A FRAMEWORK FOR ETHICAL SOURCING OF CONSTRUCTION MATERIALS

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A FRAMEWORK FOR ETHICAL SOURCING OF CONSTRUCTION MATERIALS

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Declaration

I, **Kabir, Ibrahim,** do solemnly declare that:

This thesis in its entirety, is my personal effort; and all the sources used or referred to have been recognised and duly referenced; and it has never been previously submitted partially or in full, for an equivalent or lower qualification at any other educational institution.

Signed: 

Abstract

Climate change and a speedily depreciating ecosystem are global challenges. These challenges are, in the main, attributed to activities in the construction industry, which relies heavily on the environment to provide materials. Studies show that the impact in developing countries is worse, due to the low level of awareness. Consequently, there is a dearth of research-based evidence on the ethics of sourcing of materials. This research aimed at changing that by investigating the ethics of materials sourcing in Nigeria. Epistemologically, the research is subjective and paradigmatically phenomenological. The methods used for data collection include a comprehensive literature review, collection of archival records, empirical studies of sixteen organisations that are involved in materials sourcing, transportation and production of eight construction materials across the six geo-political zones in Nigeria, that were purposefully selected. The findings reveal that the majority of the processes employed to source, transport and produce materials for the construction industry are not ethical environmentally due to their contribution to air pollution, water pollution, noise pollution and vibration, landscape damage, harm to flora and fauna and waste production. Furthermore, the study found that the majority of the organisations studied, do not produce sustainability reports for their operations. The study developed a framework for ethical sourcing of construction materials. The study recommends that organisations should utilise the framework developed in this study to enhance their sustainability practices.

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Acronyms and Abbreviations

BEA:	Building Environmental Assessment
BRE:	Building Research Establishment
C:	Carbon
CBA:	Cost Benefit Analysis
CFCs:	Chlorofluorocarbon
CH_4:	Methane
CH_3Br:	Methane Bromide
CCl_4:	Carbon Tetrachloride
CO_2:	Carbon Dioxide
CO:	Carbon Monoxide
$C_2H_3Cl_3$:	Methyl Chloroform
CSR:	Corporate Social Responsibility
DJSI:	Dow Jones Sustainability Index
EIA:	Environment Impact Assessment
EITI:	Extractive Industries Transparency Initiative
ESG:	Environmental Social Government
EU:	European Union
FEPA:	Federal Environmental Protection Agency
FTSE:	Financial Times Stock Exchange
JSE:	Johannesburg Stock Exchange
GDP:	Gross Domestic Product
GRI:	Global Reporting Initiatives
GHGs:	Green House Gases
G8:	Group of 8 comprising Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States.

HBFCs:	Hydrobromo-fluorocarbons
HCFCs:	Hydrochloro-fluorocarbons
NESREA:	National Environmental Standards and Regulations Enforcement Agency
N:	Nitrogen
N_20:	Nitrous Oxide
NPV:	Net Present Value
NGO:	Non-Governmental Agency
NOSDRA:	National Oil Spill Detection and Response Agency
NRCC:	Natural Resources Conservation Council
OCS:	Operation Context Space
O_3:	Ozone
OECD:	Organisation for Economic Co-operation and Development
RIL:	Reduced Impact Logging
UK:	United Kingdom
UN:	United Nations
UNDP:	United Nations Development Programme
UNEP:	United Nations Environmental Programme
UNGC:	United Nations Global Compact
UV:	Ultra Violet Radiation
USA:	United States of America
Pb:	Lead
IIRC:	International Integrated Reporting Committee/ Council
ILO:	International Labour Organisation
ISO:	International Organization for Standardization
MMTPA:	Million Metric Tonnes per Annum
PM:	Particulate Matter

SA8000: Social Accountability Standard

SC: Sustainable Construction

SD: Sustainable Development

SO_2: Sulphur Oxide

SRI: Socially Responsible Investment

VOCs: Volatile Organic Compounds

WCED: World Commission on Environment and Development

Definitions of Terms

Ethics: Process of taking actions and making decisions that are morally acceptable.

Ethical Sourcing: Materials extraction, transportation and production in an ethical manner.

Sourcing: Extraction, transportation and production of construction materials.

Sustainable sourcing: Sourcing (extraction, transportation and production) of materials in a manner that will not negatively affect the present and coming generations.

Chapter 1: The Research Problem and its Setting

1.1 The Construction industry

The transition of man's dwelling from caves to houses is a great step on the development path (Jimoh, 2012: 1 ; Ebohon and Rwelamia, 2001: 856). This singular accomplishment opened avenues for continuous development and rekindled man`s quest for a better life and the demand for buildings, roads; and dams (Abolore, 2012: 951 and Majdalani, Ajam amd Mezher, 2006: 33).

Osmani, Glass and Price (2008: 1147) and Shakantu (2004: 27) maintain that development projects enhance the quality of life.

According to Saidu (2016: 1), the socio-economic growth of a nation is dependent on activities in the construction industry. In most countries, the construction industry contributes to the Gross Domestic Product (GDP), and helps other sectors to flourish (Zuo, Zillante, Wilson, Davidson and Pullen, 2012: 277; Giang and Pheng, 2011: 13; Ebohon and Rwelamia, 2001: 856). For example, Olatunji and Bashorun (2006: 1177) note that the construction industry contributes between 5-10% to the GDP of most countries. However, the activities of the construction industry have an unintended negative consequence on the environment. Hill and Bowen (1997: 233) note that development alters the balance of the ecosystem. Mezher (2011: 136) and Ebohon and Rwelamia (2001: 856) explain that activities in the construction industry, such as the extraction of natural resources and production of materials not only impact the ecosystem but contribute to climate change as well.

Shi *et al.* (2012: 425) and Blayse and Manley (2004: 143) observe that globally, there is the conviction that the construction industry is not proactive in its quest to redeem its bad image.

1.1.2 Sustainability

The above perception of the construction industry has led to demands for sustainability (Abolore, 2012: 951; Presley and Meade, 2010: 435 and Majdalani *et al.,* 2006: 33). Sustainability started to gain prominence during the last decade due to the various environmental challenges threatening human survival (Abolore, 2012: 951). Sustainable development promotes the efficient utilization of resources, thereby causing less harm to the environment (Coffman and Umemoto, 2010: 9).

However, Rauschmayer, Bauler, and Schäpke (2015: 212) argue that the current sustainability approach has failed to achieve intergenerational impartiality for the sustainability agenda. This is not in tandem with the highly recognized World Commission on Environment and Development (WCED, 1987: 43) that advocated for more focus on the impact of human activity on the ecosystem.

The World Commission on Environment and Development (WCED) 1987 defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs". Glass (2012: 87) argues that the construction sector should ensure that this notion comes to reality from the planning to the decommissioning stages, in order to cater for the coming generations. According to Estevez and Janowski (2013: 94) and Jennings and Zandbergen (1995: 1019), development is sustainable when the resources extracted from the earth do not exceed the carrying capacity of the earth. This implies that the present generation should do a rethink on their resource consumption patterns. Sustainability objectives focus on having an equilibrium between social development, economic development and the safeguarding of the ecosystem (Shen, Tam Tam and Ji, 2010: 254).

Sustainable development needs arise in the construction industry because of the central position that the industry occupies in the development process. Business entities and firms can contribute to sustainability by adopting sustainability initiatives, such as the efficient use of raw materials (Mokhlesian and Holmén, 2012: 764). According to

Epstein, Buhovac and Yuthas (2015: 35), investment in sustainability initiatives is beneficial to organizations, even though it might reduce their profit.

Again, the rate at which the earth`s resources are being consumed has great consequences on the resources base, where it disrupts and depletes natural resources and pollutes water bodies (Bage, 2014: 52 and Majdalani *et al.,* 2006: 33).

Furthermore, Sev (2009: 161) maintains that the natural resource consumption pattern in developing countries is unsustainable; hence it requires a pragmatic approach because these resources are not infinite. Bon and Hutchinson (2000: 313) stress that the current methods adopted for development will only have a superficial impact on achieving sustainable development. This calls for the construction industry to be proactive in its development pattern by adopting and promoting sustainable practices (Keast and Hampsom, 2007: 364). This is also the view of Shen *et al.* (2010: 254), that the construction industry is often tasked and challenged to enhance sustainability. Consequently, research has recently emerged in the field of sustainability in the built environment and points to the need for promoting an inter-disciplinary approach in sustainability studies (Epstein *et al.,* 2015: 35).

Nag and Bhattacharyya (2016: 128), suggest that organisations should produce sustainability reports that depicts their organization's non-financial status.

Glass (2012: 88) observed that sustainability reporting by organisations should be carried out voluntarily. Zuo *et al.* (2012: 3915) and Davidson and Pullen (2012: 3915) affirm that organisations have started investing in sustainability accounting, which should enable them to assess the outcomes of the efforts towards the triple bottom line of sustainability. Adewuyi and Olowookere (2010: 523) suggest that there is a need to make sustainability reporting mandatory, in order to engender organisations commitment to sustainability.

1.1.3 Ethics

Ethical conduct by various stakeholders in the construction industry has generated a lot of interest (Zarkada, 1998: 2). Ho (2010: 411) and Sev (2009: 161) submitted that there is considerable interest in ethics in the construction industry. Bakhtiar *et al.* (2008: 25) advocate for improved ethics in order to enhance sustainability.

Ha and Nam (2016: 59) noted that as a result of the calls from stakeholders for improved ethical conduct, organisations are now willing to engender an ethical culture and to implement a code of ethics in their operations.

Bowen, Pearl and Akintoye (2007: 192) further believe that the construction industry and other sectors should be ethical in their entire decision making. According to Dean (1997: 13), organisations and businesses have responded by producing codes specifically for ethics, re-training for staff members; and setting up of units especially for ethics.

Bowen *et al.* (2007: 192) opine that organisations ought to uphold good ethical values in other to survive and flourish in a challenging and competitive business climate.

Bowen, Edwards and Catell (2012: 75) further note that stakeholders' ethical conduct in the construction industry plays a significant role in the socio-economic development and growth of an economy.

1.1.4 Sustainable sourcing

According to Sorokin (2014: 1), the environment is currently facing some challenges. These challenges are now raising concerns such as: resource depletion and pollution. Furthermore, Tencati (2015: 1) affirms that destabilisation of the ecosystem, has resulted in the loss of biodiversity and climate change. Sev (2009: 162) noted that environmental pollution and greenhouse gas emissions due to material sourcing and production have negative impacts.

Therefore, there is growing global attention to natural resource consumption patterns. Giang and Sui Pheng (2011: 632) submitted that extraction of resources from the ecosystem is heavily affecting the earth's crust and causing loss of biodiversity.

Sev (2009: 163) believes that the sustainable sourcing of construction materials can improve the environment.

1.2 Problem Formulation

The construction industry operates in an inefficient and wasteful, without considering its long-term impact on the society at large (Sev, 2009: 161).

Stakeholders in the construction industry are also concerned about the unethical practices. du Plessis (2012: 1) affirmed that the construction industry practices unethical behaviour such as: greed, unfair labour practices, corruption and destruction of the ecosystem.

Thus, the exploitation of these natural resources for the aforementioned purposes, if not planned and managed properly, would have a devastating effect on the ecosystem.

Further, the construction industry is lagging behind other industries in the practice of sustainability reporting (Glass, 2012: 87). Similarly, the absence of a well-defined mechanism for sustainability reporting is an impediment to sustainable development (Zuo *et al.,* 2012: 3910).

According to Abolore (2012: 958), the following reasons are responsible for the poor implementation of sustainability practices in the construction industry:

i. There is a poor basic understanding of sustainable construction in the industry;
ii. The absence of political commitment and the awareness to operate sustainably;
iii. Individual commitment to sustainability in the construction industry is lacking;
iv. An educational/institutional framework is not in existence;
v. The economic benefits of sustainability are not communicated;

vi. Developers are not convinced of the value added nature of sustainability implementation and,

vii. There dearth of bye-laws and regulations to enforce the concept of sustainability.

1.3 Statement of the Research Problem

There is little and disparate research-based evidence to show that construction materials are ethically sourced in Nigeria.

1.4 Statement of Sub-Problems (S-P's)

S-p 1: There are numerous environmental and health challenges in the Nigerian construction industry.

S-p 2: There is a lack of awareness of ethical sourcing of construction materials when viewed through the sustainability lens.

S-p 3: There is little knowledge and commitment in the construction industry as regards sustainability reporting.

S-p 4: Few methods have been utilised to mitigate the various challenges bedevilling the environment.

S-p 5: There is no framework for the ethical sourcing of materials.

S-p 6: There is absence of an institutional framework or structure to drive development in a sustainable manner.

1.5 Research Hypotheses

H1.1: The sourcing methods adopted lead to environmental and health challenges in the Nigerian construction industry.

H2.2: The lack of knowledge on ethics leads to challenges in the sourcing of construction materials.

H3.3: The lack of knowledge and commitment to sustainability reporting results in the unethical sourcing of materials in the Nigerian construction industry.

H4.4: The scarcity of methods utilised leads to suboptimal mitigations of the challenges in the environment.

H5.5: A framework would enable the ethical sourcing of materials.

H5.6: A framework would guide the way for the development of such a framework.

1.6 Research Objectives and Aims

The objectives of this research are to:

i. Examine the methods adopted for material sourcing for the construction industry;
ii. Assess the level of stakeholder's awareness regarding the ethical sourcing of materials;
iii. Examine sustainability reporting in materials sourcing;
iv. Assess the methods utilised to mitigate the challenges hindering the ethical sourcing of materials;
v. Review the existing frameworks on the ethical sourcing of materials;
vi. Use the outcomes of the first five objectives above to develop a practical and feasible framework that can address the challenges of the ethical sourcing of materials in the Nigerian construction industry.

The aim of this research is to develop a framework for the ethical sourcing of materials with a view to enhancing the practice of sustainability in the Nigerian construction industry.

Table 1.1: The relationship between sub-problems, research hypotheses and research objectives

Statement of Sub-problems (S-ps)	Corresponding Hypothesis (H)	Objectives
Sub-problem 1 (S-p 1)	(H1.1)	Objective 1
Sub-problem 2 (S-p 2)	(H2.2)	Objective 2
Sub-problem 3 (S-p 3)	(H3.3)	Objective 3
Sub-problem 4 (S-p 4)	(H4.4)	Objective 4
Sub-problem 5 (S-p 5)	(H5.5)	Objective 5
Sub-problem 6 (S-p 6)	(H6.6)	Objective 6

Source: Researcher's own construct, 2017.

1.7 The importance of the research

There have been increased calls for the construction industry to operate sustainably (Moir and Carter, 2012: 1486). The reason for these calls is unsustainable depletion of the environment (Bage, 2014: 52). Again, WWF-SA (2012: 8) warned that the ecological footprint has been exceeded by over 5%, hence the need to operate sustainably. The study seeks to respond to various calls made for the construction industry to do a rethink on the current development pattern adopted by developing nations that would improve the sustainability practices in the construction industry.

According to du Plessis (2014: 53) and Tietenberg and Lewis (2012: 6) the challenges currently bedevilling the environment require a new approach-particularly the development of new fields specifically targeted at the built environment and construction practices. Therefore, this study seeks to promote behavioural change and the adoption of appropriate ethical practices in the Nigeria construction industry.

This research combines and addresses the negative environmental impact of resource extraction, transportation and production jointly. The research seeks ways to provide a novel pathway for a friendlier environment and an improved ecosystem that would support continuous growth and development, thereby ensuring an economically viable and socially responsible ecosystem.

The research seeks to combine ethics, sustainability and the sourcing of materials in the construction industry, with the focus on balancing human needs with the carrying capacity of the earth; so that the needs of the future generations can be met. The study responds to various calls made for the construction industry to do a rethink on the current development pattern adopted by developing nations that would improve the sustainability practices in the construction industry.

1.8 Delimitations of the study

The research assessed the ethical sourcing of materials. However, it was limited to organisations that source, transport and produce building materials for the construction industry in Nigeria. The study covered materials such as granite, clay, ceramic tiles, sand, cement, laterite, timber and marble, due to their availability in commercial quantities across various locations in Nigeria in addition to their high demand. The organisations studied spread across eight (8) states (Kaduna, Katsina, Kogi, Edo, Niger, Ondo and Ekiti), covering the North Central, South West, South - South, North East geo-political zones. Organizations selected for the study were fully operational and at optimal capacity. The aspects covered in the study were: material sourcing, transportation and production in order to assess the impact of these activities on the environment, and the measures adopted to minimise environmental degradation. The assessment criteria used were identified criteria for sustainability assessment for the material supply chain.

1.9 Key assumptions of the study

i. Access to the required information for the research would not challenging;
ii. Organisations investigated would be engaged in sourcing, transporting and production of materials for the construction industry;
iii. Organisations studied would be operational during the field study period;
iv. Materials sourcing methods differ from one organization to the other;
v. The data and information from the study would reflect the current and true activities in material sourcing for the construction industry.

1.10 Structure of the thesis

The thesis comprises nine chapters.

Chapter One: This chapter introduces the thesis with a specific focus on the formulation of the problem, the statement of the problem and sub-problems, as well as the related hypotheses. It also describes the research aim, objectives, and delimitation of scope of the study, the key assumptions, and the structure of the thesis.

Chapter Two: This chapter provides an overview of Nigeria and the various environmental policies and legislation in Nigeria

Chapter Three: This chapter provided a description of the ethics and frameworks for the ethical sourcing of materials.

Chapter Four: The chapter discussed the theoretical and conceptual frameworks of the research based on the need for sustainability with the emphasis on ethical material sourcing.

Chapter Five: This chapter focused on the research methodology and the justification for the method adopted by the research. Furthermore, research design/strategy, the research paradigms, justification of the research's philosophical position adopted and validity/reliability were discussed.

Chapter Six: This chapter presented the data from the findings of each case study.

