness. None of the participants indicated their disagreement with any aspects of the overall model, but their useful comments were taken into consideration. The following table presents the results for each theme following the validation process:

Theme/item	Strongly Agree (5)	Agree (4)	Not Sure (3)	Disagree (2)	Strongly Disagree(1)
To what extent do you agree with the contents of the SMS model	7	2	0	0	0
To what extent do you agree the SMS model fits within the Libyan context	8	1	0	0	0
To what extent do you agree with the completeness of the SMS	6	1	1	1	0
To what extent to do you agree that the SMS model is clear	7	1	1	0	0
To what extent to do you agree that the SMS is useful	8	1	0	0	0
To what extent do you agree with the Applicability and Universality of the SMS	7	2	0	0	0

As noted, most of the participants in the validation process are in agreement that the developed SMS model is of high importance and fit within the Libyan context which is the overall purpose of this proposed SMS model. Moreover, it was noted that all of the participants agreed that the developed model is clear in terms of its contents and approach. Thus, this could suggest that the developed model is simple and easy to use by the stakeholders in Libya. The participants were in full agreement on most of the themes as presented in table 9.3 which indicates that such a model provides a systematic and integrated approach to sustainability management in the Libyan petroleum industry. In other words, it could be argued that the developed SMS model is compatible with the Libyan context and offers a practical approach to sustainability management because of its clarity and universality which was proven in the validation process.

The research participants were also asked as part of the validation process to comment and make suggestions for improvements of the developed model. Their notes were analysed following the interviews and they were mainly concerned with the issue of ensuring that a regulatory framework is established that is solid and transparent. Moreover, the participants raised the importance of sustainability reporting by companies through annual reports and sustainability indicators which will encourage companies to publish their annual performance reports so that stakeholders can be fully aware of the different activities and actions taken by the companies.

Furthermore, it was highlighted by the participants that professional training and certifications are vital in ensuring that competent personnel are employed by oil and gas companies in Libya to monitor and implement international standards and approved codes as well as carry out technical investigations. It was also indicated by the participants that methodological approaches such as Life Cycle Assessment and Environmental Impact Assessment should be embedded in the strategic management approaches within oil and gas companies. In particular, the participants were concerned about the technical skills required which enable companies to carry out their own investigations without the need of employing and recruiting external consultants and companies to carry out these investigations.

Participants raised concerns about the international role in monitoring the environmental impact of companies. They believe that multinational companies should work in collaboration with domestic companies and local non-governmental organisations to raise awareness about sustainability and environmental management. Thus, it was important that such considerations are taken into account in the proposed model so that a more comprehensive approach is achieved.

More importantly, it was highlighted by the research participants that further support and rewards from the policy makers and regulatory agencies are introduced to encourage individual companies to improve their environmental monitoring and performance as that will add more value to the company and improves its public image. This is a vital issue that was raised by the participants. Reward systems at the national level should be introduced by regulatory agencies or by the National Oil Corporation in Libya to ensure that companies are committed towards improving the performance.

To sum up, the validation process proved that the developed SMS model for the petroleum industry of Libya is of high value and importance as it provides a systematic and integrated approach to sustainability management in this vital sector. Comments and suggestions for improvement were made by the research participants which were mainly associated with professional certifications, training and rewards systems, as well as the role of multinational companies in raising awareness about sustainability at the domestic level, working with national and local NGOs to improve performance. The following section provides an amended version of the developed SMS model based on the outcomes of the validation study.

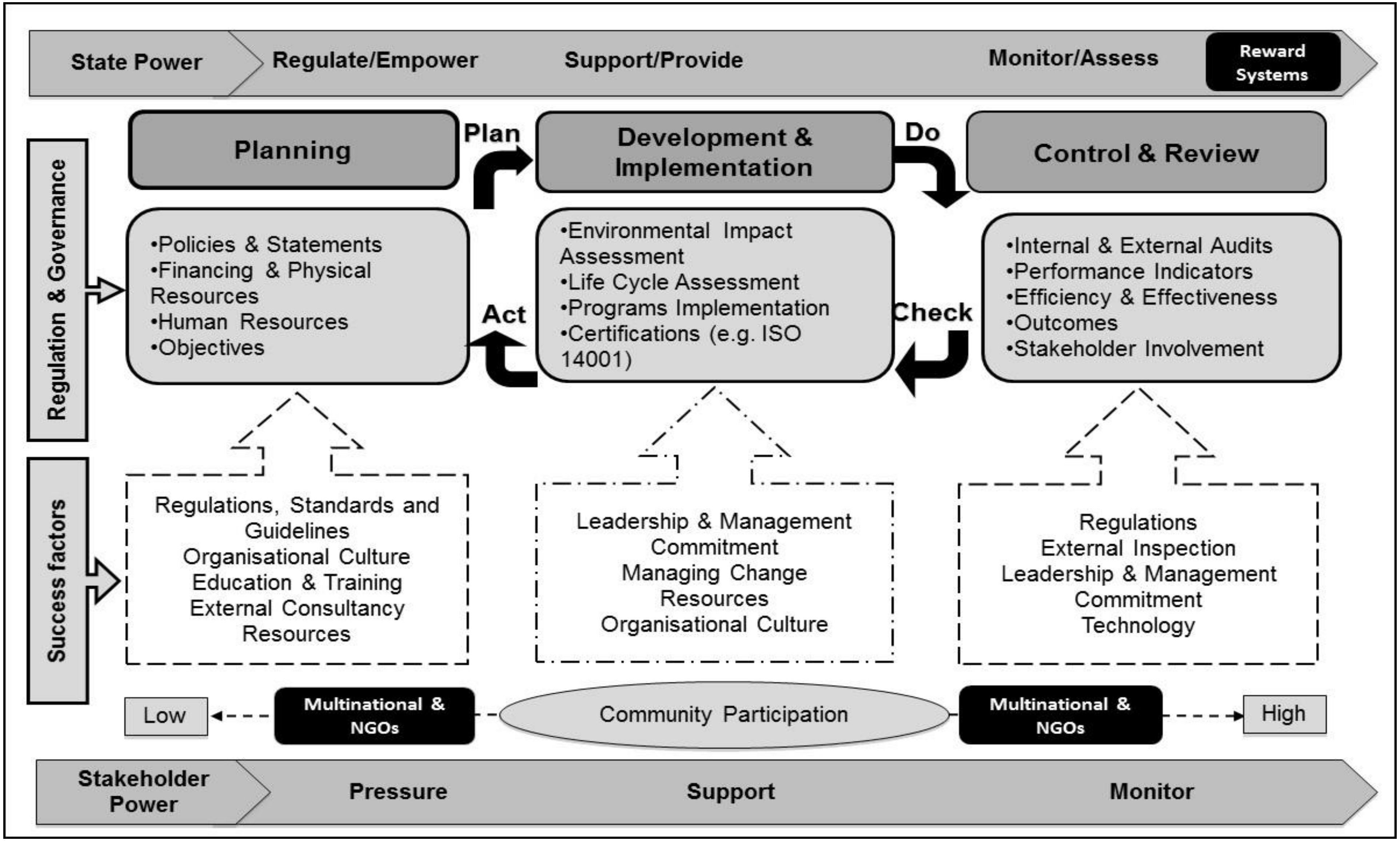

Figure 9.3: Revised Sustainability Management System for Libyan Petroleum Sector

9.8 Benefits of the Developed SMS

The researcher believes that for petroleum companies in Libya to successfully implement sustainable business practices, a holistic principle of sustainability needs to be understood and integrated into the strategic planning of the organisation. Sustainability needs to be seen as an important element in strategic planning to improve and enhance the operational performance and should not be viewed as add-ons. Taking this in mind, the proposed Sustainability Management System (SMS) for the Libyan petroleum sector emphasises the concept of strategic sustainability in which many different stakeholders need to show commitment towards adopting sustainability.

The proposed system encourages companies to move beyond meeting compliance requirements to a more sustainable future that will benefit the system as a whole. Petroleum companies need to develop a more long-term focus on the value of sustainability by examining the threats and opportunities as well as strengthening their relationships with the external environment. This will help companies to perceive sustainability as an organisation-wide goal which incorporates each and every aspect of the business as well as its relationships with the external environment. For this purpose, the proposed SMS model encourages companies in Libya's oil sector to adopt a system thinking approach in which they need to value the role that each stakeholder plays towards adopting sustainability. The proposed SMS calls for a top-down and a bottom-up approach to implement sustainability practices in the oil sector. The expected benefits from adopting the proposed SMS can be described as the following:

- **Cost Reduction**: petroleum companies which intend to adopt the proposed system will have to undertake several changes as part of the planning process. In other words, sustainability focuses on the economic, social and environmental aspects in which all organisations must develop new systems to reduce their negative impacts. For example, companies will have to take some operational measures such as adopting recycling systems, using low energy light bulbs, using recycling materials or using solar-powered water heating systems. These initiatives will have to be considered as part of the company's transformation system towards sustainability as these initiatives focus on the environmental dimension of sustainability. The economic dimension of sustainability will also be positively influenced as part of these initiatives. Thus, the proposed SMS leads to cost reductions and encourages companies to further improve their sustainability practices.

- **Public Image and Relations**: the proposed SMS model will help petroleum companies achieve positive public relations and an improved business image with all stakeholders. The proposed SMS emphasises the role of community participation and stakeholders' power in supporting, monitoring and reviewing the sustainability performance of petroleum organisations. Hence, it could be argued that SMS model can be considered as a source of competitive advantage to these companies.
- **Employee Satisfaction:** there is a great emphasis on the role of the human capital in achieving sustainability in the petroleum sector. Thus, through the proposed SMS mode, organisations need to invest more in their human capital and provide the required training, education and continuous development opportunities. This will have a positive influence upon the employee's satisfaction which will consequently lead to positive organisations performance.
- **Regulatory Compliance:** the proposed SMS model encourages companies to develop systems that are in line with the regulatory and law requirements. This will ensure that all petroleum companies operate under the rule of law and will improve their business image at local and international levels. This could also open the door for investment opportunities with local and international investors.
- **Improved Operational Performance:** the proposed SMS models makes it explicitly clear that petroleum companies need to adopt technical tools and advanced technologies as well as implementing environmental management systems as that will demonstrate best practice. Petroleum companies will have to disclose their data on environment, governance, social issues and energy consumption as part of their sustainability practices. Achieving certifications and accreditations from recognised international bodies such as the ISO or BSI will demonstrate that these companies are committed to continual improvement.

- **Holistic Approach to Sustainability:** the proposed SMS model provides a holistic approach to sustainability management for the petroleum sector in Libya. It emphasises the role of state power in issuing relevant regulations, laws and standards that are needed to establish efficient sustainability management systems. It also focuses on the role of education and training as well as monitoring and evaluation which are very critical to the success of any new management interventions. Thus, the proposed model provides a collective approach to sustainability management that is oriented to the Libyan oil sector as per the findings of the empirical studies.

9.9 Applying the SMS

This proposed SMS model has been developed to meet the needs of the petroleum sector in Libya. The development stages of the model involved the collection of multiple types of data from different sources to ensure that it meets the local and international requirements. Furthermore, this proposed model can be applied at regional level especially in countries that share the same cultural structure with Libya. In order for this proposed SMS to be applied in the Libyan context, the following points should be taken into consideration to ensure that the SMS is generating positive benefits to Libyan petroleum companies:

- The petroleum sector in Libya requires a robust regulatory and governance framework that should be proposed by the state power as indicated in the developed SMS. Petroleum companies should be forced by law to establish and implement sustainability practices as part of their strategic planning. The regulatory and governance framework also requires petroleum companies to adopt EIA and LCA as part of their strategic planning and management. Hence, the initial and most important step that should be taken when adopting this proposed SMS is the provision of a regulatory framework that will encourage and force petroleum companies to adopt sustainability. The regulatory framework will also require companies to report their operational performance using certain indicators.
- Petroleum companies will need to carry out extensive examination and assessment of their current performance issues on the social, economic and environmental dimensions of sustainability. This will be part of the Planning phase as proposed in the SMS model in which petroleum companies will

have to specify their sustainability issues, goals and objectives. For this to be implemented, the leadership and management of petroleum companies need to show high levels of commitment towards upgrading the organisational structure and integrating sustainability as part of the strategic planning process. This means that all stakeholders need to be involved. This was taken into consideration when developing the SMS.

- The provision of physical and human resources is vital to the successful adoption and application of this proposed SMS model. Sustainability requires organisations to carry out some important changes in the organisational structure, operations and also in terms of measuring performance. Furthermore, there are certain tools, techniques and technologies that need to be adopted so that organisations can capture the full benefits of sustainability. Hence, it was clearly highlighted in the proposed SMS that resources are vital in achieving sustainability. This includes the provision of training and education opportunities, provision of technology and finances as well as seeking external support. Such elements should be specified as part of the planning phase.
- A key and integral element that should be taken into account by the top management and leadership of petroleum organisations is that sustainability is all about stakeholders' involvement. These companies operate in different locations in Libya in which they need to establish relationships that are based on mutual trust and respect. The social dimension of sustainability requires organisations to provide social good to local communities. Hence, community participation was important when developing this proposed model. All stakeholders including the regulatory agencies, media, customers, suppliers and local communities should be involved as part of the strategic planning process.