Chapter Seven: This chapter presented and analysed the research data from the findings of the combined case studies.

Chapter Eight: This chapter presented the interpretation of the data and discussions of the research findings.

Chapter Nine: This Chapter summarises the research; and it also draws conclusions and recommendations.

1.12 Conclusive remarks

Chapter one presented background on ethical sourcing of materials in the Nigerian construction industry. The chapter stated the research problem; the research questions; the aim; objectives; and the hypotheses. Also, the delimitation of the study and the importance of the study, the assumptions and the structure of the thesis were presented. This chapter has shown evidence that a problem does exist, which needs to be systematically addressed for the continuous survival of the ecosystem. The subsequent chapter presents a review of the extant literature.

Chapter 2: The Literature Review

2.1 Introduction

The thrust of this chapter is to present an overview of Nigeria and the various environmental policies and legislation relative thereto.

2.2 An overview of Nigeria

Nigeria is located in the West Africa sub-region, surrounded by francophone countries such as Niger, Chad and Cameroun to the North, and Benin to the West. Abuja is the capital. Nigeria has a land mass of about 8000 km^2 (Abubakar, 2014: 81). According to Nwilo and Badejo (2006: 1), the Nigerian coastline extends to about 853km and lies between latitude 4^o 10' to 6^o 20'N and longitude 2^o 45' to 8^o 35' E. The major rivers that cut across Nigeria are the Benue and Niger, and a tributary Lokoja.

According to BusinessTech (2018: 1), Nigeria is the largest economy in Africa with a GDP of about $376.3 billion. Nigeria has a Federal constitution, with three arms of government, the Federal, the State and the Local Governments (Okolie, 2011: 21). Nigeria currently has 774 Local Governments and 36 States. The population of Nigeria is currently estimated to be above 189 million (FocusEconomic, 2018: 1). The official language in Nigeria is English; and the other languages spoken are: Hausa, Ibo and Yoruba.

The major sources of foreign exchange for the Federal Government are: Oil, gas and minerals (Chindo, 2011: 10). The major minerals in Nigeria are: Coal, Barite, Limestone, Iron ore, Zinc/lead, Bitumen and Gold (Chindo, 2011: 107). Figure 2.0 shows the map of Nigeria.

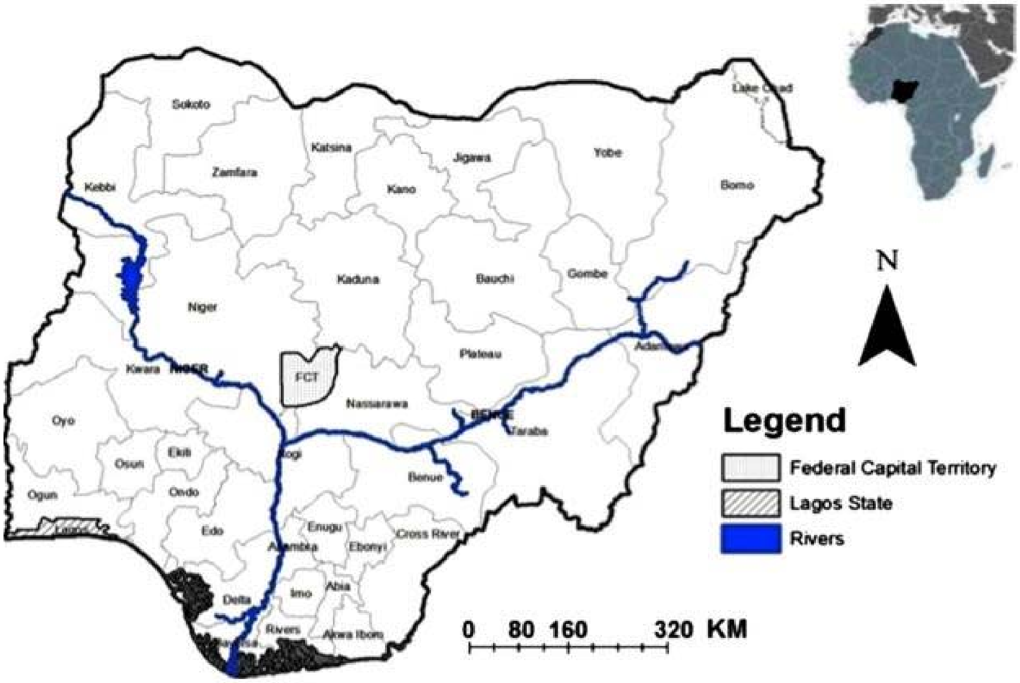


Figure 2.1: Map of Nigeria

Source: Abubakar (2014: 82)

2.3 Environmental policies and legislation in Nigeria

General environmental policies in Nigeria emerged in the late 1980s. Previously, such policies were virtually non-existent. According to Omolola (2013: 386), before the 1980s, little attention was paid to the environment. Government agencies reacted, after disasters such as the Koko waste pollution in 1988. The Federal Government of Nigeria established the Federal Environmental Protection Agency (FEPA) in 1988.

Nigeria is a signatory to international accords such as:

- 1968.The African Convention on the Conservation of Nature and Natural Resources;
- 1972. The UN Conference on the Human Environment (the Stockholm declaration);
- 1992. UN Conference on Environment and Development (Rio Summit); and,
- The Kyoto Accord/Kyoto Protocol on global warming.

There exists a lot of environmental challenges in Nigeria. Ajayi and Ikporukpo (2005: 343) noted that environmental challenges in Nigeria are not limited to the destruction of flora and fauna, air pollution, water pollution, landscape damage, erosion, flooding and desertification. A study carried out by Fentiman and Zabbey (2015: 623) on the Bodo community in Ogoni land, noted that environmental challenges have affected the Bodo community socially, economically and culturally.

Ovri and Iroh (2013: 350) noted that environmental pollution is causing rapid deterioration of walls and roofs. Omo-Irabor *et al*. (2008: 666) attributed these challenges in Nigeria to exploration and production of crude oil. Adedeji and Ako (2009: 647) attributed the ongoing environmental degradation to the weak laws and lenient punishment of offenders.

Contemporary environmental policies in Nigeria are:

2.3.1 National Environmental Standards and Regulations Enforcement Agency (NESREA) Act

Due to weak enforcement, the Federal Environmental Protection Agency (FEPA) law was replaced by the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act in 2007. Section 7(c) of the NESREA Act empowers the body to enforce: (1) Compliance with the provisions of international agreements; (2) Compliance with all the protocols signed by the government; (3) Compliance with conventions and treaties on the environment; (4) Compliance regarding climate change; (5) Compliance on biodiversity issues; (6) Compliance regarding flora conservation; (7) Compliance concerning desertification; (8) Compliance on forestry; (9) Compliance regarding oil and gas; (10) Compliance as to the usage of chemicals; (11) Compliance on hazardous wastes; (12) Compliance on ozone depletion; (13) Compliance on the legislation relating to marine and wild life; (14) Compliance to anti-pollution legislation; (15) Compliance regarding sanitation; and (16) Compliance to other environmental agreements, as may, from time to time come into force.

Even with the above powers given to NESREA, it has come under criticism. Anejionu *et al.* (2015: 73-74) argued that the words used in the NESREA Act are not explicit regarding the powers and functions of the regulating agencies, and the lack of political will to enforce the standards. Furthermore, Anyanwu (2012: 4) believed that environmental challenges still persist in Nigeria; because NESREA is not empowered to prosecute oil and gas polluters.

2.3.2 Environmental Impact Assessment (EIA) Act

The Environmental Impact Assessment Act (EIA) was promulgated on the 10th of December 1992 by the then Military Head of State. The Act was intended to guide against the destruction of the environment by carrying out a detailed study of the impact that projects would have on the environment. It also focuses on, minimizing the socio-economic and health impact of projects. The EIA Act requires that reports should be produced for projects such as: (1) Agriculture; (2) Airports; (3) Drainage and Irrigation; (4) Fisheries; (5) Forestry; (6) Housing; (7) Industry; (8) Infrastructure; (9) Seaport; (10) Mining; (11) Refinery; (12) Power generation and transmission; (11) Quarries; (12) Railways; (13) Transportation; (14) Waste treatment and the disposal plants; and (15) Water supply.

The Act requires collaboration between relevant stakeholders. Anyadiegwu (2012: 68) affirms that the EIA Act should be considered during the stages of project briefing, design, construction, operation, and decommissioning. Ingelson and Nwapi (2014: 4) and Anyanwu (2012: 1) note that although, the EIA report is mandatory, the authorities do not enforce it. This has affected most States and cities where projects are sited in incorrect places (Yusuf *et al.,* 2007: 81). Ingelson and Nwapi (2014: 14) also posit that the EIA Act does not make provision for wildlife and ethno-diversity.

2.3.3 National Oil Spill Detection and Response Agency (NOSDRA) Act

The National Oil Spill Detection and Response Agency (NOSDRA) was promulgated in 2006, as a government agency mandated to protect the environment. The NOSDRA Act focuses exclusively on the oil and gas sector. Its mandate includes: preparedness;

detection; and response to disasters- particularly oil spillages. The objectives of the agency according to the Act establishing NOSDRA are:

- Launching a workable national strategy that ensures a safe, timely, effective and appropriate response to major or disastrous oil pollution;
- Maximum effective use of the available facilities and resources of corporate bodies, their international connections and oil-spill co-operatives i.e. Clean Nigeria Associates (CNA) in implementing appropriate oil-spillage responses;
- Make sure there are appropriate and sufficient pre-positioned pollution-combating equipment and materials and functional communication network system required for effective response to major oil pollution;
- Ensure a programme of activation, training and drill exercises to ensure readiness to oil-pollution preparedness and the management of operational personnel;
- Collaborate and provide advisory services, technical support and equipment for responding to major oil-pollution incidents in the West African sub-region, when requested to do so by any neighbouring country, particularly where a part of the Nigerian coastline may be threatened;
- Support research and development (R&D) locally for the development of methods, materials and equipment for oil-spill detection and response;
- Co-operate with the International Maritime Organization and other national, regional and international organisations in the promotion and exchange of results of research and development programmes relating to the enhancement of the state-of-the art technology in oil-pollution preparedness and response, including technologies, techniques for surveillance, containment, recovery, disposal and clean-up;
- Establish agreements with neighbouring countries regarding the rapid movement of equipment, personnel and supplies into and out of the countries for emergency oil-spillage response activities;
- Determine and ensure the pre-positioning of vital oil spill combat equipment at the most strategic areas for immediate response;

- Establish procedures for the Nigerian Customs Service and the Nigerian Immigration Service to ensure the rapid importation of extra support-response equipment and personnel;
- Develop and implement an appropriate audit system for the entire plan; and
- Carry out such other activities, as are necessary, or expedient for the full discharge of its functions and the execution of the plan.

The NOSDRA Act has its shortcomings. Kadafa *et al.* (2012: 27) argued that the NOSDRA Act is sufficient; but they noted that monitoring and implementation have not been well carried out. They also noted the need to regularly revise the Act.

2.3.4 Natural Resources Conservation Council (NRCC) Act

The Natural Resources Conservation Council Act was promulgated in 1989. Its duties include: (1) Managing natural resources conservation; (2) Policy formulation to protect natural resources; (3) Supervision of other agencies regularly to ensure their performance; (4) Managing the affairs of the agencies under it; and (5) Execution of other duties and obligations that arise.

Elum *et al.* (2016: 1288) noted that even though the National Resources Conservation Council Act exists in Nigeria, the implementation of this Act is a major challenge. Abere and Jasper (2011: 940) insist that the Act is outdated; and that it needs to be reviewed to deal with the challenges of today.

2.4 Concluding remarks

This chapter discussed the relevant legislative instruments in the Nigerian environmental scene. Issues discussed include: An overview of Nigeria, the environmental laws and agencies responsible for implementing the laws to protect the environment. The next chapter presents literature on Ethics and frameworks for Ethical sourcing of construction materials.

Chapter 3: Ethics and Frameworks for Ethical Sourcing of Construction Materials

3.1 Introduction

This chapter provides an overview of ethics; sources of ethical theories; approaches to ethical theories and framework for the ethical sourcing of construction materials.

3.1 General overview of Ethics

Thiroux and Krasemann (2012: 2) submitted that ethics originates from ethos, a Greek word that means human character. Viviers (2007: 106) views ethics as the logical assessment of an action. Fan *et al.* (2001: 20) claim that ethics is concerned with making moral decisions. Lecher (2002: 109) adds that ethics guide individuals to behave responsibly. Worrell and Appleby (2000: 4) opined that the adoption of good ethical practices enables the proper utilisation of natural resources.

The application of ethics in all human endeavours promotes growth and development. In business, the consideration of ethics as a guide would enable business to distinguish between what is right and wrong in their continuous operation (Fan *et al.,* 2001: 20).

Smit and Cronjé (1997: 490) believe that ethics is concerned largely with being upright. Ethics promotes good characters that contribute positively to the immediate environment (Satava *et al.,* 2006: 274).

Ethical behaviour could be influenced by the individual's belief and culture. Ononogbo *et al.* (2016: 36) and Vee and Skitmore (2003: 3) suggest that ethical behaviours are determined by individual convictions and cultural beliefs. Ford and Richardson (2013: 18) illustrated a contingency model of ethical decision-making, as shown in Figure 3.1.

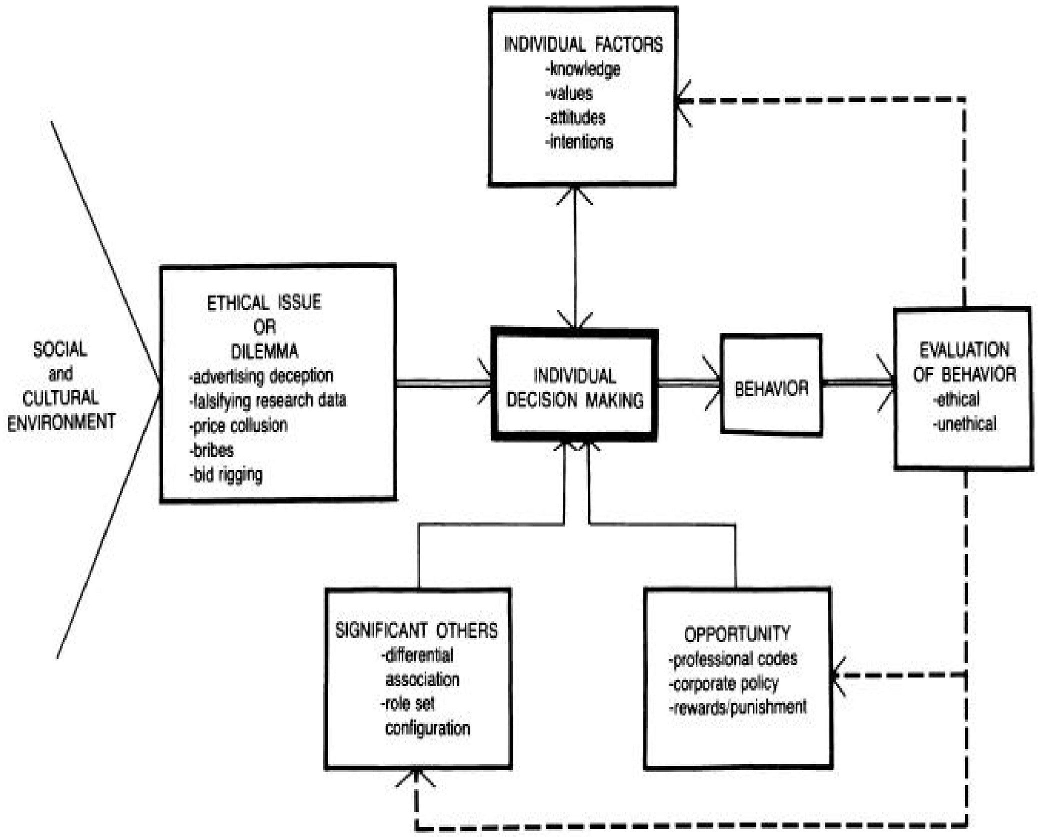


Figure 3.1: Contingency model for making ethical decisions

Source: Ford and Richardson (2013: 18) and Ferrell and Gresham (1985: 89)

Halis *et al.* (2007: 129) view ethics as principles, values, rules and customs that direct individuals in a society. Bennett-woods (2005: 2) proposes that ethics is a subset of philosophy; and it focuses on morality. Ononogbo *et al.* (2016: 36) in their study, noted that organisations establish a code of ethical practices to guide their conduct. Bennett-woods (2005: 2) thinks that the three major areas of ethics are:

- **Meta-ethics:** Meta-ethics focuses only on whether an act can be judged to be right or wrong. Meta-ethics serves as a foundation for normative ethics.
- **Normative ethics:** The normative ethics seeks to formulate rules and regulations that guide the ethical actions of people.

- **Descriptive ethics:** Ethics is illustrated here in terms of the actions of an individual, or a group of people, when compared to mainstream acts.

3.2 Sources of ethical theories

Ethical theories emerged from various sources, and were later adopted to provide guidance and sources for reference during interaction. These sources, according to Viviers (2007: 116) include: religion, philosophy, culture and tradition, legal consideration and professional values. Lombardo (2016: 2) believes that ethical theories emerged from religion, traditions, and philosophy.

3.2.1 Religion

Many religions exist, and they guide people in their activities. Christianity, Islam and Judaism are among the major religions. The Christians believe in the Holy Bible; while the Muslim's are guided by the Holy Quran when making ethical decisions.

These religions all have in common, the need to follow the laid down rules diligently, so as to be just and fair to everyone in their dealings. Abdallah (2010: 292) noted that in Islam that, the teachings and guidance are often guided by the ethical values enshrined in the Quran. The Quran is often referred to during dealings and discussions between Muslims.