9.10 Limitations of the SMS

With regards to the limitations associated with the application of the proposed SMS model, there are some aspects which can be considered as limitations of the overall usefulness and appropriateness:

1. Developing a holistic approach to sustainability management may not be feasible as the field of sustainability management is still emerging especially in developing countries. Hence, the applicability of the proposed SMS can only rely on the existing literature and available data.
2. The proposed SMS model was developed for petroleum companies that operate in Libya without specifying whether these companies are Libyan or foreign companies that operate in the country. Hence, some might argue that there is already some application of sustainability practices by foreign companies that operate in the country which might influence the generalisability of the proposed model.
3. The proposed SMS's applicability can also be influenced by the implementation barriers and challenges that are discussed in the literature review. Such barriers include lack of commitment, organisational culture, lack of required infrastructure, lack of required resources and poor accountability system. Hence, such factors may have a direct impact upon the applicability of the proposed SMS.
4. Timeliness in relation to the validity of the proposed SMS; there are no conceptual frameworks that existed before this research study began which was very challenging to the researcher to develop a country-oriented model based on empirical data. This leads to questions in relation to the time factor in terms of the applicability of the model. In other words, the SMS elements may require alteration if state power issues relevant legislations to adopt sustainability or embedding EIA and LCA as part of the strategic planning of petroleum companies.
5. Generalisation of the proposed SMS has not been tested and further research is needed to validate the use of the proposed SMS and its applicability within different national contexts.
6. Cost-effectiveness in relation to the adoption of the proposed SMS is not assessed fully which might raise questions about the SMS's ability to improve financial performance.

9.11 Discussion

The proposed Sustainability Management System for the Libyan petroleum sector aims to provide a holistic and systematic way for the petroleum companies in Libya to review and improve their operations, so that better performance at the environmental, social and economic levels can be achieved. The proposed SMS will help the organisations meet their compliance requirements and also ensure that sustainability becomes part of the organisational culture and an integral element of the strategic planning process. Specifically, the proposed SMS model aims to enhance the environmental performance of petroleum companies as there are increasing concerns about the environmental impacts of the operations involved in the oil and gas industry. Considering these increasing concerns, it can be concluded that a systematic approach to sustainability management is urgently needed in the Libyan sector.

Currently, the Libyan petroleum sector operates within a weak regulatory framework. For this reason, the proposed SMS model emphases the governance and regulation aspect as part of the process. While this is the case in developing countries such as Libya, many developed countries have passed laws and regulations that organise and monitor the work of the petroleum sector to reduce the environmental impact. Another essential point that was highlighted in the proposed SMS model is the need to have formal monitoring and evaluation process as per the requirements of the law.

Numerous studies have demonstrated the importance of having a systematic approach to environmental management which contribute to the development of many environmental management systems that are currently being adopted by companies in different sectors. However, an integrated approach to sustainability enables organisations to improve their overall performance at all levels and thus, the proposed SMS model emphasises the need to involve stakeholders at all levels. Commonly, organisations operate in social context which requires them to comply with norms and beliefs that exist in the society.

Additionally, organisations need to ensure that they have access to resources in order for them to adopt sustainability practices. Hence, in the proposed model, it was clearly stated that organisations need to identify and manage the relevant stakeholders as they have a role to play in transforming the overall culture towards sustainability management. Furthermore, it was pointed out in the proposed model that organisations should continuously monitor their performance using the PDCA cycle to ensure they comply with the compliance requirements and also meet the expectations of their stakeholders at all levels. On the other hand, due to the poor regulatory framework that exists in Libya, adopting the proposed SMS model may prove to be difficult in the short term without a clear and solid commitment from policy makers at the state level.

Essential to this is the need to have solid management commitment to ensure that sustainability practices are incorporated within the organisation's strategic management and planning process. Without the commitment, leadership and support from the top management, sustainability efforts will not be successful as they are the only ones who can establish, encourage and promote sustainability practices as well as provide the required resources.

It can also be assumed that the lack of awareness and understanding of sustainability in Libya may lead to different interpretations which might also influence the motivations behind implementing sustainability systems. This could means that some might consider it as a risk or a burden on the organisation while others may perceive it as a vital element in achieving goals. For this reason, the proposed model focuses more on the need for the provision of training and education especially at the planning phase in which the sustainability issues and goals need to be identified. Otherwise, there will arise difficulties among the organisation in terms of prioritising the initiatives, plans or strategies which could lead to negative impacts on the overall performance.

Adopting sustainability practices requires organisations to ensure that resources are available and allocated to long-term objectives to ensure sustained and continuous progress. The researcher believes that apprehensions may be created as a result of the poor understanding of the benefits and requirements to adopt sustainability. For this reason, effective change management strategies and plans need to be put in place to ensure that any interventions take place with the minimum resistance from the stakeholders involved. Changing routines and practices may not be totally accepted by all parties involved, thus, clear change management policy should be in place as part of the implementation process. It could be argued that if there is no firm and robust plans in place that take into consideration all the external factors such as the availability of resources and financial capabilities, any improvement efforts will be exposed to failures as the level of engagement and commitment from all parties will drop. Another essential point that was highlighted in the proposed model is the role of the community and external parties in monitoring the progress of sustainability management systems within the petroleum sector.

Based on the findings of the literature review, it was observed that implementing environmental management systems requires a financial commitment to cover all the costs associated with provision of training, technology, equipment, storage costs, documentation and auditing services. Therefore, for the proposed SMS to be successful and beneficial, it was pointed out that resources are considered as success factors in all the phases of the developed model. The lack of supporting technology as identified by the empirical studies conducted in Libya could be seen as a barrier that might hinder the adopting of the proposed SMS. Therefore, financial resources that are needed to provide the required technology, expertise and also training is vital. Petroleum companies need to invest in recycling systems, monitor sensors and power saving fittings as well as monitoring devices to track and measure environmental impacts caused by the different operations.

Commonly, the implementation of sustainability systems is time-consuming as highlighted in the literature chapters. This goes back to the need to focus on the PDCA cycle as a core concept of implementing the proposed SMS model as the process of implementation should be seen as an ongoing process which requires continual management support for it to be efficient.