Lombardo (2016: 3) opined that religious believers are often guided by ethical commands, which they follow with full conviction; and the laid down rules diligently, so as to be just and fair to everyone in their dealings. Abdallah (2010: 290) noted the need for religious beliefs, attitudes, and values to be the ethical reference point for the human race to prosper. Pojman and Pojman (2012: 641) noted that religions inform humans of the limit of the influence they have on the world.

3.2.2 Philosophy

A philosophical position taken by a person will determine how he/she reasons. Batson and Neff (2012: 9) noted the following philosophical positions that guide how individuals behave:

- **Personal experience:** Human beings do at some point witness events in life. This experience is obtained from events that often determine the philosophical position they do take.
- **Believing in fairness:** Believing that the principles of fairness should be upheld would shape how an individual interacts with others. This could be the reason why some people, irrespective of their background or religion, are fearful in their dealings with others.
- **Stereotyping:** This is often the positive or negative bias for a particular group of people.
- **Information available:** The amount of information readily available points to which philosophical position an individual has taken. Some critical decisions might be taken from the available information at that moment, which might be detrimental in the long run.
- **Perfection:** When a person is inclined to perfection, he/she might not appreciate the amount of effort others put in to accomplish a task.

3.2.3 Culture and tradition

Culture and tradition could have an impact on an individual's ethical perspective. Thiroux and Krasemann (2012: 15) believe that culture and tradition determine one's ethical view. Thiroux and Krasemann (2012: 15) affirmed that most culture promotes good ethical conduct. Hence, culture and tradition promote harmony, unity and co-existence.

3.3 Approaches to Ethical theories

Ethical theories enable a better understanding of the issues regarding ethics. Ethical theories are the concepts that guide human conduct and consciousness. They include: Utilitarianism, Deontology, the Ethical egoism theory, the feminist theory, and the ethics of care.

3.3.1 Utilitarianism theory

Utilitarianism is one of the early ethical theories. The utilitarianism principle emerged from Britain in the seventeenth century. Batson and Neff (2012: 28) argued that utilitarianism considers the merits and demerits of the decisions being taken. Bennett-woods (2005: 22) noted that utilitarianism is deeply rooted in the utility principle, which promotes acts that guarantee maximum satisfaction to society at large. Therefore, if the impact of the decision taken does not add value, then it can be viewed to be unethical or immoral; and therefore redundant in that situation.

Mainga (2012: 9) argued that utilitarianism promotes acts that maximize the benefits to be derived by the concerned parties in decision-making.

Chonko (2012: 2) and Viviers (2007: 128) categorized utilitarianism as act-utilitarianism and rule-utilitarianism. They believed that for act-utilitarianism, individuals reflect on the consequences of their resolution and actions; and they further make an assessment of whether the choice made produces pleasure to all the parties involved. On the other hand, rule-utilitarianism focuses on the impact of the rules made and the need to consider which rule would yield greater satisfaction to the majority of the population. Batson and Neff (2012: 28) noted that the major setback with utilitarianism is its inability to consider the minority; rather it gives preference to the will of the majority.

3.3.2 The Deontology theory

Viviers (2007: 128) noted that the deontological theory is concerned with moral obligation and the responsibility of actions taken. Actions, such as taking illegal acquisition of funds to help the needy is a condemnable act, according to the Deontologists. Chonko (2012: 1) noted that deontology promotes good character. Abdallah (2010: 290) and Sampson (2002: 61) point to a shortcoming in the deontological theory: its inability to look at the intentions of the actions taken.

3.3.3 Ethical egoism theory

Zarkada (1998: 77) views self interest in human beings as when they are concerned about themselves, in preference to others. Batson and Neff (2012: 31) noted that ethical egoism focuses solely on the person that takes the decision not minding the impact that such a decision would have on others. Chonko (2012: 3) also agreed that ethical egoism puts the interests of the individual first – before considering others. Thiroux and Krasemann (2012: 32) contend that ethical egoism does not necessarily translate to being self-centered. They also identified the different categories of ethical egoism:

- **Individual ethical egoism:** This promotes people to push for their own interests first, before considering those of others.
- **Universal ethical egoism:** Universal ethical egoism supports everyone fighting for his or her own cause and supporting those with a goal that would give special consideration to him or her.
- **Personal ethical egoism:** Personal ethical egoism supports every one making a case for his/ her self-interest, regardless of the personal interests of others.

A drawback for ethical egoism theory is its inability to consider others, rather than its own self (Thiroux and Krasemann, 2012: 32). The ethical egoism theory does not seek to involve and develop humanity as a whole.

3.3.4 Feminist theory

According to Bennett-woods (2005: 25), the feminist theory takes both the social and the political views into consideration. Sampson (2002: 36) submitted that the feminist theory makes a case for equality, fairness and justice in the distribution of natural resources to everyone. The Feminist theory is championing the shift in the power balance – to favour the women and other weak parties; hence it does not support other moral principles (Bennett-woods, 2005: 25).

3.3.5 Ethics of care

Ethics of care is deeply rooted in nursing. Bennett-woods (2005: 28) submitted that the ethics of care is similar to the feminist theory. Sampson (2002: 51) believed that women are created to be more caring than their male counterparts. Hence, women due to their nature, are made to give affection, care and also to show love. Thiroux and Krasemann (2012: 41) argued that ethical egoism is not often ranked among the consequentialist ethical theories.

3.4 Ethical principles

These principles are not limited to beneficence, the non-maleficence principle, or the least harm but also include the justice principle.

I. The Beneficence principle

The beneficence principle seeks to champion admirable virtues from acts and deeds. Chonko (2012: 1) believed that the principle of beneficence promotes doing the good and right things all the time. Bennett-woods (2005: 9), in the same vein, noted that the beneficence principle makes it obligatory to always do good, regardless of the situation. The beneficence principle is not the reverse of the non-maleficence principle (Bennett-woods, 2005: 9). It should be acknowledged that both principles seek to promote good acts and good deeds.

II. Non-maleficence principle

The non-maleficence principle is an ethical principle that considers others. Bennett-woods (2005: 9) noted that the non-maleficence principle promotes decisions that will not cause any harm to others. Here, the non-maleficence principle considers the impact of an individual or a group of people's acts on others. Chonko (2012: 1) believes that when making decisions that will have a negative impact, attention should be given to decisions that would cause very little harm. Bennett-woods (2005: 9) cautions that a person or group of people who knowingly cause harm or even put others at risk due their actions have gone against the non-maleficence principle.

III. The Fidelity principle

The fidelity principle seeks to promote good deeds. Bennett-woods (2005: 11) submitted that this principle promotes absolute loyalty, fulfilling any promises made, and ensuring that all the initial agreements are fulfilled. People come in conflict due to the fidelity principle, as they fail to meet up with their own part of the agreement (Bennett-woods, 2005: 12).

IV. The Justice principle

The Justice principle promotes fairness and equity to others, irrespective of their affiliation and background (Bennett-woods, 2005: 13). Chonko (2012: 1) noted that the justice principle advocates for fair play always. Risks and benefits should be shared equally between all the parties involved (Bennett-woods, 2005: 13). There is the need to carry all the parties along with one, irrespective of the circumstances, in order to ensure justice and fairness. According to Thiroux and Krasemann (2012: 147), the justice principle promotes paying back exactly what has been done to you. They further explained that the reward for good should be good; while the reward for bad should be bad.

3.5 Unethical practices in the Construction Industry

People exhibit different behaviours. These behaviours can be ethical or unethical. Thiroux and Krasemann (2012: 2) argued that ethical practices are practices that are often good and worthy of being emulated; while unethical practices are practices that are bad and not attractive. Furthermore, Tenbrunsel and Smith-Crowe (2008: 549) believed that the distinction between ethical and unethical practices lies in the legality and the public acceptance of such practices. They further submitted that ethical practices are often legal and widely accepted; while unethical practices are not legal; and generally, they are not accepted.

The construction industry has often been criticized for many unethical practices. These unethical practices are not limited to the following:

3.5.1 Degradation of the environment

Many activities involving the construction industry, such as the extraction of materials, transportation and production contribute to environmental degradation and climate change. Wirahadikusumah and Ario (2015: 126) argue that the construction industry pollutes the environment and disturbs the environment. Abdul-Wahab *et al.* (2015: 587) explain that aggregate extraction and the crushing of rock for construction purposes have an adverse impact on the environment. Olusegun *et al.* (2009: 5) note that in Ogun State, Nigeria, drilling, blasting and the crushing of rock bodies pollutes the environment. Furthermore, County and Nthambi (2015: 95) submit that sand mining in Kenya has an adverse impact on the environment– resulting in water scarcity, noise pollution during sand transportation and damage to the existing infrastructure.

The study of Hansen and Treue (2008: 587) on the impact of illegal timber logging on the environment revealed that the process causes noise pollution and landscape destruction. The study carried out by Sarkodie (2014: 43) on the environmental Impact of clay sourcing at Mpraeso Aman in the Eastern region of Ghana revealed the destruction of water bodies and the damage to arable land earmarked for agricultural purposes.

3.5.2 Bribery and corruption

Bribery and corruption are scourges currently affecting the construction industry like other industries. Vee and Skitmore (2003: 118) note that bribery and corruption are among the most highly discussed unethical practices in the construction industry. Ameh and Odusami (2010: 1) argue that bribery and corruption spread across the construction project life cycle from the initial stage to the demolition stage. The study of Shan *et al.*(2013: 8) on the collusive practices in China divulge that major unethical practices are: the wrong issuance of qualification certificates to contractors; inadequate supervision of site work; the omission of prequalification requirements for contractors, the submission of false tenders, the endorsement of pointless job-change orders, the collusive tendering process, in addition to favouritism of a specific contractor or supplier.

The study carried out by Bowen *et al.* (2007: 646) and Shakantu (2006: 44) in South Africa on the ethical practices in the construction industry showed that collection of bribes by consultants is very high. Furthermore, Brown and Loosemore (2015: 386) in their study in Australia found that the construction industry seems to nurture unethical acts; and largely corruption. They further noted that kickbacks, fraud and bribery are the major unethical practices in Australia. Nordin *et al.* (2013) poignantly noted the presence of unethical practices in Malaysia, notably bribery and corruption that is now having a negative impact on the construction industry.

Jancsics and Jávor (2012: 92) highlighted that high levels of bribery and corruption cases exist in Hungary. They also submitted that all the tools and initiatives put in place by the government, such as regular auditing, the establishment of regulating agencies and the use of judiciary, have not been effective in dealing with the scourge. The above cases show that unethical practices are common in the construction industry across all the continents.

3.5.3 Discrimination

Human beings are noted to be different from one another. Some people differ by the language they speak, their sex, the colour of their skin, religions, character and cultural inclination. Loosemore and Chau (2002: 100), in their study on the occurrence of discrimination against Asian workers in the Australia construction industry, disclosed that discrimination occurs generally between the lower-level workforce in the form of telling jokes about one another, offensive graffiti, fighting and swearing. Also, a study by McDonald and Dear (2008: 46) on discrimination in the construction industry shows that discrimination exists in the workplace in the form of bullying and sexual harassment, age, sex, race and family responsibilities.

Furthermore, the study undertaken by Loosemore and Lim (2015: 322) in investigating discrimination in the construction industry revealed that unfairness, favoritism, and deceptive behaviors are common in the construction industry. Bowen *et al.* (2013: 632) sought the views of different professionals in the construction industry regarding discrimination in South Africa. The study showed that harassment and discrimination based on ethnic backgrounds, sex and gender are some of the challenges they face. Wong and Lin (2014: 416) conducted a survey to determine the various experiences of ethnic minority construction workers in Hong Kong. Their study showed that workers are directly or indirectly abused, based on their race; and they are often treated unequally in the respective units where they work.

Regmi *et al.* (2009: 411) conclude that despite the establishment and implementation of several employment Acts, in the United Kingdom, that are intended to guard against employee discrimination, based on their gender or ethnic origin, the scourge still persists. They also noted that Nepalese construction workers are still discriminated against, due to their ethnic origin. The study of Kumar (2013: 52) on gender discrimination among female construction workers in Vijayawada, India, shows that women face discrimination from their employers during the payment of their wages and salaries, promotion and training.

3.5.4 Fraud

Fraud is also an unethical practice currently affecting the construction industry globally; and van Bergeik (2007: 127) posits that there is a high level of fraud cases in the Dutch Construction industry perpetuated by the various cartels. Furthermore, Hertogh (2010: 320) noted that collusion and 'bid rigging' by cartels who own major construction companies in the Netherlands are actively involved in illegal clearing systems. The study by Reeves-Latour and Morselli (2016: 9) study exposes the evolution of bid-rigging networks in the construction industry in Laval-Canada. They also noted that top construction companies, which carry out major construction projects, are often supported by the actions of organised crime groups.

Furthermore, Hudon and Garzon (2016: 292) in their study on fraudulent procurement practices, argue that fraud is carried out by an established link involving government officials, politicians and players from the private sector, in order to satisfy their personal and selfish interests. Corporate fraud perpetuated in an organisation increases the risk of an organisation being declared insolvent, thereby leading it to liquidation (Hass *et al.,* 2016: 723). The study of Gunduz and Önder (2013: 521) on fraudulent practices in the construction industry in Turkey shows that the tabling of fake invoices of goods and services received, the inflation of items on invoices and the bid rigging in favour of a particular contractor are the most-used methods in perpetuating fraud.

3.6 Frameworks for Ethical Sourcing of Construction Materials

The international community has put in great effort to develop significant frameworks to enhance sustainability practices. Vigneau *et al.* (2014: 473) noted that the developed frameworks are globally accepted; and they give guidance on key areas that would enhance sustainability in their businesses. The following frameworks were developed by governments, groups and individuals to guide and improve all the sustainability practices.

3.6.1 BES 6001 framework standard for responsible sourcing of construction products

The BES 6001 framework originated from the UK in 2014; and it seeks to enhance sustainability practices. The framework provides an avenue to trace the source of materials used in the construction industry (Upstill-Goddard *et al.,* 2015: 2). Standards and certification in the BES 6001 framework are in line with other certification body standards. The framework is based on performance, in which points are allocated to organisations, according to their level of performance. It can also be used for testing, assessment and certification purposes. Glass (2011: 168) declared that BES 6001 specifically centres on organisational management, supply-chain management and environmental and social requirements.

Upstill-Goddard *et al.* (2015: 3) unmasked a shortcoming in the BES 6001 framework, by submitting that the framework did not state how it can be applied to other related sectors. Glass (2011: 169) also noted that the lack of understanding of the scope for BES 6001 framework for responsible sourcing in the construction industry has affected its adoption, because of its similarity with other established tools.

The BES 6001 framework for responsible sourcing provides guidance in the areas of a responsible-sourcing policy, legal compliance, quality management system and operational management of responsible sourcing, supplier management system, Supply-Chain Management Requirements (material traceability through the supply chain), environmental management systems in the supply chain, greenhouse gas emissions, energy use, resource use, waste prevention and waste management and transport impacts, as shown in Table 3.1.

Table 3.1: BES 6001 framework for responsible sourcing

Requirement	Description	Performance rating
Responsible sourcing policy	The organisation shall have a written policy, appropriate to the purpose and activities of the organisation, to address the responsible sourcing principles described in Section 4 of this Standard. The policy shall be approved and monitored by the organization's senior management.	Compulsory 1
Legal compliance	The organisation shall establish, implement and maintain a procedure(s) i. to identify and have access to all applicable local, national and ratified international laws and regulations by which the organisation is bound. ii. to determine how these laws and regulations apply to the implementation of its policy established in the BES framework. The organisation shall ensure that these are taken into account in establishing, implementing and maintaining its management systems.	Compulsory 1
Quality management system & operational management of responsible sourcing	The organisation shall have in place a documented quality management system, following the fundamentals of ISO 9000 clause 2, to implement its quality and responsible sourcing procedures, and which includes in its scope the assessed product.	Compulsory 1
	To achieve a higher 'Performance Rating', the organisation shall have a quality management system that conforms to ISO 9001 or equivalent, certificated by an accredited organisation, to implement its quality and responsible sourcing procedures, and which includes in its scope the assessed product.	2
Supplier management system	The organisation shall have in place, appropriate to the purpose and activities of the organisation and its products, a documented management system for its purchasing process and for approval of its suppliers. The management system shall implement the policy established in clause of BES 6000 Standard. The management system shall conform to the	Compulsory 1

	requirements of clause 7.4 of ISO 9001 and be integrated into the organization's quality management system. AND The organisation shall maintain a list of suppliers of constituent materials in the assessed product. AND Where the organization under assessment acquires constituent materials from any supplier based outside the EU, or from states that have not declared adherence to the OECD Guidelines for Multinational Enterprises, the organization shall undertake an appropriate risk assessment and demonstrate due diligence in its monitoring of the supplier's compliance with the ILO Declaration on Fundamental Principles and Rights at Work. For example, the following shall be considered appropriate mechanisms for demonstrating due diligence: I. Membership of the Ethical Trade Initiative ii. Membership of the United Nations Global Compact iii. Certification to the Social Accountability International SA8000 standard Where the assessed organization is responsible for the extraction of a raw material at source, the organization shall demonstrate traceability from the source of the raw material to the assessed product through any subsequent processes of product realization. If any constituent material is sourced from a supplier based outside the EU/OECD, risk assessments and due diligence shall be provided for 98% of constituent materials (by mass and volume).	
Supply Chain Management Requirements (material traceability through the supply chain)	A minimum of 60% of the mass and volume of constituent material(s) in the assessed product shall be traceable to the supplier(s) responsible for: i. The extraction of raw materials; ii. The recovery of recycled materials;	Compulsory 1

	ii. The production of by-products iv. The processing of commodity traded chemicals. The following mechanisms shall be considered appropriate for demonstrating traceability: i. The identification and traceability of constituent material(s) is managed at each stage of the supply chain to the source of the constituent material(s) through clause 7.5.3 of ISO 9001, and implemented at each exchange of responsibility for the constituent material(s) through clause 7.4 of ISO 9001. The organisation responsible for the constituent material(s) at each stage of the supply chain shall be certificated by an accredited organisation to ISO 9001; or Equivalent documented evidence of traceability. Where there is already an established industry benchmark this shall be taken as the 'compulsory' level. An independently audited full chain of custody scheme to the raw materials source of the constituent material(s) satisfies the requirement for traceability.	
	To achieve a higher 'Performance Rating', 75% of the constituent material(s) in the assessed product shall be traceable according to the criteria described in a) above.	2
	To achieve a higher 'Performance Rating', 90% of the constituent material(s) in the assessed product shall be traceable according to the criteria described in a) above.	3
Environmental management systems in the supply chain	The traceable constituent material(s) in the assessed product (the assessed portion of the supply chain as established in clause 3.3.1) shall be traceable to supplier(s) with a documented environmental management system (EMS).	Compulsory 1
	The EMS shall follow the fundamentals of ISO 14001 and shall include within its scope key processes of raw material extraction and primary material production, where appropriate to the scope of its operations.	
	All requirements in 3.3.2 apply to the portion of the supply assessed against requirement 3.3.1 of this Standard, including the organisation under assessment.	
	Constituent materials which are recycled materials or by-products shall be deemed to satisfy this requirement without further verification.	

	To achieve a higher 'Performance Rating', at least 60% of the constituent material(s) in the assessed product shall be traceable to supplier(s) with an EMS certificated by an accredited organisation to: i. ISO 14001; ii. EU Eco-Management and Audit Scheme (EMAS); or for small companies: a. confirmation that the company EMS is structured in compliance with BS 8555 (or equivalent) and the EMS has completed phase audits one to four as outlined in BS 8555 (or equivalent).	
	To achieve a higher 'Performance Rating', 75% of the constituent material(s) in the assessed product shall be traceable to supplier(s) with a certificated EMS, according to the criteria described in b) above.	3
	To achieve a higher 'Performance Rating', 90% of the constituent material(s) in the assessed product shall be traceable to supplier(s) with a certificated EMS, according to the criteria described in b) above.	4
Greenhouse gas emissions	According to the principles of ISO 14064-1, the organisation shall quantify the: i. emissions and removals of greenhouse gases (GHG) related to its direct operations; and ii. indirect emissions and removals of GHG related to energy use in its direct operations. AND The organisation shall establish a policy, supported by a documented management system, for the monitoring and reduction of the GHG intensity of its operations. This aspect may be managed within the scope of an existing management system. NOTE: refer to ISO 14064-1 for definitions.	Compulsory 1
	To achieve a higher 'Performance Rating', the organisation shall report to its stakeholders on the emissions and removals of greenhouse gases, according to the principles of ISO 14064-1.	3
	If legal requirements related to competition mean that reporting cannot be legally conducted at company level then the information shall be reported at sector level. This may be via a trade body.	
	To achieve a higher 'Performance Rating', the organisation shall have external verification of the information and data reported above according to the principles of ISO 14064-3.	5

Energy use	The organisation shall establish a policy, supported by a documented management system, for the monitoring and reduction of the energy intensity of those operations over which the organisation has financial and/or operational control. NOTE energy intensity is the amount of energy required for each unit of output	1
Resource use	The organisation shall establish a policy, supported by a documented management system, for the efficient use of constituent materials, to address the following issues, as appropriate to the product under assessment: i. Use of renewable and/or abundant materials over nonrenewable and/or scarce materials ii. Material resource efficiency – using less material to achieve a given function iii. Reuse of materials iv. Use of recycled materials and/or by-products v. Use of recyclable materials	Compulsory 1
	To achieve a higher 'Performance Rating' the organisation shall demonstrate at least two of the following: i. Actions taken to improve future resource use at end-of life, including any post-consumer retrieval schemes in place. ii. Actions to extend the lifetime of the assessed product, such as provision of refurbishment, maintenance or repair services iii. Staff and supply chain engagement activities to promote behavioural change and share best practice.	3
	To achieve a higher 'Performance Rating' the organisation shall report to its stakeholders on its performance against the above a) and b).	5
	A supplementary point may be awarded if the organisation provides any externally verified evidence of environmental stewardship at the source of raw material. The environmental stewardship shall follow material specific, appropriate and recognised principles.	1
Waste Prevention and waste Management	The organisation shall establish a policy, supported by a documented management system, for the diversion of waste from landfill or incineration without energy recovery in accordance with the	Compulsory 1

	waste hierarchy AND The organisation shall provide evidence that all controlled waste arising from its operations is stored, transported and treated such that risks to human health and the environment are low and that all local regulatory requirements are fulfilled.	
	To achieve a higher 'Performance Rating', the organisation shall report to its stakeholders its performance in terms of waste prevention and waste management. This shall include: I. Levels of waste production relative to output set against targets for reduction over time; and ii. comparison to industry benchmarks, where available	2
	To achieve a higher 'Performance Rating', the organization shall have external verification of the information and data reported above.	3
	A supplementary point may be awarded if, the organization reports to its stakeholders on at least two of the following aspects: I. Overview on the relevant sector and its typical levels of waste production (relative to output), reuse, recycling, recovery and disposal. ii. Actions being taken to encourage post-consumer Reuse, recycling and recovery of the assessed product. iii. Actions being taken to improve future reuse, recycling and recoverability of the assessed product. iv. Levels of community reuse and recycling of waste produced by the organisation. v. Levels of waste production relative to output set vs targets for reduction over time, and there after reported on an annual basis, as a minimum. vi. Staff and supply-chain engagement activities to promote behavioural change and to share best practices.	1
Transport impacts	The organisation shall establish a policy, supported by a documented management system, for	Compulsory

	continually reducing environmental impacts associated with the transport of materials, goods and people involved in its operations. The policy shall identify appropriate, significant, direct environmental impacts associated with the modes of transport used by the organisation. The policy analysis shall include impacts associated with: i. Energy use (fuel) ii. Normal emissions to air, land and water iii. Accidental emissions to air, land and water (e.g. spills, escapes) iv. Noise v. Packaging used for the purpose of transport and/or distribution The methodology used to identify significant environmental impacts shall be documented. The policy shall include mitigation strategies for significant environmental impacts.	1
	To achieve a higher 'Performance Rating', the organisation shall extend the scope of its transport policy and metrics to cover the supply of traceable constituent material(s) in the assessed product (according to the criteria described in clause 3.3.1in BES 6001).	
	Where the assessed organisation is responsible for the constituent material(s) at the source, the scope and boundaries of the policy shall cover all transport modes used, from the source of the constituent material(s) to the assessed product(s).	3
	A supplementary point may be awarded if the organisation reports performance against its transport policy and objectives to its stakeholders, on at least two of the following aspects: i. Methodology for identifying significant environmental impacts. ii. Significant environmental impacts identified by the organisation.	1

	iii. Mitigation strategies. iv. Performance against targets	

Source: BRE Global (2014: 14-35)

3.6.2 Operational context space (OCS) framework

The Operational Context Space Framework was developed to determine the success recorded in each stage of the project regarding sustainability. The framework focuses on resource-consumption patterns, environmental loadings and effect, delivered facilities and socio-economic impacts of human operation on the environment. A shortcoming for this framework is that, it has failed to present indices for assessing the sustainability parameters. Presley and Meade (2010: 449) argued that the framework for operational context space is not specific to measurable parameters. Again, Sarkis *et al.* (2012: 51) noted that the framework fails to include the process of sustainability implementation in the parameters identified.

An analysis of the framework for operational context space (OCS) is summarised in Figure 3.2:

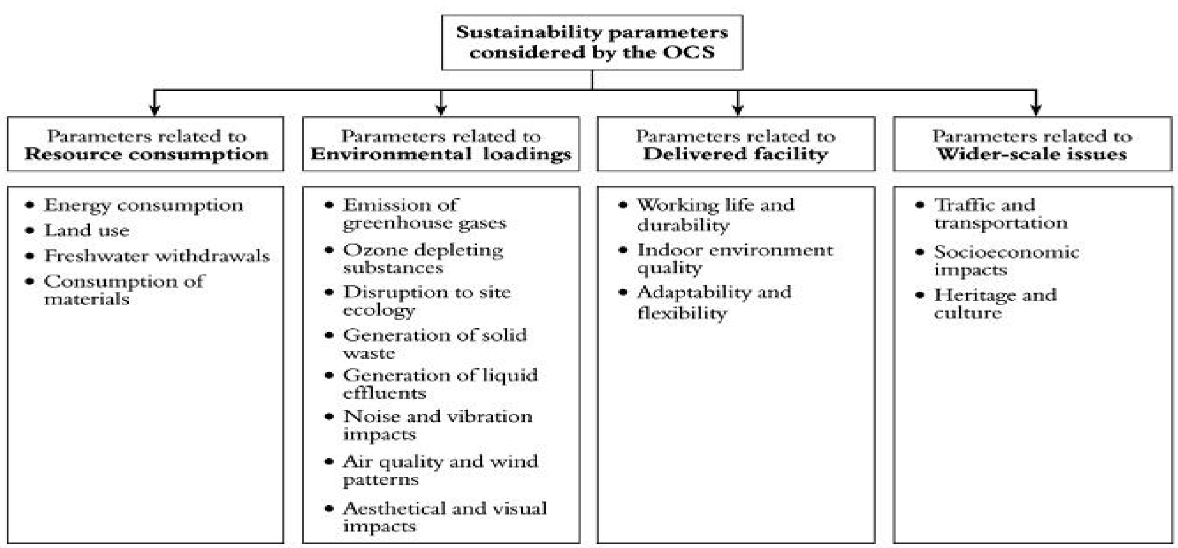


Figure 3.2: Operational context space framework

3.6.3 Organisation for Economic Co-operation and Development (OECD) Guidelines

The Organization for Economic Co-operation and Development (OECD) comprises suggestions to organisations operating in foreign countries on how to operate ethically. The guidelines were first adopted in 1976, with the aim of improving sustainability practices generally. Other partners to the OECD guidelines are governments and other stakeholders comprising committees from other nations (Abu-Tapanjeh, 2009: 559). There are at least thirty-five OECD and thirteen non-OECD countries that have fully endorsed these guidelines and also pledged to work with them. Some countries that adopted and have used the OECD guidelines, have noted their impact.

Shahwan and Mohammad (2016: 114) avowed that adoption of the OECD guidelines would increase organisations' and stakeholders' relationships positively in Jordan. Abu-Tapanjeh (2009: 558) believes that the OECD guidelines promote transparency, accountability and accurate disclosures by organisations. The OECD Guidelines for Multinational Enterprises cover areas, such as: the disclosure of the relevant information, employment and workers' industrial relations, environment, bribery and corruption, the interests of the consumers, healthy competition and taxation. A summary of the OECD guidelines is presented in Table 3.2.

Table 3.2: OECD guidelines for multinational enterprises

Guidelines	Areas covered
Sustainability objectives (environmental, social and economic)	Disclosure
	Employment and industrial relations
	Environment
	Combating bribery, bribe solicitation and extortion
	Consumer Interests
	Science and Technology
	Competition
	Taxation

Source: OECD(2011: 5)

3.6.4 Principles for responsible investment (PRI): a reporting framework

The Principles of Responsible Investment (Reporting framework) is an idea established by an international network of investors working together to ensure that the six Principles for Responsible Investment are put into practice, and have the supportof the United Nations. The principles considered in the framework seek to promote sustainability practices for responsible investment. Table 3.3 illustrates the six principles and their possible course of actions.

Table 3.3: Principles for Responsible Investment Reporting Framework

S/No	Principles	Possible actions
1.	We will incorporate environmental, social, and corporate governance (ESG) issues into investment analysis and decision-making processes.	▪ Address ESG issues in investment policy statements. ▪ Support development of ESG-related tools, metrics, and analyses. ▪ Assess the capabilities of internal investment managers to incorporate ESG issues. ▪ Assess the capabilities of external investment managers to incorporate ESG issues. ▪ Ask investment service providers (such as financial analysts, consultants, brokers, research firms, or rating companies) to integrate ESG factors into evolving research and analysis. ▪ Encourage academic and other research on this theme. ▪ Advocate ESG training for investment professionals.

2.	We will be active owners and incorporate environmental, social, and corporate governance (ESG) issues into our ownership policies and practices.	▪ Develop and disclose an active ownership policy consistent with the Principles. ▪ Exercise voting rights or monitor compliance with voting policy (if outsourced). ▪ Develop a engagement capability (either directly or through outsourcing) Participate in the development of policy, regulation, and standard setting (such as promoting and protecting shareholder rights) ▪ File shareholder resolutions consistent with long-term ESG considerations. ▪ Engage with companies on ESG issues. ▪ Participate in collaborative engagement initiatives ▪ Ask investment managers to undertake and report on ESG-related engagement.
3.	We will seek appropriate disclosure on environmental, social and corporate governance (ESG) issues by the entities in which we invest.	▪ Ask for standardized reporting on ESG issues (using tools such as the Global Reporting Initiative). ▪ Ask for ESG issues to be integrated within annual financial reports. ▪ Ask for information from companies regarding adoption of/adherence to relevant norms, standards, codes of conduct or international initiatives (such as the UN Global Compact). ▪ Support shareholder initiatives and resolutions promoting ESG disclosure.

4.	We will promote acceptance and implementation of the principles within the investment industry.	▪ Include Principles-related requirements in requests for proposals (RFPs). ▪ Align investment mandates, monitoring procedures, performance indicators and incentive structures accordingly (for example, ensure investment management processes reflect long-term time horizons when appropriate). ▪ Communicate ESG expectations to investment service providers. ▪ Revisit relationships with service providers that fail to meet ESG expectations. ▪ Support the development of tools for benchmarking ESG integration. ▪ Support regulatory or policy developments that enable implementation of the Principles.
5.	We will work together to enhance our effectiveness in implementing the Principles.	▪ Support/participate in networks and information platforms to share tools, pool resources and make use of investor reporting as a source of learning. ▪ Collectively address relevant emerging issues. ▪ Develop or support appropriate collaborative initiatives.
6.	We will produce report on our activities and progress towards implementing the principles.	▪ Disclose how ESG issues are integrated within investment practices. ▪ Disclose active ownership activities (voting, engagement, and/or policy dialogue). ▪ Disclose what is required from service providers in relation to the principles. ▪ Communicate with beneficiaries about ESG issues and the principles. ▪ Report on progress and/or achievements relating to the Principles using a 'Comply or Explain' approach. ▪ Seek to determine the impact of the principles. ▪ Make use of reporting to raise awareness among a broader group of stakeholders.

Source: PRI (2015)

3.6.5 Extractive Industries' Transparency Initiative (EITI)

The Extractive Industries Transparency Initiative (EITI) was floated at the World Summit on Sustainable Development in Johannesburg in the year 2002 by the then UK prime minister Tony Blair (Hayes and Knox-Hayes, 2014: 53). The EITI was established to protect the environment, to promote and to ensure transparency in the extractive industries of the participating nations. The participating nations include: Azerbaijan, Belgium, the Democratic Republic of Congo, Equatorial Guinea, France, Germany, Ghana, Indonesia, Italy, Japan, Kazakhstan, Mozambique, Netherlands, Nigeria, Norway, Sierra Leone, Timor-Leste, Trinidad and Tobago, the United Kingdom, and the United States of America.

Caspary (2012: 181) submitted that the EITI has gained popularity over the years, due to its multi-stakeholder approach and its adaptability in major areas, such as oil and gas and the mining industry. The EITI reports are prepared based on:

- The country reported;
- Its status;
- The period of disclosure;
- The reporting company;
- The year in which the report was prepared;
- The sector reported; and,
- The manner of reporting the findings.

3.6.6 United Nations Global Compact (UNGC)

The UNGC was launched in 2000 by the United Nations, with the aim of supporting organisations to advance, enhance and to uphold ethical-sourcing initiatives. The United Nations Global Compact (UNGC) was derived from the Universal Declaration of Human Rights; the International Labour Organization’s Declaration on Fundamental Principles and Rights at Work; the Rio Declaration on Environment and Development; and the United Nations Convention against Corruption.

Cetindamar and Husoy (2007: 164) profess that the UNGC promotes accountability, responsibility and transparency in organisations. Any organisation that is noted to be operating contrary to the law is frequently heavily sanctioned. Perez-Batres *et al.* (2011: 844) adapted the UNGC framework to show stakeholders how to legitimately operate their business.

Cetindamar and Husoy (2007: 167) sought to promote sustainable development by championing ethical values. However, Sethi and Scheepers (2014:167) noted the shortcomings with the UNGC, which are: The lack of accountability for their actions; the inability to generate the needed funds to execute its projects; and the lack of a uniform implementation level by the participating countries. The ten principles covered in the framework are illustrated in Table 3.4.

Table 3.4: The United Nations Global Compact Principles

S/no	Areas	Principles
1.	**Human Rights**	1: Support and respect the protection of internationally proclaimed human rights.
		2: Make sure that they are not complicit in human rights abuses.
2.	**Labour Standards**	3: The freedom of association and the effective recognition of the right to collective bargaining.
		4: The elimination of all forms of forced and compulsory labour;
		5: The effective abolition of child labour; and,
		6: The elimination of discrimination in employment and occupation.
3.	**Environment**	7: Support a precautionary approach to environmental challenges;
		8: Undertake initiatives to promote environmental responsibility; and,
		9: Encourage the development and diffusion of environmentally friendly technologies.
4.	**Anti-Corruption**	10: Work against corruption in all its forms, including extortion and bribery.

Source: UNGC (2015)

3.6.7 Summary of the frameworks for the ethical sourcing of materials

The need to clearly understand the items identified in the reviewed frameworks and to give a better view of the key items needed in the study necessitated a summary of the frameworks. The summary is presented in Table 3.5. The summary considered: The BES 6001, Operational context-space framework; the OECD guidelines; the Principles for Responsible Investment (PRI) Reporting Framework; the Extractive Industries Transparency Initiative (EITI); and the United Nations Global Compact (UNGC).