It could be argued that the proposed SMS model offers companies the opportunity to discuss and assess sustainability performance alongside other business metrics which will raise their profile and credibility among all stakeholders. Thus, the researcher believes that the proposed SMS model can help organisations move down the path to sustainability with minimum challenges as it focuses on the need to integrate different functions and build strong relationships with all stakeholders. Equally important is the need to ensure that continuous management support and commitment is present throughout the whole journey as that will influence the perception of other stakeholders towards sustainability. Organisations can adopt environmental standards to drive alignment and consistency among the business functions as well as creating a culture of continuous learning and improvement.

A central theme of the proposed model is need to have a robust monitoring and evaluation system in place that aims to help the organisation learn from its lapses and weaknesses. Likewise, organisational culture has been described as one of the barriers that might hinder the implementation which suggests that a culture towards sustainability needs to be created at the institutional level for it to be accepted by other stakeholders. The state should play a more powerful role when it comes to the management of oil companies' environmental performance. In other words, there should be a robust legal framework in which petroleum companies are required to implement, monitor and report their sustainability practices. For this reason, the proposed SMS model was based on the provision of a regulatory framework that is compliant with the international agreements and regulations to support and empower as well as enforce companies to integrate sustainability thinking.

To sum up, it could be assumed that the proposed SMS model provides the opportunity for Libyan petroleum companies to improve their environmental social and economic performance by following a holistic and systematic approach. This is because the proposed model emphasises the need to involve all the stakeholders to ensure that each member’s goals are aligned with those of the organisation. Each organisation will have the ability to identify the barriers and challenges that face them at each stage following a rigorous assessment of their performance using different tools as outlined in the proposed SMS model.

9.12 Summary

The purpose of this chapter was to present and discuss the proposed Sustainability Management System (SMS) that was developed for the Libyan petroleum sector. The chapter presented the proposed model following a brief discussion on the development process that was undertaken to come up with the model. The SMS model’s elements have been identified and described along with the benefits and limitations of the developed SMS model. A discussion on how the model can be applied has also been including along with a general discussion on the applicability and usefulness of the proposed model and its relevance to the published literature.

The proposed SMS model is the first of its kind that provides a holistic approach to sustainability management for the petroleum sector in Libya and provides an insightful tool for policy makers in the country to identify the value of sustainability. It also guides them towards adopting a systematic approach to implementing sustainability practices in the petroleum sector. The developed SMS model is going to provide a number of benefits such as improving the organisational performance at the operational and financial level, improving public relations and image as well as enhancing employees' satisfaction and commitment.

Chapter 10
Conclusions & Recommendations

10.1 Introduction

The above chapters have detailed the research design, findings and analysis of the results along with presenting and validating the sustainability management system for the Libyan petroleum sector. The aim of this chapter is to briefly present and discuss the key conclusions, contribution to knowledge and the implications of the study. The chapter also presents a list of recommendations and discusses the study limitations and providing some ideas for future research.

10.2 Restatement of Research Objectives

The aim of this research was to develop a sustainability management system (SMS) for petroleum companies through critical investigations of sustainability related impacts, issues and the identification of barriers to the existing sustainability approaches in order to enhance sustainability performance, minimise environmental impacts and overcome implementation barriers. The objectives of this research study were as following:

- To critically review the literature on the concept of sustainability, environmental sustainability and environmental management systems as it applies to the petroleum industry.
- To empirically investigate the sustainability situation at the Libyan petroleum sector in order to identify and assess sustainability related issues and environmental risks.
- To identify and critically analyse the barriers and success factors of implementing sustainability approaches and environmental management systems in the Libyan petroleum industry.
- To explore the extent to which sustainability is being practiced in the oil and gas industry in Libya through quantitative and qualitative approaches and using case-studies.

- To develop a Sustainability Management System (SMS) for petroleum companies operating in the oil and gas industry in Libya.
- To evaluate and validate the developed SMS and create guidance to support its implementation in the Libyan petroleum industry.

This study has adopted a triangulation research methodology in order to achieve the above aim and objectives. The study adopted qualitative and quantitative tools along with technical methodological approaches through the use of case-studies in Libya. Semi-structured interviews, questionnaire survey, LCA and EIA were all used in order to develop an integrated sustainability management system for the petroleum sector in Libya. Following the development of the system, there was a need to validate the system through the systems users in which the results were very supportive of the developed SMS model.

10.3 Conclusions

With reference to the overall aim and objectives of this study, significant findings were accomplished. Firstly, the Libyan petroleum industry was explored in great detail as highlighted in Chapter four in which it was found the significant impacts are caused along with a lack of a systematic approach to environmental management and sustainability in the sector. The current environmental impact of the sector was assessed and the stakeholders, policy makers and employee perspectives on the issues, challenges and barriers that face the petroleum sector in Libya from adopting sustainability practices were investigated through the use of multiple methods. Thus, based on the findings and analysis of the data that was generated in this study, the overall conclusion is that the modern approaches and advances in environmental and sustainability management worldwide and in particular to the use of technical methodologies such as LCA and EIA have not penetrated the Libyan petroleum sector.

It was also concluded that current managerial processes and practices in oil and gas companies in Libya follow a paternalistic and bureaucratic organisational structure which influences the adoption of advanced technologies and technical methodologies. It could also be concluded that due to the absence of flexible organisational structures and the absence of a rigid regulatory framework in the country, the oil industry’s environmental impact was very excessive.

The findings of the different study phases indicated that environmental management and sustainability are not at the top of the agenda of policy makers in the country due to the lack of awareness, lack of resources, absence of competent personnel and lack of advanced technologies. More importantly, the lack of a regulatory framework that organises, monitors and supports domestic companies to enhance their environmental performance. The study findings also reported that several and multiple complex factors have contributed to the weaknesses in environmental management in the Libyan petroleum sector. Hence, the researcher has developed an integrated and systematic approach to sustainability management in Libya based on the findings of the empirical studies.

It is argued that the current approaches adopted by oil and gas companies are not matched with the developments in the sustainability field in other developed countries nor do they fit with the managerial or governance processes. LCA results show that there is a high environmental impact caused by the Libyan petroleum industry, which requires the implementation of a Sustainability Management System to minimise these impacts. Furthermore, the EIA results show the level of risk of the environmental impacts is high. The high risk impacts were mainly air emissions (GHGs and hazardous H_2S) and oil spillages. The extreme amount of gases exhausted from the heavy duty machinery and flaring were significant. Therefore, the study proposed a dynamic model that offers an integrated approach to sustainability management in Libya.