Table 3.5: Summary of the frameworks for the ethical sourcing of materials

S/no	Frame-work	Description	Area of attention
1.	**BES 6001**	The framework originates from the UK, in response to calls for the construction industry to implement sustainability practices. The frameworks was designed to work in line with other frameworks	Responsible sourcing policy Supplier management system
			Legal compliance
			Quality management system and operation management of responsible sourcing
			Supply management system
			Supplier chain Management Requirements
			Environmental management systems in the supply chain
			Greenhouse gas emissions
			Energy use
			Resources use
			Waste prevention and waste management
			Transportation management
2.	**Operational context space framework**	The framework was developed to measure sustainability practices at each project stage.	Resources consumption
			Environmental loading
			Delivered facilities
			Other key issues
3.	**OECD Guidelines**	The OECD Guideline was Established in 1976, with the aim of improving sustainability practices	Disclosure of relevant information
			Employment and

		generally. OECD guidelines seeks to promote transparency, accountability and accurate disclosures by organisations.	industrial relations Environment Combating bribery, bribe solicitation and extortion Interest of the consumers Science and Technology Competition Taxation
4.	**Principle for Responsible investment (PRI) Reporting Framework**	PRI was established by an international network of investors working together to ensure the six Principles for Responsible Investment are put into practice.	Environmental, social and corporate governance (ESG)
5.	**Extractive Industries Transparency Initiative (EITI)**	The EITI was floated at the World summit on sustainable development in Johannesburg in 2002 by the former UK prime minister Tony Blair	Environment
6.	**United Nations Global Compact (UNGC)**	UNGC was launched in 2000 to promote accountability, responsibility and transparency in organisations.	Human Rights Labour Standards Environment Anti-Corruption

Researcher's own construct, 2017.

3.7 Concluding remarks

In this chapter, relevant literature to the research area has been broadly discussed. Matters discussed include: Ethics, sources of Ethical theories, approaches to Ethical theories, Ethical principles, unethical practices in the construction industry and frameworks for Ethical sourcing of construction materials. The next chapter discusses the theoretical and conceptual frameworks for the research.

Chapter 4: Theoretical and Conceptual Frameworks of the Research

4.1 Introduction

This chapter presents the viewpoint which the research addresses, as well as theoretical and conceptual frameworks. Bothman *et al.* (2010: 96) contend that the introduction of frameworks gives the research credibility and acceptability. A framework presents the theory and perspectives of the problems that revolve around the research.

4.2 Location of the Theoretical Framework

The construction industry has positive impacts on humanity, because it provides infrastructure and employment for citizens. However, the industry also pollutes the environment and exploits the earth resources. Stakeholders in the construction industry have been calling for a new approach to achieve sustainability in the industry due to the magnitude of environmental effects.

Following the review of literature in the previous sections, some salient constructs emerged which included: environmental sustainability, sustainability reporting, materials production and materials transportation approach, which constituted the pillars adopted in the theoretical framework. Again, the pillars in the theoretical framework further resonated from the problem the research sets to address. Hence, the pillars in the theoretical framework present the theory that supports the research.

The theoretical framework adopted for this research is situated at the intersection of environmental sustainability, sustainability reporting, materials production and materials transportation approach (see Figure 4.1 presenting the theoretical framework). These approaches seek to explain the concept of sustainability where each concept extends in to the other. Ethics happens to be the commonality between environmental sustainability and sustainability reporting, environmental sustainability and materials production and materials transportation, materials production and materials transportation and sustainable reporting.

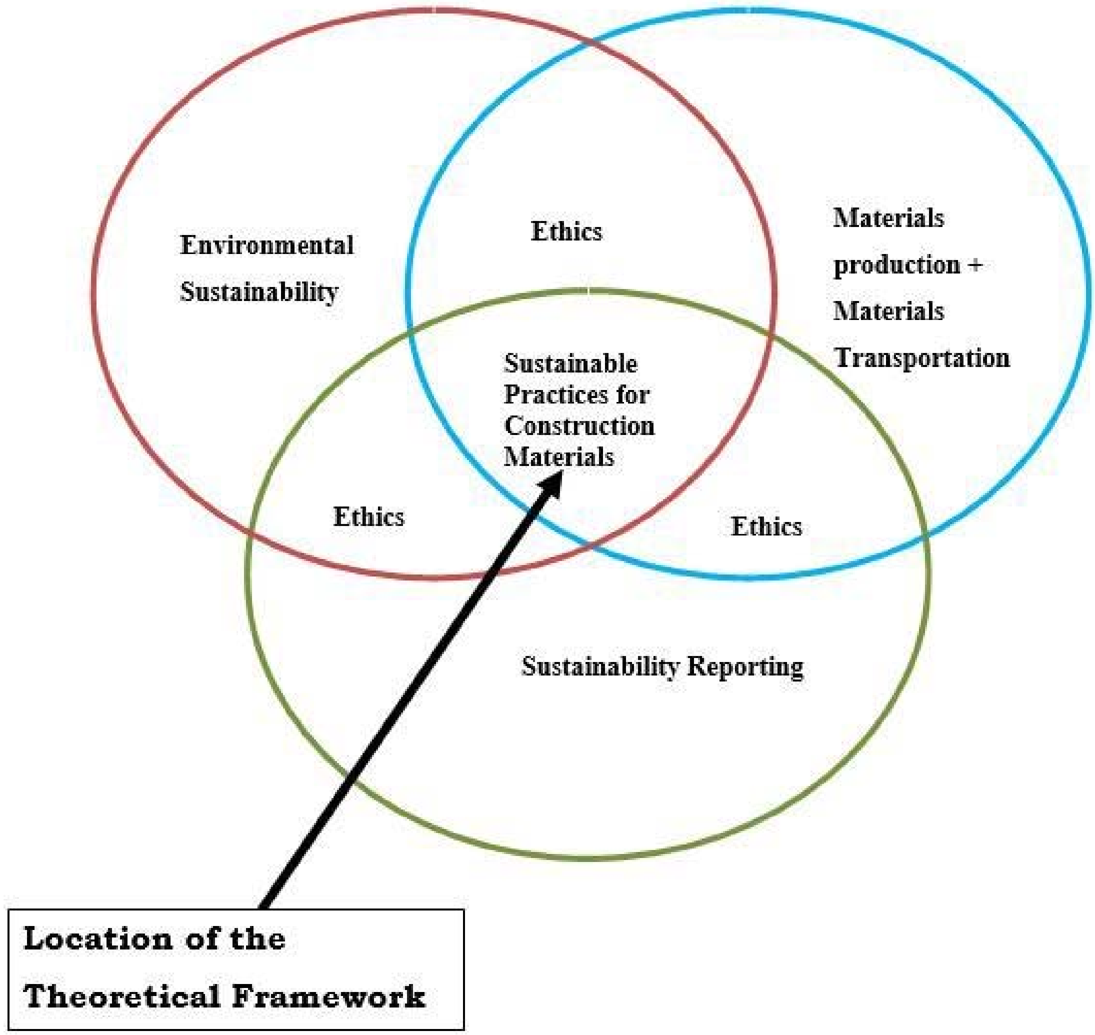


Figure 4.1: The research theoretical framework

Source: Researcher's own construct, 2017

4.3 The concept of Sustainability

Impact of Human activities on the environment, ranging from the extraction of resources; the production and use, have necessitated the call for sustainability. According to Lee (2014: 57), sustainability originated from Germany in the 17th century, as a term used to illustrate the nurturing of forest resources. Warde (2011: 153) also agreed that sustainability emerged from Germany in the 1713 forestry book called

"SylviculturaOeconomica" Since then; the sustainability uptake has improved across many disciplines including the construction industry.

However, Cowan *et al.* (2010: 524) argue that sustainability is an offshoot of the United Nations commission on environment and development in 1992, which proclaimed that ‘‘development is sustainable, where it meets the needs of the present without compromising the ability of future generations to meet their own needs”. Ali (2015: 2) viewed sustainability as the capacity of the ecosystem to keep up with all human activities. In theory, however, sustainability contains three pillars. These are economic, environmental, as well as social (Ali, 2015: 2). Robinson (2004: 369) explains that sustainable development should focus on balancing how society goes about growth and development with the ecosystem, which might be difficult to achieve – owing to the complications involved.

Kajikawa *et al.* (2011) believe that, sustainability movement also includes Building Environmental Assessment (BEA); since the intention is to promote sustainability in many spheres that determine human ongoing existence but not limited to energy, water, biodiversity, health and poverty reduction, thereby ensuring the sustainability of the rural and urban societies. Ali (2015: 3) shows that sustainability entails the capture of all the socio-economic and environment aspects. This is illustrated in Figure 4.2.

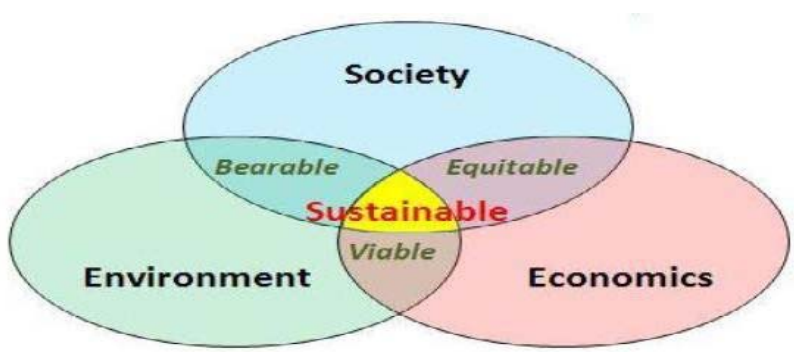


Figure 4.2: Sustainability constituents

Source: Ali (2015: 3)

Amalgamation of social, economic and environmental features is imperative for sustainable development considering human needs (Shakantu, 2004: 42). Hill and Bowen (1997: 224) declare that consumers' apprehension over the environmental impact of the production of goods and services has increased due to the ongoing depletion of resources and production and pollution.

Ali (2015: 47) believes that the global sustainability constituents are: social equity and cultural issues, economic constraints and environmental quality. Further details of the global sustainability context are illustrated in Figure 4.3.

Figure 4.3: The Global context of sustainability
Source: Ali (2015: 47)

4.4 Environmental Sustainability

Environmental sustainability is imperative for survival; since its stability determines human survival. The demand for environmental sustainability usually arises from the policy-makers and the agencies of government (Adamowicz, 2004: 425). Developed nations have a technological advantage because of their economic resources and the technological advantage they have over emerging economies. Consequently, they have the ability to effectively evaluate the impact of their operations on the environment (WCED, 1987: 49). Morelli (2011) viewed environmental sustainability as an equilibrium, rigidity and link that permits humanity to achieve their desired growth and development target and whilst not impairing on the stability of the ecosystem to support humanity.

The environment will fail to support humans if its threshold is exceeded due to human activities (Infante, 2014: 40). Tietenberg and Lewis (2012: 3) submit that there has been an increase in greenhouse gas emission into the atmosphere, since the industrial revolution period. Many studies have emphasised these negative impacts on the environment (du Plessis, 2014: 55; Randolph, 2012: 65 and Hansen, 2009: 258). Randolph (2012: 65) highlighted these negative impacts as: rising sea-level, flooding, irregular weather patterns and severe drought. du Plessis (2014: 55) contends that the sea level has been rising since 2010. This has also been supported by Hansen (2009: 258), who contends that the sea will continue to rise astronomically over the next century if humans do not address the negative environment effect of development, which is evidently not sustainable.

4.4.1 Sustainability assessment and indicators

Assessing sustainability can be viewed as a way of environmental evaluation; since the intention is to guard against the excessive use of resources. Infante (2014: 36) viewed these as:

i. Environmental impact assessment: Uptake started in 1970, to safeguard the environment against the effect of the developmental projects carried out.
ii. Systems analysis (Green accounting): This professes to be a way out of the inability to estimate the cost of resources in the environment.
iii. Cost-benefit analysis: This takes into account the social cost of a developmental project.

The study conducted by Ness *et al.* (2007: 500), showed that environmental sustainability should be addressed under three categories:

- Indicators and indices (non-integrated and integrated);

- Product-related assessment tools, which target material and energy flows when viewed from a life-cycle perspective; and,
- Integrated assessment, which involves tools on policy and project implementation.

4.4.2 Environmental challenges and Climate change

Man`s quest for development has made him rely on the ecosystem for the provision of resources. Tietenberg and Lewis (2016: 4) and White (2011: 1) note that the sun`s radiation in and out of the earth`s surface, enables greenhouse gases, including water vapour and other gases to retain some energy, which helps to regulate the temperature for survival on earth; but where the amount of green gases present in the atmosphere is high, this leads to increased temperatures, causing climate change. Caney (2010: 203) maintains that the earth is currently witnessing some intense changes, which he has attributed to various human activities. May (2013: 41) supports these assertions, by stating that the high rate of natural resource consumption, which is energy intensive is linked to climate change.

Again, du Plessis (2014: 55) submits that the average earth temperature has continued to rise recently. Bhagat (2016: 143) and du Plessis (2007: 4) note the impact of climate change on the polar regions, such as the rapid melting of icebergs. Despite the negative effects of climate change, the release of poisonous carbon monoxide gas, the high rate of energy consumption for various purposes and the waste generated continues unabatedly (du Plessis, 2007: 4). Robertson (2014: 80) forecasts a severe and lengthy heat wave intensity with a damaging impact on agricultural production, increased forest fires and extensive destruction of the ecosystem. These assertions on the impact of climate change are consistent with those of Caney (2010: 203), who contended that climate change impacts humans by: rising sea-levels, which destroy habitable land, settlements and infrastructure and increased exposure to greater risks of storm-surges.

Dimitrov (2010: 797) also argues that the cost of climate change and global warming on the environment and humans includes: a reduction in agricultural output, shortage of water, an increase in human health problems, the melting and evaporation of sea ice and the disappearance of the Greenland ice sheet. Furthermore, a continuous rise in the sea level is increasing migration across continents. Abbott (2012: 585) maintains that the climate change that the ecosystem is witnessing is attributed to the collective activities of human beings on earth and their past and present decisions taken. These activities and decisions do affect human survival.

Energy-consumption patterns, both industrial and commercial have a significant impact on climate change due to the release of pollutants into the atmosphere, such as dust emission from quarry sites (Tietenberg and Lewis, 2012: 361). The demand for resources and their utilization, is higher in developed and developing countries, due to the technological breakthrough. However, this cannot be said for underdeveloped countries due to their low level of technology. The impact of climate change, such as droughts, floods and global warming is felt more in under-developed countries due to their low adaptive capacity; even though they contribute very little to the greenhouse gases (Tietenberg and Lewis, 2012: 4).

Randolph (2012: 65) summarizes the risks associated with climate change and environmental challenges, as follows:

- Erosion of coastal areas, such as beaches, which affects the social and environmental stability of the areas.
- Spread of wildfires across vast arable farm-lands and forests that destroy the landscape, flora and fauna.
- Vulnerability of the environment to hazards relating to geology, such as volcanic eruption, erosion, landslides and earthquakes;
- Unbalanced weather pattern resulting in flooding, hurricanes, increased temperature, drought and tornados.

In addition, Houghton (2009: 4) noted the various impacts of climate change to include: (1) Irregular rainfall patterns in selected parts of the world such as the semi-arid areas, which often leads to drought and food shortage; (2) Rise in sea level, as a result of the heating of large water bodies, which expand and overflow their banks – causing floods, as witnessed across all the continents; (3) Abnormally high temperatures that cause death to people, plants and livestock; (4) Increase in the intensity of storms linked to hurricanes or typhoons that destroy cities and property; and (5) Rising temperatures in the polar regions.

Dimitrov (2010: 798) insists that water shortages do persist; and affect 20–25 percent of the world's population, with a devastating impact on 75–250 million people in Africa. On the contributions of developing and developed nations to climate change, Akadiri (2011: 29) envisaged that according to Figure 4.5, the contributions of developing countries to total greenhouse gas emission will supersede the amount released by their developed counterparts after 2015.

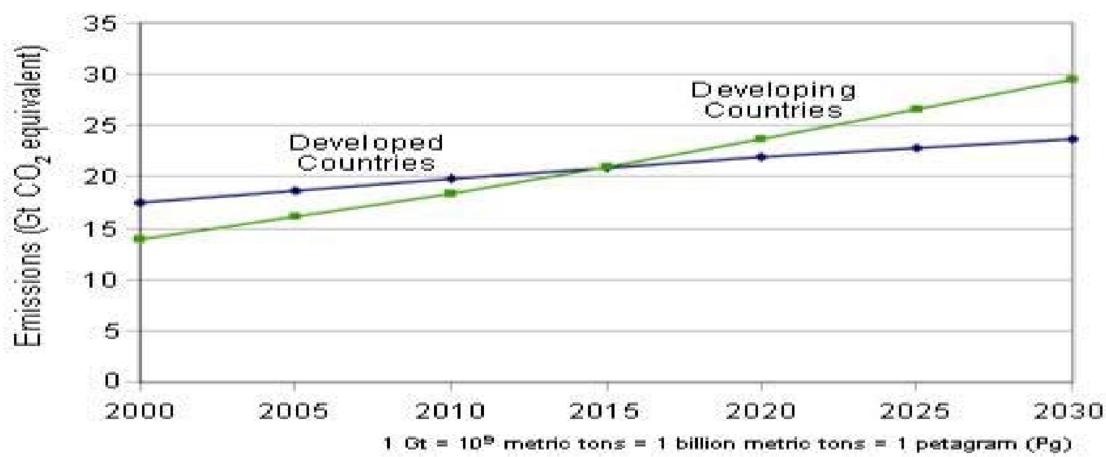


Figure 4.5: CO_2 Emission pattern in Developing and Developed countries
Source: Akadiri (2011: 29)

Caney (2010: 205) investigated the best practice to mitigate the impact of climate change; and stressed that the mitigation and adaptation approaches are appropriate. However, he acknowledged that both approaches are tailored towards sustainability; the mitigation approach focuses on the duties and efforts that would stop climate change. The adaptation approach focuses on ways to ameliorate the impact of climate change by building sea-walls to prevent flooding and paying people off to vacate their houses and land. Caney (2010) advocated for the need to consider both approaches; since the world is currently witnessing the impact of climate change; and it is necessary to put a stop to behaviours that increase the impact of climate change.

White (2011: 1) recommends the urgent need to mitigate climate change by cutting down emission pathways, and for the general public to acknowledge these changes, so as to develop the adaptive capacity to combat the effect of climate change.

4.4.3 Factors influencing Climate change

Climatic conditions differ over time. This has been attributed to human factors. Pojman and Pojman (2010: 334) identify the major sources of greenhouse gases (GHGs) as:

Carbon dioxide: This is largely from the combustion of fossil fuel, cement production and land-use.

- Methane: Fossil fuels (mines, natural gas production) burning of biomass, landfill sites.
- Nitrous oxide: This gas emerges from various industrial sources and bush burning.
- Chlorofluorocarbons: Burning of foams; release of gases from aerosol cans; and polymers specifically from Teflon.

Metz *et al.* (2005: 23) state that the major source of CO_2 emission is industrial processes and activities. They submitted that the cement production process is the highest source of greenhouse gases. Pojman and Pojman (2012: 414) submit that the industrial revolution has also contributed to climate change due to the various activities executed by man against the natural forces, such as variability in the amount of heat radiated, earth movement and the frequency of volcanic action. They affirm that the following have contributed to climate change with respect to industrialisation:

i. Change in land utilisation: Various human activities ranging from deforestation to agricultural activities do contribute to climate change by warming and cooling of the earth`s surface. The cutting and clearing of the land surface enhances the reflection of solar energy into the atmosphere.
ii. Aerosols and sprays: Combustion of fossil fuels and sprays from cans do increase or decrease the average atmospheric temperature, as a result of the release of sulphate aerosols and black carbon soot. Sulphate aerosols contribute to cloud formation and decreasing average temperature; while black carbon soot warms the earth`s surface.
iii. Cosmic rays: Cosmic rays also have an impact on cloud formation, which contributes to change in the long run. However, recent studies hint that cosmic rays contribution to climate change is milder than that of the greenhouse gases.

4.4.5 Global warming

Global warming is a major debacle facing the ecosystem. du Plessis (2014: 51) noted that global warming is a complex challenge ravaging the world in the 21st century, necessitating actions and policies to address the challenge. Akadiri (2011: 27) believes that climate change is similar to global warming; since both are caused by the upsurge of greenhouse gases, as a result of energy in the atmosphere.

Houghton (2009: 2) expounds that human activities are the major cause of climate change currently ravaging the world; and these activities include the emission of chlorofluorocarbons (CFCs) into the atmosphere. Escape of refrigerants and industrial gases together deplete the protective ozone layer. Houghton (2009: 2) also added that carbon dioxide is released into the atmosphere, as a result of the flames from the combustion of fossil fuels, coal, oil and gas.

According to the UNEP report (2007: 1), the construction industry contributes 30-40% of greenhouse gas emissions. This is attributed to energy use in the sector.

Houghton (2009: 3) provided evidence of the steady rise in average temperature; and he validated his argument that continuous warming of the planet witnessed for over half a century is due to greenhouse gases in the atmosphere, notably CO_2. Dos Santos (2011: 4216) contends that various human activities are the major factors that contribute to global warming and the climate change currently impacting the earth. du Plessis (2014: 52) argues that since global warming is a threat to sustainability, there is urgent need not to only trim down the emissions pathway, but to also establish and implement laws that would drastically reduce the amount of greenhouse gasses released into the atmosphere.

Caney (2010: 203) avers that increased global warming is a threat to sustainability by causing deaths due to drought and malnutrition. Caney (2010: 203) further submitted that, climate change brings about increased temperatures, causing death due to heat stress; changing patterns of rainfall in some regions, which result in flooding and other natural disasters. Robertson (2014: 83) adds that with the current environmental changes in the ecosystem, there is need to find a way to reduce green-house gas emissions if the present and future generations are to survive; and recommended the establishment of programmes, such as:

Planning: This would involve laying out a roadmap for the responsibilities to be carried out and the goals to be achieved. The set goal or goals should be measurable, so as to benchmark the initial position. The set goal could include the cutting down of greenhouse gas emission from the present level. Boundaries should also be considered during the planning stage, so as to actualise the plan, such as limiting the greenhouse gas-emission source from the operational vehicles of organisations. Consideration should also be given to the scope of the plan, so that limits can be set for the proposed plan to succeed. Leaders should be delegated with specific duties and responsibilities for the proper monitoring of the plan.

Accounting: After completing the plan, the next step is to carry out a detailed account for green house emission largely for carbon footprint assessment. The accounting process should take stock of various emission pathways and help to determine the highest sources of greenhouse emissions and how decisions could be made to reduce the emissions. The measurement process should also involve the establishment of boundary emissions, the collection of the relevant data, the calculation of greenhouse gas emission, in addition to quality control for checking and preventing financial penalties, litigation and also for evaluation to monitor whether the set goal(s) have been achieved.

Emission reduction: The approach should be set to achieve the planned goals, in order to cut down emissions. An inventory for greenhouse gas emissions would help to determine the best method that would guarantee the best practice. Similarly, there is a need for the early execution of climate action plans, so as to avoid negative criticism that might threaten the programme.

4.4.6 Pollution

Human activities generate unwanted by-products, which are often harmful. Robertson (2014: 136) indicates that these by-products are transferred from one point to another largely through air and water. Houghton (2009: 2) notes minute quantities of pollutants e.g. chlorofluorocarbons (CFCs) emitted from industrial gas emissions into the atmosphere could travel long distances and cause serious damage along the way. The burning of fossil fuels, from vehicles, plant and machinery renders the ecosystem vulnerable to climate change due to the release of poisonous gases into the atmosphere (Houghton, 2009: 2).

Barrow (2006: 290) classifies pollution into primary and secondary categories. He submitted that primary pollutants have an instant effect on the environment when released into the atmosphere; but the secondary pollutants have to interact with moisture, sunlight and other pollutants to affect the atmosphere, water bodies and soil. He further noted that pollution may be toxic or non-toxic, such as chemical, biological, radiation, heat, light, noise, dust or offensive odours.

Robertson (2014: 138) categorizes pollution in three basic sources. These include:

Air pollution: This arises as a result of industrial activities that discharge dust and particles from the production process. Released pollutants are inhaled by humans and animals as they breathe in oxygen. Primary pollutant particles, such as: Carbon monoxide (CO), sulfur dioxide (SO_2) and lead (Pb), are deleterious to humans and animals.

Soil and land pollution: Soil and land pollution are largely attributed to economic activities, such as mining and oil drilling. The production processes of these activities discharge harmful substances, including leaked oil, Cadmium and Lead, which are often washed into rivers, streams and lakes, where they can affect marine animals and fishes.

Water pollution: Water is known to be a universal solvent, due to its ability to dissolve other substances. This unique characteristic makes it vulnerable to contamination due to its ability to dissolve, carry and transport pollutants from one point to another. Remediation measures for polluted water are often expensive and complex to carry out.

4.4.6.1 Pollution prevention

Pollution in water, soil, land and air affect the ecosystem negatively. Akadiri (2011: 118) puts forward steps to reduce pollution emanating from various construction processes. These include:

- Carpooling during the transportation of construction materials;
- Resourceful management of site activities;
- Use of methods and practices that reduce waste generation from various construction activities; and,
- Recycling of the construction waste generated.

4.4.7 Sustainable construction

The term sustainable construction (SC), emerged after the initial International Conference on sustainable construction in Tampa-Florida in 1994 (Bourdeau ,1999: 354

and Hill and Bowen, 1997: 225). According to Hill and Bowen (1997: 225), the concept of sustainable construction emerged due to human need and the demand for infrastructure, such as buildings, roads and bridges, which use large quantities of natural resources. This called for the construction industry to be responsible in the pattern of consumption (Hill and Bowen,1997: 225). Maduka *et al.* (2016: 1) view sustainable construction as a division of Sustainable Development, which encompasses economic development, social advancement and conservation of the environment. Bourdeau (1999: 354) views sustainable construction as the process of minimising the impact human activities have on the environment. du Plessis (2009: 46) highlighted that sustainable construction is underpinned by development, social well-being and limiting of the environmental impact, as shown in Figure 4.6.

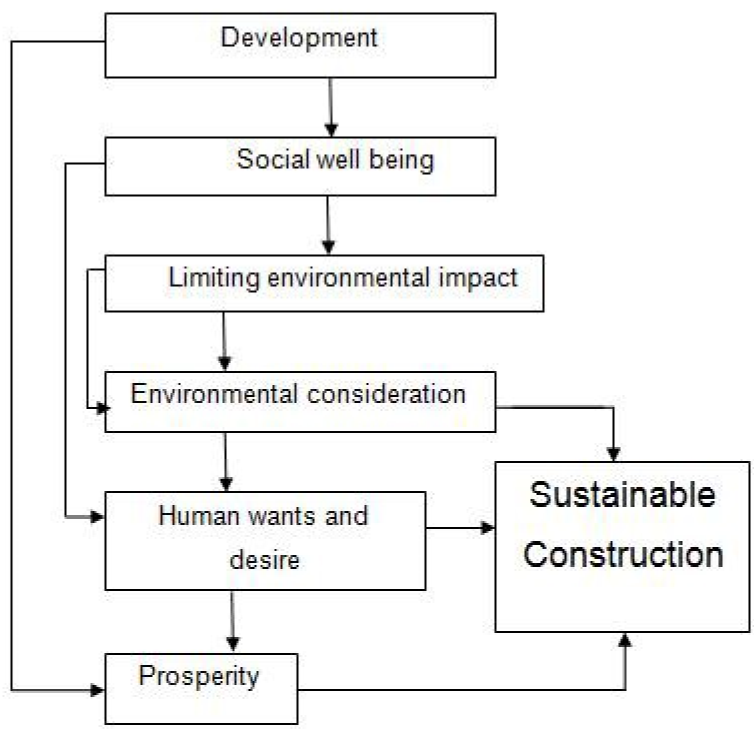


Figure 4.6: Constructs underpinning Sustainable Construction

Adapted from du Plessis (2009: 46)

Sev (2009: 163) developed a framework for evaluating sustainability principles and strategies in the construction industry. The framework outlines the three principles for sustainable construction. These include: resource management, life-cycle design and design for humans. Besides these three principles, there are strategies for sustainable construction, which are further divided into ten steps, as illustrated in Figure 4.7.

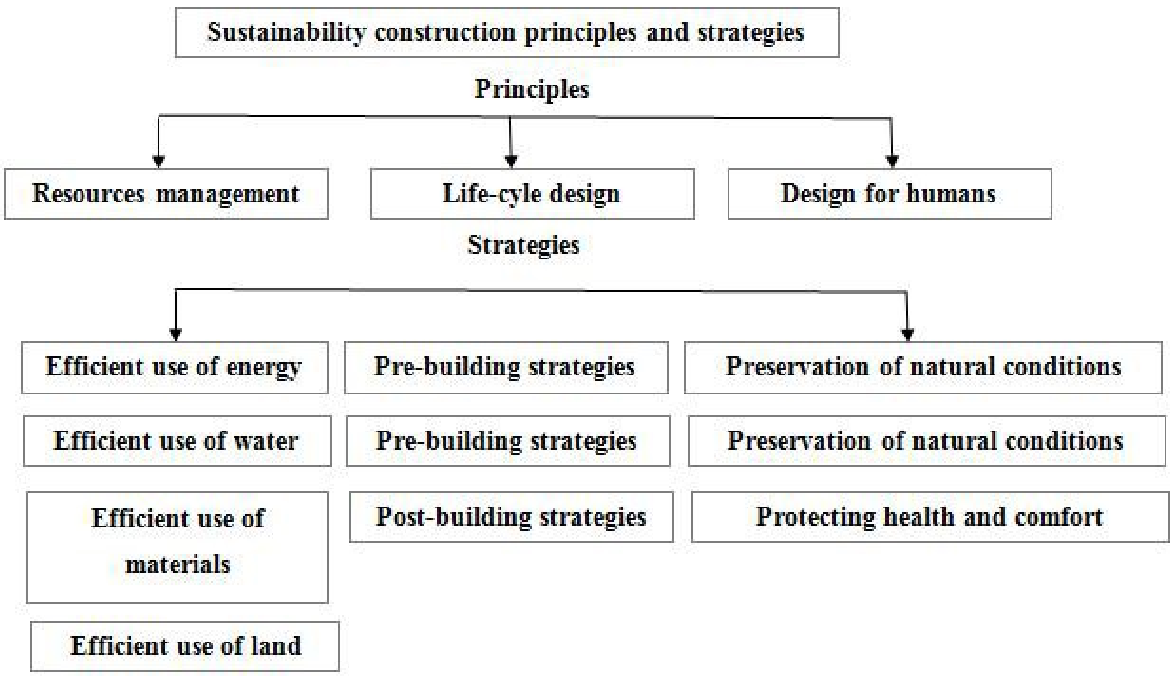


Figure 4.7: Framework for Construction Industry Sustainability evaluation
Source: Sev (2009: 163)

Presley and Meade (2010: 447) developed a framework for sustainable construction that encompasses best practices for organisations to include: a balanced scorecard, and multi-attribute decision models. The model incorporated parameters for sustainability measurement, which includes key parameters to measure construction practice and to achieve sustainability. Kibert (2007: 595) views sustainable construction as a rejoinder to various impacts of human activities, in order to lessen the impact on humans and animals. Furthermore, the pressure exerted by the construction industry includes: material-extraction processes, construction-material manufacturing, construction stage, repair of components, energy and water utilisation. Hill and Bowen (1997: 227) suggested some approaches for sustainable construction, which are divided into social, economic, biophysical and technical. The analysis of sustainable construction, according to Hill and Bowen (1997: 228) can be summarised as follows.

- **Social sustainability:** This focuses on the upliftment of the general human standard of living, ensuring equity from one generation to another, equitable provision of facilities and amenities to humans; policy planning and implementation for the poor and the middle class in society; as well as a special provision for human health and development.
- **Biophysical sustainability:** This involves planned materials and the extraction of natural resources and their usage; recycling and the reuse of energy, water and material resources. Cutting down pollution to air, land and water. Promotion of policies and acts that would enable the earth's resources to be regenerated.
- **Technical sustainability:** Buildings and structures constructed should stand the test of time; quality should be a key criterion for assessing projects; as well as the restoration and retrofitting of ancient building and structures to meet the current standards.
- **Economic sustainability:** The housing and facilities provided should be affordable to citizens; job creation and use of people rather than machines and robots; prices and tariffs should be competitive; supplier engagement should be based on reputation and track records.

Presley and Meade (2010: 437) advocate that sustainable construction should be integrated with the goals of the host community, which should be in line with the global best practices. The integration of sustainable development concepts and principles into the construction process would ensure sustainable construction (Kibwami and Tutesigensi, 2016: 65). Bourdeau (1999: 357) noted that sustainable construction approaches and concerns vary from one country to the other; but he explained that this is a wake-up call for the construction industry stakeholders to be more compassionate to the ecosystem, in order to ensure a sustainable planet. Furthermore, for sustainable construction to be achieved, solutions should be found for the following challenges:

I. Physical challenges that are impediments to the natural environment;
II. The tackling of biological challenges to population survival; and,
III. The sociological challenges associated with the continued existence of the present and the incoming generation.

The importance of sustainable construction to sustainability is recognised by Adebayo (2002: 1), who mentioned that sustainable construction should be a priority; since it focuses on balancing the political, economic, social and developmental concerns within an area. Bakhtiar *et al.* (2008: 65) examined sustainable construction in their study; and they concluded that sustainability indicators include: (1) Waste reduction policies; (2) Saving costs on projects; (3) Time saving; (4) Quality achieved; (5) Recycling of used construction materials; (6) Safeguarding the fauna and flora; (7) Air-pollution prevention; (8) Noise-pollution reduction; (9) Reduction in energy usage; and (10) Prevention of water pollution.

Sustainable construction specifically targets techniques that would cut pollution levels for waste generation; gas pollutants from the burning of fossil fuels and noise levels, so as to reduce the contaminants discharge into the environment (Presley and Meade, 2010: 437). The urgent need to promote actions that improve sustainability caused Petri *et al.* (2014: 457) to suggest that the way to advance sustainable practice in the construction industry would require designing a knowledge-integrated approach to enhance sustainable construction by the dissemination of knowledge between the relevant stakeholders within the construction industry.

The study has contributed to sustainable construction by providing a platform, from which sustainability-related information, such as energy utilisation and low carbon solutions could be shared amongst the professionals.

4.4.7.1 Barriers to sustainable construction

The lack of proper implementation of sustainable practices in the construction industry has often been attributed to various factors. du Plessis (2007: 70-71) highlights that the barriers to sustainable construction in developing countries include: environmental distortion, population explosion; poverty; inadequate amenities; low levels of education; unpredictable economies; and weak institutional capacity.

In the opinion of Matar *et al.* (2008: 261-253), the barriers to sustainable construction are:

- Lack of adequate commitment from the stakeholders;
- An inadequate understanding of sustainable construction;
- A long duration in harvesting the benefits of sustainable construction;
- The cost of implementing sustainable construction;
- The lack of established practices and principles for sustainable construction;
- The absence of a structured framework applicable to sustainable practices in the construction industry;
- Non-uniform methods of project delivery; and,
- Inadequate innovation and development by various stakeholders.