The proposed Sustainability Management System (SMS) gives a comprehensive approach to sustainability management in Libya in which it incorporates several main components, activities and outcomes. It also takes into account the internal and external factors which increases the scope of government and stakeholders' participation in the process of sustainability management in the oil and gas sector in Libya. The proposed SMS model can also be widely utilised in other developing countries that witness environmental impacts as a result of the oil and gas industry. Specifically, the proposed SMS model aims to enhance the environmental performance of petroleum companies as there are increasing concerns about the environmental impacts of the operations involved in the oil and gas industry.

10.4 Contribution to Knowledge

This research is in line with the definitions of originality that were introduced by Hart (1998) which include; not been done; new in style, character, substance or form; without copy or imitation; authentic, the result of thought and produced using researcher' own faculties. Moreover, Nottingham Trent University (NTU) (2012) outlined that a PhD degree should be awarded to researchers who have proven to carry out an independent research project using appropriate research methods in which new knowledge is created in the chosen field.

It was highlighted by Phillips and Pugh (1994) that originality is not only restricted to rocket science but to the researcher's ability in understanding and investigating a subject area in a specific field of study to generate new ideas and knowledge. Hence, this study's main contribution arises from the absence of validated knowledge about sustainability in the petroleum sector in Libya. Following the comprehensive literature review, there was a clear gap in the literature about sustainability in the petroleum sector in Libya which this study has explored. There was also lack of sustainability related research studies in Libya in general and the oil and gas sector in particular. There was also an absence of an integrated and systematic approach to sustainability management in the petroleum industry in developing countries and that existing EMS systems do not provide a holistic approach to sustainability planning, implementation and control.

The main contribution of this thesis can be summarised in the following statement:

- This research study contributes to knowledge by providing a clear understanding of the problems and challenges of sustainability management in petroleum companies in Libya with experts in the field as well as examining the success factors that could improve the extent to which sustainability is being practiced in the petroleum sector in Libya. Original new understanding of undiscovered key sustainability related issues in the Libyan oil and gas sector were gained through a first time used empirical investigations (i.e. primary data sources- interviews, survey questionnaire and case studies).
- The development of a conceptual Sustainability Management System for the Libyan Petroleum industry based on the empirical studies is an original

contribution to knowledge. The developed system was based on empirical investigations in which data from multiple sources was used to develop it.

- The validation of the operational SMS model through users is a significant contribution to knowledge. The developed system will minimise the environmental impact of the petroleum operations and activities in Libya and could be also used in other developing countries.
- The critical synthesis of the published knowledge about sustainability and its significance in the oil and gas sector is a vital contribution to knowledge.
- No previous published studies have been carried out in Libyan petroleum fields using LCA and EIA. The study affirmed and emphasised the value of LCA and EIA in the planning and control stages of different petroleum operations.
- The study contributes to the academic and theoretical field through the publication of two peer-reviewed journal articles, five conference papers and two poster presentations, in addition to a book chapter.

The critical analysis of the current thinking on sustainability management in the oil and gas industry has enabled the researcher to develop an operational SMS model for the petroleum sector in Libya so that the environmental impact of the operations associated with this industry are reduced to minimum levels as per the international standards and agreements. The developed model highlights the importance of integrating different regulatory and policy functions with organisational and individual factors. It also emphasises the importance of raising public awareness about the issue through stakeholders' involvement at all levels. More importantly, the developed model emphasised the need to enhance the technical and technological skills of current managerial processes within oil and gas companies and that sustainability should be embedded within the corporate policy and also at the national agenda of governments.

In particular, the main contributions of this study can be summarised below as:

- The research study is the first study that developed a Sustainability Management System for the Libyan petroleum sector which can aid the industry to minimise its environmental impact and also can help policy makers to understand the significance and value of sustainability. The proposed SMS model can also be used by other researchers as a point of reference to evaluate and improve sustainability practices in other sectors.

- The study had also reviewed the relevant frameworks and models that are used in sustainability management and identified their weaknesses and success factors.
- This study is the first that focuses on the issue of sustainability in the petroleum sector in Libya, and thus, could provide a theoretical contribution to the body of literature regarding sustainability in developing countries and in particular to the oil and gas sector.
- The study has identified and grouped many different factors that could hinder the implementation of sustainability systems within the oil and gas sector using multiple sources of evidence such as the need for regulations, technology and culture change. It was found in the literature that several factors hinder the adoption of environmental management systems but most of these studies and findings are based on studies that were carried out in Western and developed nations. Hence, the findings of this study provide some specific factors that are relevant to the Libyan context.
- It is anticipated that the findings of this study can be of interest to academic and professional communities as well as it will add value to the practice and theory and in particular to Libyan policy-making. In other words, the study contributes to the need to develop professional and policy guidance for sustainability in the petroleum sector where employees should be encouraged to share their concerns about the environmental impact of their organisation's policies and practices and raise the attention of the management and leadership to sustainability management in the oil sector.
- Finally, the study aimed at adding to the body of knowledge of Life Cycle Assessment and Environmental Impact Assessment and their applications in developing countries such as Libya.

10.4.1 Theoretical Implications

This study adds to the theoretical debate on sustainability management in the oil and gas industry by providing empirical data on one of the developing countries that is rich in oil and gas. Hence, the theoretical contribution of this study is of high significance as a number of manuscripts and conference papers were published as a result. This generates more knowledge about this field and helps researchers and practitioners to understand the current status of research on sustainability in developing countries. It also adds to the theoretical scene a validated system that could further be tested and analysed through different case studies in the future in Libya or elsewhere.

10.4.2 Practical Implications

The practical implications of this study are important as the scope of the study was very practical and associated with several case-studies. In other words, the study's developed system will play a significant role in improving the organisational performance and in particular the environmental management practices in oil and gas companies. The use and application of LCA and EIA highlighted that oil and gas companies should be encouraged and advised to adopt such methodologies to examine their environmental performance. More importantly, the study provides a validated, integrated and systematic approach to sustainability management that will further improve performance at oil companies.

10.4.3 Policy Implications

This study has significant policy implications as it highlighted the value and importance of having an integrated approach to sustainability management. Several policy makers were interviewed as part of this study who contributed significantly to the findings and development of the SMS. Thus, the study will lead to policy changes in the process of environmental and sustainability management in the oil and gas industry. In particular, the policy implications could be attributed to the development of new guidance and codes of practices in relation to the use of LCA and EIA in the upstream and downstream operations.

In summary, this study has provided an insight about the importance of managing sustainability in the oil and gas sector from the perspective of a developing country such as Libya. It could also be concluded that this study provided a validated SMS model which can be used as a point of reference.

10.5 Recommendations

As suggested by Bryman (2008), investigation findings and research studies should propose recommendations that lead to improvement based on the study findings.

Hence, this thesis presents the following recommendations that are aimed to improve the sustainability management in oil and gas companies:

- The state has a significant role to play in promoting sustainability practices and increasing public awareness about the issue of the environmental impacts of oil and gas companies in the short and long-term. Thus, the National Oil Corporation of Libya should ensure that a regulatory framework is developed by the legislative authorities in the country which puts strict rules and pressure on oil and gas companies to comply with certain laws and rules.
- All relevant stakeholders including suppliers, customers, public, non-governmental organisations, oil and gas companies, multinational companies and regulatory agencies should be involved in the process of raising awareness and monitoring performance of oil and gas companies.
- In order for the efficient implementation and adopting of the developed SMS model, significant investments are needed at the organisational and individual levels. In other words, staff capacity development and training programmes are essential to enhance the skills and knowledge of all those involved in the process of developing and monitoring management systems. The authorities are also encouraged to ensure that needed resources are available (mainly financial resources).
- There should be a strict penalty system in place so that oil and gas companies continuously monitor and evaluate their environmental impacts. The proposed SMS encourages companies to adopt the PDCA cycle to ensure that their practices achieve the intended outcomes.
- Accountability, governance and transparency are very important values that need to be embedded within the organisational cultures of such organisations to ensure they can be held accountable for wrongdoings.
- There is a need for multinational companies that operate in Libya to collaborate with domestic companies, NGOs and with the NOC to help in the process of knowledge and expertise transfer. Such collaboration requires huge investments in infrastructure and communication systems to ensure that strong relationships are built between key stakeholders.

10.6 Research Limitations

It must be acknowledged that no study is perfect or free of flaws. However, researchers continuously aim to reduce the external factors that might influence the study design and subsequently the quality of study findings. Such research studies involve significant hardships and difficulties especially for first time-researchers who might not have the right skills and capabilities to carry out in-depth studies. Resources could also pose significant limitation to the study along with funding issues. This study was carried out by a single researcher supported by supervisors and it encountered significant difficulties such as funding, access and also personal medical issues to the researcher and his family. Therefore, it is important that such limitations are presented:

- Qualitative Interviews

Several interviews were carried out with different participants, but not all interviews were recorded which might limit the researcher's capability of analysing the qualitative data. Furthermore, interviews were carried out at different locations and through different channels which might influence the quality of the collected and analysed notes. This study was an exploratory type in which interviews contributed significantly to the findings.

- Generalisability

It could also be argued that the generalisability of the findings might be limited as the study was only carried out in the Western part of Libya due to access and security issues in the East. However, the NOC is responsible for all the oil and gas companies that operate in Libya and most of the employees have received the same standards of training in the country's national petroleum institutes that train technicians to work in the oil and gas sector. Generalisability to other developing countries may be limited due to cultural differences especially in countries in Central or Western Africa and Latin America. Thus, the generalisability of the findings of this study may be limited only to countries that share the same strengths and weaknesses, cultural aspects and managerial systems as Libya.

- Time

This study was done in four years of registration during which the researcher encountered several problems that led to extensions. However, the researcher worked hard to ensure that field-visits were carried out to further support the findings and understand the overall context of the study.

- Access

The researcher intended to carry out further methodological examinations and LCI data collection using LCA and EIA in other parts of the country, but due to rising security problems, this was not feasible. This limited the scope of the LCA investigations.

10.7 Future Research Ideas

Due to the limited published literature on sustainability and environmental management in Libya and in the oil and gas sector specifically, the following could be explored further by future research:

- To examine the extent to which sustainability practices are being adopted in foreign companies that operate in developing countries
- To examine the relationship between leadership and management styles on the adoption of sustainability and environmental management systems
- To explore the barriers that might hinder companies in developing countries from adopting EMS and adopt international standards
- To investigate the extent to which employees and stakeholders are involved in the process of strategic planning and decision making in oil and gas companies
- To explore the extent to which LCA and EIA are being implemented in other sectors rather than just the oil and gas sector in Libya
- Investigation of greenhouse gas emissions and in particular CO_2 emissions from the oil and gas industry in Libya.
- Comparison of sustainability practices in developing and developed countries.

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Appendix 1 – Interview Schedule & Sample Transcript

Interview Schedule

Verbal consent

I am doing a PhD at Nottingham Trent University. The PhD topic is about the developing a sustainability management system for the Libyan petroleum sector. You have been selected as a key informant to this project because of your valuable experience and knowledge with the Libyan petroleum sector. Your views and opinions are very important to me. I would like to assure you that the information gathered will be handled confidentially and for the purpose of this research only. Participation is voluntary and participants' identities will remain anonymous.

Thank you in advance for your co-operation.

Interviewee Information:					
Code	Name	Position	Organisation	Gender	Age
Interview Information					
Time	Date	Location	Duration	Remarks	

No	**Q & A**
1	Can you please tell a little bit about your – major features, responsibilities etc.?
2	To what extent do you think that petroleum companies in Libya are meeting the international standards in regards to reducing gas emissions? Why such companies are failing in meeting international standards?
3	Based in your experience, do you believe that petroleum companies in Libya are environmentally-friendly? Why or why not?
4	In your view, what are the actual reasons behind the environmental impacts of oil companies in Libya? Do you think these impacts are significant?

5	Do you believe that a better training for senior managers would help in minimising the environmental impacts of petroleum companies? Is top management commitment important in reducing environmental impacts?
6	In your view, what are the main challenges that face petroleum companies in Libya from implementing sustainability management systems and standards? How can they overcome such challenges?
7	Do you think that stakeholders' involvement including the public, non-governmental organisations, environmental agencies and companies is important in achieving better environmental performance? How can they be involved?
8	In regards to the government role, do you believe that the government has a role to play in helping companies adopt environmental management systems? Can give me examples?
9	Is the current technology sufficient to safeguard and protect the environment from petroleum activities and operations? Why or why not?
10	Are you familiar with methodologies such as Environmental Impact Assessment and Life Cycle Assessment? Can you tell me if they are useful for Libyan companies?
11	The final question is open-ended. It asks for any comments or suggestions that the interviewees might wish to express, which were not addressed in the earlier questions. In addition, it gives the interviewees the opportunity to expand on any of their previous responses, adding points as they deem necessary.