Similarly, Kibert (2016: 17) submits that the barriers are enormous, and include:

i. Financial hindrance: Relating to project life-cycle cost analysis and use; the cost of implementation; difference in capital and running cost; and funding challenges.
ii. Insufficient research: Challenges in securing adequate funds to improve research; less research focused on health; environment and productivity; and dissimilar research areas.
iii. Inadequate sustainability awareness: Shallow thinking approach and perceived risks.

For the construction industry to achieve sustainability, there is need for urgent attention and strategic planning to offset the barriers to sustainability in construction. du Plessis (2007: 73) proposed some strategies to overcome these barriers, namely:

- Setting reliable polices for examining and assessing sustainability performance in the industry;
- The adoption of a method and system that would promote sustainable construction;
- Aligning internal organisational tradition with sustainable construction principles;
- Development of synergy between countries and nations;
- Establishment of internal and external capacity to promote sustainable construction principles; and,
- Allocating funds to champion sustainable construction principles.

Kibert (2016: 17) advocates that barriers to sustainable construction can be surmounted by: (1) Government commitment; (2) Encouragement to private and public sectors of the economy; (3) Adoption of sustainability practice at the State and local level; (4) Public enlightenment by professionals; and (5) Research and technology adoption.

4.4.8 Population growth, resource scarcity and climate change

The demand for natural resources by humans continues to put pressure on the ecosystem. Resource demand by humans ranges from land, minerals, food and materials, which are supplied by the ecosystem. Barrow (2006: 234) views natural resources as anything that humans consider to have value, such as natural resources that can be explored and mined from the earth’s crust.

Dahabra (2014: 14) claims that the abundant natural resources for growth and development propelled the industrial revolution; but this was constrained by the paucity of skilled labour to drive the development process. Growth and development have unleashed some negative impacts on the earth`s surface, such as climate change.

Kibert (2016: 9) argues that climate change has increased the amount of carbon dioxide; methane; and other green gases on the earth’s surface.

Furthermore, continuous population growth has made these resources scarce; while the human population continues to be on the increase making competition for resources fierce.

Dahabra (2014: 14) maintains that a way out of this present debacle is to consume the resources available sustainably. Kibert (2016: 11) claims that the built environment has responded to calls for the reduction in carbon released into the atmosphere by the establishment and the promotion of policies, such as low-carbon, carbon-neutral, and zero-carbon buildings.

Barrow (2006: 237) summarised some of the operations that exploit natural resources in the earth crust to include:

- Mining operations of non-renewable natural resources;
- The production of renewable natural resources, such as sulphur from volcanic deposits;
- Agricultural products from natural vegetation, well-managed plantations, such as natural rubber, bamboo and fibres; and,
- The sourcing of unsustainable natural resources which degrade the environment.

Human activities that negatively impact on the environment are discussed in the subsequent sections.

4.4.8.1 Ozone (O_3) depletion

Sunlight radiates onto the earth`s surface, thereby heating up the ecosystem. The ozone layer is made up of gases, situated at a distance of 25-30 km over the earth’s surface; and this protects the earth from direct 97% - 99% Ultra Violet (UV) radiation from the sun, which can result into extreme heat waves (Bhagat, 2016: 144).

Ravishankara *et al.* (2009: 123) attributed the rapiddepletion of the stratospheric ozone layer to various human activities; mainly the industrial processes, which constitute the major environmental challenges in the ecosystem. Bhagat (2016: 144) states that the central cause of depletion of the protective ozone layer is the excessive release of substances that contain chlorine and bromine in the form of Chloro-fluorocarbons (CFCs), Methyl chloroform ($C_2H_3Cl_3$), Carbon tetrachloride (CCl_4), Hydro-chlorofluorocarbons (HCFCs), Hydrobromofluorocarbons (HBFCs) and methyl bromide (CH_3Br), which have a devastating effect on the ozone layer.

Ravishankara *et al.* (2009: 123) posit that Nitrous oxide and Chlorofluorocarbon have similar characteristics, many of which are unwavering, dominant abilities and when emitted, these are transported over long distances, where they damage the stratospheric ozone.

4.4.8.2 Acid rain

Acid rain is another environmental challenge facing the present generation; and it is also a potential threat to the incoming generation. Chen *et al.* (2015: 21) and Singh and Agrawal (2008: 15) attribute acid rain to the existence of pollutants in the ecosystem, which are brought about by the drive for industrialization where harmful substances are released into the atmosphere and by the burning of fossil fuels during the transportation process. These harmful substances reach the earth`s surface in the form of rain, snow and fog. Oxides released into the atmosphere from the burning of coal, the smelting of Zinc and Iron and the exhaust fumes from motor vehicles are the main sources of acid rain (Singh and Agrawal, 2008: 15).

Chen *et al.* (2015: 21) further noted that acid rain has negatively affected buildings, causing rapid deterioration, forest destruction and also a threat to aquatic life and human health. Pandey *et al.* (2014: 85) recommend the development of strategies, the use of advanced technology during the mining of raw materials and the enlightenment of the public to reduce acid rain. The environmental challenges and concerns on the environment are presented in Table 4.1.

Table 4.1: Environmental challenges and concerns caused by activities in the construction industry

S/no	Environmental challenges	Concerns
1.	Global climate change	Greenhouse gas (GHG) emissions from energy use, non-fossil fuel emissions from material manufacture (e.g. cement production, iron and steel processing), transportation of materials, landfill gases.
2.	Fossil fuel depletion	Electricity and direct fossil fuel usage (e.g. power and heating requirements), feedstock for plastics, asphalt cement, and sealants, solvents, adhesives.
3.	Stratospheric ozone depletion	Emissions of CFCs, HCFCs, Nitrous oxides (e.g., cooling requirements, cleaning methods, use of fluorine compounds, aluminum production, steel production).
4.	Air pollution	Fossil fuel combustion, mining, material processing, manufacturing processes, transport, construction and demolition.
5.	Smog	Fossil fuel combustion, mining, material processing, manufacturing processes, transport, construction and demolition.
6.	Acidification	Sulfur and NOx emissions from fossil fuel combustion, smelting, acid leaching, acid mine drainage and cleaning.
7.	License to operate and campaign	Manufacturing effluents, nutrients from nonpoint source runoff, fertilizers, waste disposal.
8.	Eutrophication	It could damage the reputation of the business. Have legal implications or wake up 'sleeping dogs' (such as environmental organisations).
9.	Deforestation, desertification, and soil erosion	Commercial forestry and agriculture, resource extraction, mining, dredging land.
10.	Habitat alteration	Land appropriated for mining, excavating, and harvesting materials. Growing of biomaterials, manufacturing, waste disposal.
11.	Loss of biodiversity	Resource extraction, water usage, acid deposition, thermal pollution.
12.	Water resource depletion	Water usage and effluent discharges of processing and manufacturing.
13.	Ecological toxicity	Solid waste and emissions from mining and manufacturing, use, maintenance and disposal of construction materials.

Source: Calkins (2009: 15)

4.4.9 International policies supporting environmental sustainability

Various policies and agreements have been developed to support environmental sustainability and to reduce the impact of climate change. These include:

4.4.9.1 The American block

The United States of America (US) is often ranked among the highly developed countries in the world, due to their global presence and advancement in technology and industrialization. Schreurs (2008: 344) claims that the United States has deliberately lagged behind other developed countries in the world in implementing issues relating to setting targets on climate change. He further illustrated that developed nations, such as Germany have recorded a reduction in their emission level by 18.7%; the United Kingdom has cut its emission to 15.7 percent; while the Swedish emission level is 7.4%, from 1990 to 2005.

Guber (2012: 3) submitted that Americans recently are highly divided across political lines on issues relating to environmental hazards. Some want positive change; while others remain nonchalant. The reason for this political division and nonchalant attitude of the citizens is traceable to conflicting statements issued by environmental advocates on the effects of climate change; and scientists, who on the other hand, discredit these statements (Guber, 2012: 4).

In Canada, activities in the extractive industry have pushed the emission level up by 17% above what was obtainable in the early nineties (May, 2013: 62). This makes Canada more vulnerable to climate change. In a study conducted by Rivers (2010: 212), it was noted that the Canadian government is campaigning uncompromisingly for its citizens to trim down the greenhouse gas emissions below that obtained in 2006, i.e. 20%. The implication is that greenhouse gas emissions would go down between 30 to 40% by 2020; and this would reduce production activities and affect businesses.

4.4.9.2 The European block

Regions have prominent roles in mitigating climate change. The European block has displayed a serious commitment, as signatories to the international regulation on climate change (Keohane and Victor, 2011: 13). According to May (2013: 56), the European block member states which comprise twenty-two active countries, have generally agreed to lower their global emission against the level recorded in the late nineties. By the year 2020, this should be reduced further, thereby demonstrating their commitment to reducing climate change; through adoption of internal domestic laws and policies (Keohane and Victor, 2011: 13).

Dröge *et al.* (2009: 14) suggested that the European block has been proactive by forming a global alliance, which comprises both European and non-European countries for the creation of a global carbon market, in order to mitigate global carbon emission.

The European block, in order to set an example for others, has established a new policy that will minimize their emission levels. van Asselt and Brewer (2010: 44) observed that the European block drastically changed its policy against the previous one; where they planned for a new emission cap policy by 2013 to cut down their emission levels.

4.4.9.3 The Asian block

Asian countries have recorded rapid development recently. China and most Asian countries have evolved to become the highest global production and manufacturing arenas. However, development in this block contributes to climate change due to large amounts of pollution and emissions from various production processes (Keohane and Victor, 2011: 13). Keohane and Victor (2011: 13) noted that, the Asian block is also proactive in reducing the impact of climate change by joining a coalition to support black carbon regulations and to enhance sustainability.

The Chinese government policy on climate change has achieved a lot on issues relating to the environment, due to the continuous drive for industrial activities and economic growth (Schreurs, 2008: 346). Li and Lin (2013: 671), however, maintain that China's model to cut down carbon emissions would not achieve the desired objectives; because they are currently among the world`s industrialized nations that manufacture goods and emit more carbon. Chen *et al.* (2015: 32) recommends a holistic approach that would involve other Asian countries in promoting climate change.

4.4.10 Global milestones against Environmental Challenges and Climate Change

4.4.10.1 Kyoto protocol

Prominent among global efforts to deal with the issues relating to climate change and environmental challenges is the Kyoto protocol. According to Cox (2007: 128), the Kyoto protocol, was established with the aim of reducing the global emission of greenhouse gases that pollute the atmosphere. The Kyoto protocol is a result of accords among different countries on the need for policies to minimise Greenhouse gas pollution. May (2013: 75-58) asserts that the Kyoto protocol is an offshoot of the United Nations (UN) Framework conference on climate change held in Japan in 1992, which was done in agreement with almost all the countries in the world; and it was named the "earth meeting".

Among the agreements reached at the Kyoto protocol was the need to cut down the emission levels globally of Carbon dioxide (CO_2), Methane(CH_4), Nitrous oxide(N_2O) that must not exceed 6–8% of the 1990 levels for the developed nations (Chan *et al.,* 2010: 1665).

Similar global initiatives to reduce climate change from the present level have emerged. Szabo *et al.* (2006: 72) submit that the adoption of emission trading at the international level is a concept that emerged from the Kyoto Protocol on climate change, in an attempt to mitigate greenhouse gas emissions. The outcome of the accord has, however, attracted substantial criticism due to its low impact. Keohane and Victor (2011: 10) and Boiral (2006: 6) note that the United States opposed the Kyoto protocol's non-inclusion of the duties and responsibilities of developing countries, with respect to the minimization of greenhouse gas emission from various sources.

Keohane and Victor (2011: 10) affirm that efforts are under way to ensure that the Kyoto Protocol, includes those regions that were omitted. Ravishankara *et al.* (2009: 123) report that Nitrous oxide, a greenhouse gas in the atmosphere has received little attention for its control under the Kyoto Protocol on emissions. Pojman and Pojman (2012: 453-454) in their own submission on the Kyoto Protocol identified the following as the reason why it received global condemnation:

- Measures developed to combat emissions were ineffective due to the fact all the stakeholders involved were not compelled to operate, according to the Kyoto Protocol declaration;

- Countries were given the opportunity of trading their unused emission capacity and the acceptance of forests as sinks for the emissions released;
- Not reaching a substantive agreement on some important details in the protocol; and
- The backing out by the then president of the United States, even though the USA was a central figure in the Kyoto Protocol.

4.4.10.2 The Montreal protocol

The Montreal protocol is among the major global coalitions to combat climate change. Keohane and Victor (2011: 11) argue that the Montreal Protocol aimed at combating climate change and reducing the depletion of the ozone layer, was convened due to some lapses noted in the Kyoto protocol on global warming and climate change. National governments around the globe, have embraced and adopted the Montreal Protocol to curb pollution from industrial processes; but not much success has been recorded (Keohane and Victor, 2011: 11). Nettleton (2010: 174) posits that the developed countries, such as America and Germany under the Montreal protocol, have made provision to protect the ozone layer through their commitment to the low percentage of chlorofluorocarbon emissions.

4.4.10.3 G8 Countries

The G8 countries comprising Canada, Germany, the United States, France, the United Kingdom, Japan, China and Italy. They emerged due to various challenges faced by the ecosystem, mainly climate change. Keohane and Victor (2011: 11) argue that one of the goals of the G8 nations is to ensure that the average temperature stays at 2 degrees Celsius above pre-industrial levels. Furthermore, they also remain resolute to ensure that the greenhouse gas emissions reduce drastically globally by the year 2020 (May, 2013: 56).

Neuhoff (2008: 5) explains that the G8 leaders reached a consensus for a drastic reduction on carbon emissions to a minimum of 50% by 2050. Keohane and Victor

(2011: 11), however, noted that the G8 countries have not achieved much because of their size constraint that has dwarfed their impact.

4.4.10.4 International standards organisation (ISO)

The International Organisation for Standardization (ISO) is a non-governmental international private body, which was established in 1947, with the aim of promoting basic standards in international trade, communications and manufacturing (Ward, 2011: 2).

The ISO standards (2008: 1) were developed to tackle challenges relating to climate change namely: (1) Monitoring climate change; (2) Quantifying GHG emissions and communicating on environmental impacts; (3) Promoting good practice in environmental management and design; and (4) Opening world markets for energy-efficient technologies. The ISO also developed another standard to promote efficient energy use, which was tagged the ISO 50001 in 2011.

Fiedler and Mircea (2012: 2) noted that the ISO 50001 standards are adaptable for any organization, business in any geographical location; and they also provide the opportunity to control energy efficiently. It is also applicable to energy management, carrying out energy reviews, the assessment of prospects to improve energy performance, the establishment of standards and performance indicators for tracking, monitoring targets for energy performance improvement and the execution of planned actions.

Pakbin (2014: 1) believes that the implementation of the international standard for energy management, ISO 50001 gives an organisation an advantage over its competitors for consumer confidence, with a net effect on their sales. Zhao, Zhao, Davidson and Zuo (2012: 278) submit that the adoption of the ISO standard as a veritable tool for construction, has been voluntary. Petrovic-Lazarevic (2008: 97) noted that the implementation of the International Organisation for Standardization policies fosters harmonious relationships with partners–including government agencies, communities and investors.

4.4.10.5 Pollution, Emission Trading and Tax

The quest for development and industrialization by developed and developing countries brings about the release of poisonous and harmful gases into the atmosphere, causing climate change and global warming. Activities, such as production by industries, mining activities and deforestation release dangerous gaseous elements into the air. Caney (2010: 221) posits that developed countries contribute more to environmental pollution than the developing countries. Gou (2014: 3) notes that India, a developing country, happens to be the first country to approve the carbon tax for its extractive industry, which is largely the coal-mining industry. Caney (2010: 221) advocated the need to develop measures that would dissuade the continuous emission of harmful substances by developed countries, by supporting adaptive capacity, such as paying more carbon taxes.

Rivers (2010: 1101) maintains that the Canadian government has a proactive policy on greenhouse emission. This makes it mandatory for fossil-fuel emitters to obtain a permit from a designated agency for any type of greenhouse gas that could be emitted into the atmosphere. He further added that the policy allows greenhouse gas emitters to save costs by choosing either to change their sources of power to less harmful ones, or to adopt energy-efficient policies to reduce the emissions.

On the other hand, Bassi *et al.* (2009: 3057) and Weber and Peters (2009: 439) contend that the United States' policies on climate change to cut down greenhouse gas emissions would impact negatively on the production and manufacturing sector, making their goods and services less attractive to products from other countries. They also added that the deployment of technology and favourable policies could reduce the impact of taxies and levies on the production and manufacturing sector in the United States.

van Asselt and Brewer (2010: 42) argue that a possible drawback to sustainability is carbon leakage, which may occur in countries that do not have strong climate policies in place. They further stated that such countries have fixed a levy on the amount of carbon emitted to attract manufacturers to their countries, which extensively release poisonous gases into the ecosystem.

Neuhoff (2008: 112) suggests three (3) key measures that can be used to address carbon leakages and other issues emerging from the carbon-pricing regulations. These are: The reduction of costs allocated, as a result of carbon trading scheme; ensuring a balance for carbon prices, irrespective of the different policies across countries; and, a uniform agreement on the carbon price at the international level.

4.4.10.6 Agenda 21 for Sustainable Construction in Developing Nations

The need for sustainable development in the construction industry precipitated the establishment of Agenda 21 for Sustainable Construction in Developing Countries. The construction industry relies heavily on the ecosystem for its supply of materials; because its activities consume a lot of resources and also generate large amounts of waste. Gama *et al.* (2010: 1418) report that the Agenda 21 framework was developed to highlight the negative impact the construction industry has on the environment and some possible solutions of this situation.