Sample Transcript

By Ammar Irhoma

Interviewee Information:				
Code	Name	Position	Organisation	Gender
IN3	Anonymous	Manager	NOC	M

Interview Information			
Time	Date	Location	Duration
10:00 AM	03/01/2014	Tripoli	38 minutes

No	**Q & A**
1	Can you please tell a little bit about your – major features, responsibilities etc.?
I work as a line manager within the NOC operations department. I am responsible for managing 25 employees who are located in different regions. I am also responsible for coordinating with our companies in terms of staffing, production and maintenance works.	
2	To what extent do you think that petroleum companies in Libya are meeting the international standards in regards to reducing gas emissions? Why such companies are failing in meeting international standards?
Well, I believe that petroleum companies in Libya do not fully follow the international standards in particular to gas emissions and honestly we don't have indicators which we can measure. I think this is because of lack of regulations and monitoring from certain agencies and bodies. The problem is very serious and we should have laws in place to meet these standards with climate change now increasing.	
3	Based in your experience, do you believe that petroleum companies in Libya are environmentally-friendly? Why or why not?
I have been in the industry for over 20 years now and I have worked in many parts of Libya. I think we still have a lot of work to do in order to reduce the environmental impact. We lack technology and training as well as lack of regulations. The company are not environmentally friendly because we don't have a system at the NOC in which can put pressure on companies to be environmentally friendly.	

4	In your view, what are the actual reasons behind the environmental impacts of oil companies in Libya? Do you think these impacts are significant?
I believe that because we explore and produce oil as well as gas, so our impacts are high, we think that because most of our operations are in the desert that tight not affect the environment but I think this is wrong. Our impacts can be significant to the air quality, to the land and to the sea as well as to our people who work in these fields. Many reasons include poor technology and old systems of work. We just care about pumping oil form the ground.	
5	Do you believe that a better training for senior managers would help in minimising the environmental impacts of petroleum companies? Is top management commitment important in reducing environmental impacts?
Absolutely, without the support from the senior managers and policy makers there will be no improvements. The employees cannot change anything as they need policies in place as well as tools and resources. The top management commitment I believe plays significant role in minimising the environmental impact, something that we lack in Libya at the moment.	
6	In your view, what are the main challenges that face petroleum companies in Libya from implementing sustainability management systems and standards? How can they overcome such challenges?
Well, in my view the most important thing is having strict laws and regulations from the government. Secondly, financial resources, and also training. Currently we don't have the technologies that can help us improve our work and also support our production performance.	
7	Do you think that stakeholders' involvement including the public, non-governmental organisations, environmental agencies and companies is important in achieving better environmental performance? How can they be involved?
Surely, all people should be concerned about the environment. If the public awareness increases then they will put more pressure on us to improve our services and operations. Therefore, all stakeholders including ourselves, the government, the public and of course the NOGs who can put indirect pressure on the government to monitor our work.	
8	In regards to the government role, do you believe that the government has a role to play in helping companies adopt environmental management systems? Can give me examples?

I think I answered this question above. Because of the importance of the regulations and laws, the government should ensure that laws that aim to protect the environment are in place which will encourage companies to take practical steps to avoid wrongdoings at all times. The government should also monitor and give rewards to companies to encourage others. For example, if a company is fully complied with the law, it should receive reward which will improve its image and reputation.	
9	Is the current technology sufficient to safeguard and protect the environment from petroleum activities and operations? Why or why not?
Well, as NOC, we should honestly ensure that our operations and planning is based on the use of up-to-date technology but I think current practices are based on old routines and procedures which means that we lack technological advancements. I think a new strategy should be put in place to consider new technologies and learn for other companies in other countries such as UK.	
10	Are you familiar with methodologies such as Environmental Impact Assessment and Life Cycle Assessment? Can you tell me if they are useful for Libyan companies?
Yes, I am familiar with these concepts as I studied them in the University but honestly, we don't practice them. Of course they are useful, they will help us in minimising the environmental risks but unfortunately, I think most companies do apply such approaches. It is our fault too.	
11	The final question is open-ended. It asks for any comments or suggestions that the interviewees might wish to express, which were not addressed in the earlier questions. In addition, it gives the interviewees the opportunity to expand on any of their previous responses, adding points as they deem necessary.
Well, I want to thank for choosing this interesting subject and also very happy that want to listen to our views in this subject. I think education and awareness are important to increase our focus and the focus of our workers on sustainability.	

Appendix 2 - Copy of the Survey Questionnaire

Part 1.

Q1. What is your Age Group?:

- 18 – 25 ❑
- 26 – 30 ❑
- 31 – 40 ❑
- 41 – 45 ❑
- 46 – 50 ❑
- 50^{+} ❑

Q2. Is your company?

State Owned (Owned by Libya's NOC) ❑

Joint Venture with NOC ❑

Exploration and Production Sharing Agreement company (EPSA) ❑

A Foreign Company Operating in Libya ❑

Q3. How many years of industrial experience do you have?

- Less than three years ❑
- 4 to 9 years ❑
- 10 to 15 years ❑
- 16 years or over ❑

Q4. Which of the following petroleum operations are you involved in?

- Petroleum Exploration ❑
- Drilling ❑
- Petroleum Production ❑
- Oil Refining ❑
- Maintenance ❑
- Natural Gas Processing ❑
- Administration and Management ❑
- Environment, Health and Safety ❑
- Marketing and Distribution ❑
- Petrochemical & Chemical Manufacturing ❑

Q5. What is your employment position at your company?

- An employee (technical etc.) ❑
- A Middle Manager (Engineer/Team Leaders/ Supervisor) ❑
- A Senior Manager ❑

Q6. In your opinion, how do you classify your company in regards to the environment?

- Green (Environmentally friendly) ❑
- Low Environmental Impact ❑
- High environmental impact (emissions and wastes ❑

Q7. Does your company operate using a Sustainability system or an Environmental Management System?

- Yes (*If so, please provide us with more details*) ❑
- No ❑

Q8. Does your company have a Sustainability Policy?

- Yes (*If so, please provide us with more details*) ❑
- No ❑

Q9. Does your company have a manager or team responsible for environmental issues?

- Yes (*If so, please provide us with more details*) ❑
- No ❑

Q1
frameworks related environment and sustainability?

Accredited: ISO14001-14004 ❑ EMAS ❑ BS ❑ None ❑ Others: ……………………..
Addressing: ISO14001-14004 ❑ EMAS ❑ BS ❑ None ❑ Others: ………………………

Q11. What do you consider to be the main barriers to the introduction of environmentally friendly practices, environmental systems and sustainability approaches implementation in your company? ***(Please mark as applicable)***

Leadership and management issues (lack of management commitment)	❑
Lack of awareness to Sustainability issues	❑
Organisation culture	❑
Lack of implementation framework for sustainability systems	❑
Insufficient technology	❑
Lack of skilled human resources and experienced workers in sustainability	❑
Lack of financial incentives	❑

Lack of legislative framework and strict sustainability policies ❑

Insufficient drivers and motivations for Sustainability practices ❑

Negative attitudes of employees ❑

Corruption and lack of transparency ❑

Other (Please specify) ❑

as applicable)

- Management commitment ❑
- Establishment of strict regulations and policies ❑

Effective cultural management ❑

- Raising awareness of sustainability ❑
- Effective management of change ❑
- Use of technological advancement (i.e., green technologies and approaches) ❑
- External consultancy ❑
- Training programs ❑
- Other (Please specify) ❑

- Reducing resources ❑
- Cost savings ❑
- Increased efficiency ❑
- Reduction of waste ❑
- Reduce the energy consumption ❑
- Enhancing the corporate image and reputation ❑
- Saving our globe (global warming; climate change issues etc.) ❑
- Others, please specify: ❑

Q14. In your opinion, what do you consider to be the best solution to minimise the negative environmental impact of your company and enhance sustainability practices? ***(Please mark as applicable)***

- Continuous improvement culture ❑
- Sustainability framework ❑
- Management commitment ❑
- Raising awareness ❑
- Training ❑
- Establishing regulations and policies ❑
- Government support ❑
- Others, please specify ❑

Part 2:

To what extent do you agree or disagree with the following statements. *The following statements describe some aspects of Sustainability and EMS practices in the petroleum industry. For each of the following statement, please indicate the extent to which you agree/disagree with these statements in your company by choosing the right scale from (Strongly agree) to (strongly disagree)*

Particulars	**Strongly Disagree**	**Disagree**	**Neither disagrees nor agree**	**Agree**	**Strongly Agree**
My company has Sustainability / Environmental Management System					
My Company has sustainability policy					
My Company is having a separate team/manager responsible for environmental issues.					
My company is accredited to ISO 4001:14004 standard					
My Company is addressing ISO 4001:14004 standard					

Barriers to Introducing Sustainability

State the extent you agree or disagree with the following statements.

Particulars	**Strongly Disagree**	**Disagree**	**Neither disagrees nor agree**	**Agree**	**Strongly Agree**

The main barrier to introducing sustainability is:					
Lack of management commitment					
Lack of awareness					
Organisational culture					
Lack of implementation framework for sustainability					
Insufficient technology					
Lack of skilled workers in sustainability					
Lack of financial incentives					
Corruption and lack of transparency					

Factors Contributing to the Success of Sustainability Management System (SMS)

Particulars	**Strongly Disagree**	**Disagree**	**Neither disagrees nor agree**	**Agree**	**Strongly Agree**
Major factor contributing to the success of Sustainability Management System (SMS) is:					
Management commitment					
Establishment of strict regulation and policies					
Effective cultural management					
Raising awareness of sustainability					
Effective management of change					
Use of technological advances (i.e., green)					
Training programmes					

Motivations for Implementing Sustainability Management System

Particulars	**Strongly Disagree**	**Disagree**	**Neither disagrees nor agree**	**Agree**	**Strongly Agree**
The main motivation for implementing SMS is:					
Reducing environmental impact					
Cost savings					
Increase efficiency					
Reduction of waste					
Reduce the energy consumption					
Enhancing the corporate image and reputation					

Solution for Reducing Negative Environmental Impact and Enhancing Sustainability

Particulars	**Strongly Disagree**	**Disagree**	**Neither disagrees nor agree**	**Agree**	**Strongly Agree**
The major solution to reducing negative environmental impact and enhancing sustainability is:					
Continuous improvement culture					
Sustainability system					
Management commitment					
Raising awareness					
Establishing regulations and policies					

Many thanks for answering this questionnaire

Appendix 3 – Participant Information Sheet & Cover Letter

NOTTINGHAM TRENT UNIVERSITY

STATEMENT OF CONSENT

Project Title: Development of Sustainability Management System for Libyan Petroleum Sector

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project
- have had any questions answered to your satisfaction
- Understand that if you have any additional questions you can contact the research team
- Understand that you are free to withdraw at any time, without comment or penalty
- Agree to participate in the project

Please tick the relevant box below:

- ☐ I agree for the [interview] to be [audio recorded]
- ☐ I do not agree for the [interview] to be [audio recorded]

Name: …………………………………….

Signature: ……………………………..

Date: ……………………………………...

RESEARCH TEAM CONTACTS

Name: Mr. Ammar Irhoma – PhD student

School/College: College of Art Architecture Design and Humanities, School of Architecture Design and the Built Environment

Telephone: +44 (0)115 941 8418

Email:ammar.irhoma@ntu.ac.uk

PARTICIPANT INFORMATION SHEET

PROJECT TITLE

Development of Sustainability Management System for Libyan Petroleum Sector

RESEARCH TEAM

Principal Researcher: Mr. Ammar Irhoma – PhD student, College of Art Architecture Design and Humanities, School of Architecture Design and the Built Environment, email:ammar.irhoma@ntu.ac.uk

Associate Researchers: Pof. Daizhong Su and Martin Higginson, Nottingham Trent University.

DESCRIPTION

This project is being undertaken as part of a PhD for Mr. Ammar Irhoma. The overall purpose of this project is to develop a sustainability management system (SMS) for the petroleum companies through critical investigations of sustainability related impacts, issues and the identification of barriers to the existing sustainability approaches in order to enhance sustainability performance, minimise environmental impacts and overcome implementation barriers.

PARTICIPATION

Your participation in this project is entirely voluntary. If you do agree to participate, you can withdraw from the project without comment or penalty. If you withdraw, on request any identifiable information already obtained from you will be destroyed. Your decision to participate, or not participate, will in no way impact upon your current or future relationship with your employer. Your participation will involve an interview or filling in a questionnaire survey. It will take approximately [30 to 40 minutes of time] of your time. If you agree, the interview will be audio recorded. The type of questions will include questions such as: 1- What kind of challenges that face petroleum companies in managing their environmental impacts? 2- Based on your knowledge and experience, are there any suggestions or recommendations you would like to share that can help petroleum companies implement new systems?

EXPECTED BENEFITS

It is expected that this project will not benefit you directly. However, it will improve the way that petroleum companies in Libya manage their environmental impact and develop sustainability indicators for the future, by developing a well-designed and suitable procedural framework for implementing sustainability management systems.

RISKS

There are no risks beyond normal day-to-day living associated with your participation in this project.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially and your name is not required in any of the responses.

CONSENT TO PARTICIPATE

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate.

FURTHER INFORMATION

If you have any questions, please contact the principal investigator using the following contact details:

Name: Mr. Ammar Irhoma – PhD student

School/College: College of Art Architecture Design and Humanities, School of Architecture Design and the Built Environment

Telephone: +44 (0)115 941 8418

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