The Agenda 21 focuses on sustainability interventions for the construction industry in developing countries. These objectives include:

- To establish the challenges and barriers inhibiting the adoption and implementation of sustainable construction in developing countries;
- To indicate an intervention programme for developing countries, so as to ameliorate the challenges against sustainable construction;
- Provide a framework for investment and research for sustainable construction in developing countries.

- Promote the cross-breeding of ideas regarding sustainable construction, so as to foster development in emerging countries.

The document further categorized the impact of the construction industry on sustainability into the: social, environmental and economic impacts in developing countries.

- Social impact concerns the employment opportunities, poverty reduction and heritage preservation;
- Economic impact concerns continuous demand and employment from the construction projects' demand from inception to conclusion, investment and business opportunities, optimum resource utilization and reduction in waste generation.
- The environmental impact focuses on pollution to water, noise, greenhouse gas emissions and deforestation.

The first draft of Agenda 21 also seeks to address issues ranging from education and training, administration and management, purchase and supply, gender equality, research into methods and building materials, cultural diversity to sustainable dwellings. However, Robichaud and Anantatmula (2011: 50) noted that the sustainability agenda of the Agenda 21 framework was not tailored to focus on socio-economic issues for developing countries. Serpell *et al.* (2013: 274) also highlighted the lapses in the Agenda 21 framework for developing countries – for not considering the financial implications of implementing sustainable construction.

4.5 Sustainability Reporting

The demand for detailed reporting regarding non-financial performance from companies has changed the method of performance reporting in the corporate world. Investors' awareness and demands for ethically sourced goods and fair trade business dealing is on the increase (Holder-Webb, Cohen, Nath and Wood, 2009: 497). Furthermore, Klassen and Vereecke (2012: 103) and Daryl and Ranganathan (2001: 47) submit that disclosures by business organisations of their environmental footprint is now on the rise.

The United Nations Economic Commission for Africa and African Union (2010: 124) has attributed the improvement in business organization's sustainability reporting to the great response to the clarion call made at the Johannesburg Declaration on Sustainable Development. Daryl and Ranganathan (2001: 47) noted the need to consolidate on the success recorded regarding sustainability reporting by enforcing the relevant policies and the development of a framework.

There is a need for organisations to give their details of stewardship to stakeholders on social and ethical issues. Rasche and Esser (2006: 252) maintain that when organisations release the relevant details of their activities, plans and actions relating to sustainability, this shows how ethically and transparently such organisations operate. This reduces conflicts or misunderstandings among the various stakeholders. Rasche and Esser (2006: 252) projected three processes for social and ethical accountability: identify the issues and indicators; information verification and information communication. Figure 4.8 shows the process required for social and ethical accountability.

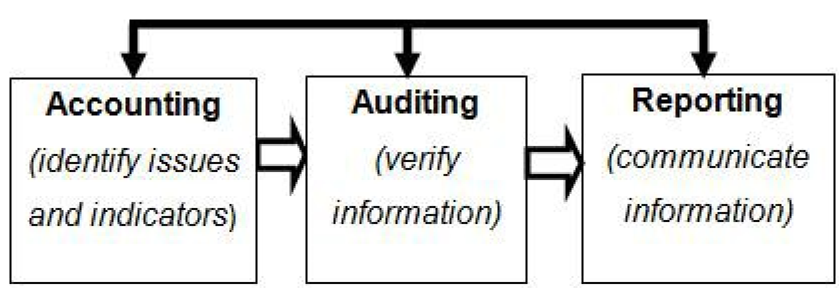


Figure 4.8: Process for social and ethical accountability
Source: Rasche and Esser (2006: 253)

There is a need for a synergy among the various stakeholders on the issues regarding the climate, biodiversity and forestry sector – so as to enhance sustainability uptake and implementation globally (Rasche and Esser, 2006: 253). Knox and Maklan (2004: 514) advocated the involvement of key members and top management in sustainability reporting. Uwuigbe (2011: 61) noted that the production of sustainability reports by firms in some developed countries has been in existence since the mid-1970s. However, this is not the case in developing countries, such as Nigeria.

Weisheng *et al*. (2015: 7) attributed this to the lack of awareness level in developing countries compared to what is obtainable in developed countries

According to Daryl and Ranganathan (2001: 48), the Netherlands offers a new approach for sustainability reporting by mandating all sectors to report issues on climate change, ozone depletion, acidification, eutrophication, dispersion of toxic waste and substances. This approach has mandated the submission of reports annually regarding the pollutants emanating from production and transportation activities. The fusion of both indicators for the macro-level and the micro-level reporting reinforces a parallel basis for reporting. In developing countries, the approach to sustainability reporting is generally not in tandem with the global best practices, owing to the challenges ranging from perception, technology and the willingness of policy makers (Daryl and Ranganathan, 2001: 50).

Glass (2012: 90) attributed the inability of some companies to carry out sustainability reporting to the following reasons:

- Cost;
- Process for collecting and processing the data;
- The process of verification by external agents;
- Task of gathering the internal and external agents required to complete the report;
- Time needed to check the information needed in the report; and,
- Challenging task of harmonising the sustainability report.

Kolk (2010: 368) highlights the reasons for reporting and not reporting sustainability by organisations. These are highlighted in the Table 4.2

Table 4.2: Reasons for reporting sustainability and not reporting sustainability by organisations

S/no	Reasons for reporting	Reasons for not reporting
1.	Enhanced ability to track progress against specific targets	Doubts about the advantages it would bring to the organisation
2.	Facilitating the implementation of the environmental strategy	Competitors are not publishing reports
3.	Greater awareness of broad environmental issues	Customers (and the general public) are not interested in it, it will not increase sales
4.	Ability to clearly convey the corporate message internally and externally	The business already has a good reputation for its environmental performance
5.	Improved all-round credibility from greater transparency	There are many other ways of communicating about environmental issues
6.	Ability to communicate efforts and standards	It is too expensive
7.	License to operate and campaign	It is difficult to gather consistent data from all operations and to select correct indicators
8.	Reputational benefits, cost savings identification, increased efficiency, enhanced business development opportunities and enhanced staff morale	It could damage the reputation of the business. Have legal implications or wake up 'sleeping dogs' (such as environmental organisations)

Source: Kolk (2010: 368)

Additionally, Eccles and Saltzman (2011: 58) noted that companies make public, sustainability reports to:

- Show their commitment to sustainability;
- Symbolise how the company is doing by communicating with the stakeholders; and
- Demonstrating that a company has a sustainability policy.

Weisheng *et al.* (2015: 5) support the assertion of Eccles and Saltzman (2011: 58) on the reasons why companies disclose their efforts on sustainability; but they added that the increasing need for reputation and acceptability are factors that make business organisations carry out sustainability reporting.

Amran and Haniffa (2011: 143) contend that until recently, the non-financial reporting spotlight focused on environmental issues; but it has now progressed to encompass the corporate social responsibility of an organization's operation. The contribution of the extractive industry to the growth and development of a nation is significant, according to the Financial Times Stock Exchange (FTSE) and the Johannesburg Stock Exchange (JSE) employment generation; and this boosts the profits of the investors (Mitchell, 2014: 2).

However, Jenkins and Yakovleva (2006: 272) and (Mitchell, 2014: 2) argue that the South African mining industry, like most extractive industries, is lagging behind on issues relating to sustainability, because of the amount of pollution released into the atmosphere. Glass (2012: 89) argues that companies in the UK carry out sustainability reporting to ensure that they comply with the relevant regulations; and additionally to reduce the risks involved that might affect them.

Zuo (2012: 3912) examined sustainability reporting by construction contractors in China. The study indicated that contractors in China report their sustainability activities from time to time; but a significant number of the construction companies' reports produced are not listed by the Global Reporting Index (GRI). No single construction contractor in China has yet made the list of the Dow Jones Sustainability Index (DJSI); and only a few of the contractors are active with the UN Global Impact. Furthermore, there is a variation in the mechanism adopted for reporting sustainability practice between the contractors studied. They, however, noted that sustainability reporting mainly covers areas, such as energy usage and pollution. It can be observed that sustainability reporting efforts by contractors in China are not encouraging even with their level of development and technology advancement. Consequently, reporting on social and economic issues is hardly considered. Vives and Wadhwa (2012: 2) observed that sustainability reporting now covers new items that were previously regarded as non-issues.

4.5.1 Sustainability reporting guidelines and standards

There are guidelines and standards for sustainability reporting. Alxneit (2015: 144) noted that these guidelines should legally underpin the corporate social responsibility framework. Gilbert and Rasche (2007: 188) report that the available reporting standards and guidelines are tailored to encourage ethical behaviour by business organisations, in order to boost the confidence of the stakeholders.

4.5.1.1 Global Reporting Initiative (GRI)

The Global Reporting Initiative (GRI) is a 1997 initiative of the United States of America (USA). The GRI was established to support sustainability from the environmental, social and economic perspectives; and it renders assistance to organisations through guidelines for the broad disclosure of issues relating to non-financial performance (Mitchell, 2014: 54).

The UN Global Compact; the Environment Programme; the Organisation for Economic Co-operation and Development have an understanding with GRI; and this is aimed at achieving a global sustainable economy through developed reporting guidelines for sustainability reporting. The guidelines developed compel organisations to be accountable over the reports presented and to show that they are transparent (Mitchell, 2014: 55). Ackers (2009: 6) and Jenkins and Yakovleva (2006: 274) note that when organisations report to various stakeholders transparently, this goes a long way to boost their confidence, which is key for survival. Mitchell (2014: 55) added that GRI is done voluntarily; and it is a determinant to sustainability reporting uptake, thereby ensuring that the organisations that adopt these guidelines, report separately. Ali (2015: 41) claims that GRI is rated as the most advanced and highly comprehensive mechanism for reporting corporate sustainable development.

But, Marx and Dyk (2011: 55) revealed in their study that only a few companies go the extra mile to confirm the veracity of their sustainability reports. The components of sustainable development, namely: environmental and economic components, are key to organisations' agenda for corporate governance, which appeals to stakeholders' need for sustainability reporting (Ali, 2015: 42). Figure 4.9 shows the Framework for structural ranking of the Global Reporting Initiative.

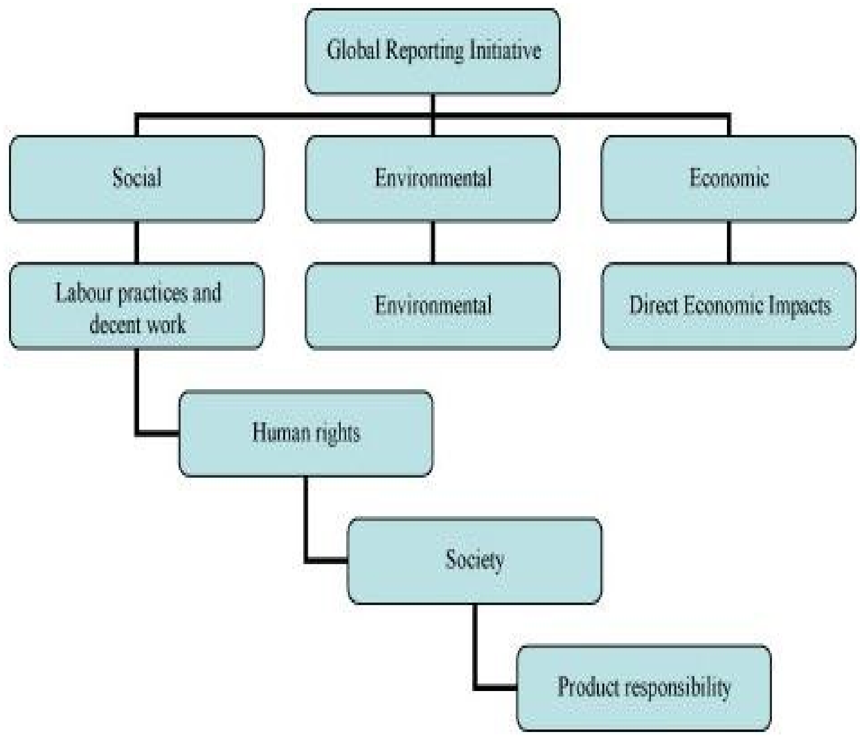


Figure 4.9: Framework for structural ranking of the Global Reporting Initiative
Source: Global Reporting Initiative (GRI) (2002)

Lozano (2013: 59) and Loosemore and Phua (2011: 28) assert that GRI is widely accepted in the construction industry, according to the reports considering economic, environmental and social achievements by construction companies. Siew *et al.* (2013: 3) add that the GRI formation is a conglomeration of practitioners in academia and private practice. Furthermore, GRI separates the key pillars of sustainability; but it fails to promote the benefits that could be acquired over a long period of time. Again, Lozano and Huisingh (2011: 104) noticed a shortcoming with GRI due to its inability to implement the guidelines set by the G3 for reporting.

4.5.1.2 Social accountability 8000 standard (SA 8000)

The social accountability 8000 standard is among the highly regarded standards for sustainability reporting. The standard was established in 1997. According to Gilbert and Rasche (2007: 201), the social accountability 8000 standard is the foremost standard that champions the rights of workers. The Social accountability 8000 standard also considers the rights of workers (Beschorner and Muller, 2007: 14); and it also promotes ethical business practice (Gilbert and Rasche, 2007: 201). The key areas in the guidelines provided in the social accountability standard are presented in Table 4.3.

Table 4.3: Guidelines for social accountability standards

S/No	Social Accountability standard 8000
1.	Child labour: No workers under the age of 15; minimum lowered to 14 for countries under the ILO convention 138 developing countries exception; remediation of any child found to be working.
2.	Forced labour: No forced labour, including prison or debt-bondage labour; no lodging of deposits or identity papers by employers or outside recruiters
3.	Health and Safety: Provide a safe and healthy environment; take steps to prevent injuries; regular health and safety worker training; system to detect any threat to health and safety; access to bathrooms and potable water.
4.	Freedom of association and right to collective bargaining: Respect the right to form and join trade unions and bargain collectively; where the law prohibits these freedoms, facilitate parallel means of association and bargaining.
5.	Discrimination: No discrimination based on race, caste, origin, religion, disability, gender, sexual orientation, union or political affiliation, age; or sexual harassment.
6.	Discipline: No corporal punishment, mental or physical coercion or verbal abuse.
7.	Working hours: Limited to 48 hours per week and overtime at 12 hours per week.
8.	Compensation: Wages paid for a standard work week must meet the legal and industry standards and be sufficient to meet the basic need of workers and their families; no disciplinary deductions.
9.	Management systems: Facilities seeking to gain and maintain certification must go beyond simple compliance to integrate the standard into their management systems and practices.

Source: Gilbert and Rasche (2007: 200)

Despite the merits derivable from adopting social accountability standards, Gilbert and Rasche (2007: 201) noted the lack of justification for some items in the standard; and they cited the failure to define how dialogue would be done with key stakeholders and an involuntary adoption of the initiative, as the shortcomings of the standard. The social accountability standard does not focus on individual challenges; but it is rather, too generic (Beschorner and Muller, 2007: 14).

4.5.1.3 Carbon disclosure project

The carbon disclosure project was established in 2008; and it comprises a conglomerate of investors (Kim and Lyon *2011: 1)*. Kim and Lyon (2011: 22) affirm that an organisation's involvement in carbon disclosure does not increase a company's share price and organisations that subscribed to the carbon disclosure project attracted some sympathy during their difficult moments. Kolk *et al.* (2008*)* noted that the amount and details of disclosure in the carbon disclosure project need to be reworked.

Figure 4.10: Sustainability reporting concept

Source: Researcher's own construct, 2017.

This study argues that: What to report? How to report? When to report? Who to report to? Who reports and why reporting are major items to be considered when carrying out sustainability reporting as depicted in Figure 4.10.

4.6 Material Transportation

Material transportation or movement from one location to another is an economic function in the material-supply chain. The need for the supply and transportation of construction materials from various locations is imperative for project completion. Material transportation has a negative impact on the environment. Shakantu (2004: 42) asserts that construction operations consume resources from project inception to completion for building production. Geerlings and van Duin (2011: 657) submit that the transport sector is lagging behind other sectors in cutting its CO_2 emission level.

Yan and Crookes (2010: 652) believed that adopting a comprehensive and appropriate strategy could minimise the adverse impacts of material transportation on the environment. Shakantu (2004: 42) noted the need to transport construction materials sustainably.

4.6.1 Methods of material transportation

The various methods for materials transportation are:

4.6.1.1 Road transportation

Movement of goods and services by road is a popular method of transportation. Road transportation supplements transportation by air, rail and water. Kamakaté and Schipper (2009: 3750) aver that the most frequently used method of transportation to move goods from one point to another in Europe is the road transport because of the flexibility and speed it offers. However, they submitted that the implication of road transportation is the high volume of fuel used for this process and carbon emissions which contribute to climate change. Nwanya and Offili (2013: 170) note that majority of developing countries including Nigeria, depend heavily on roads to transport materials from one point to another.

The majority of trucks and other vehicles used for transporting materials by road, often utilize fuel to power their engines. There are health and environmental risks linked with the use of powered engines. Shahraeeni *et al.* (2015: 26) ; Lewis *et al.* (2009: 3) posit that diesel powered engines emit greenhouse gases into the atmosphere such as: mono-nitrogen oxides (NOx), Sulphur oxides (SOx), Carbon monoxide (CO), Volatile organic compounds (VOCs), and Particulate matter (PM). There are other negative implications with the use of road transportation. Kamakaté and Schipper (2009: 3751) note that noise and traffic congestion challenges are synonymous with road transportation. Chapman (2007: 357) suggests that change of attitude by humans would help in cutting down fuel use and air pollution attributable to road transportation. Liao *et al.* (2011: 723) further suggested that regular vehicle maintenance and raising the costs attached to driving a vehicle are viable factors that would reduce greenhouse gases emission.

4.6.1.2 Air transportation

Air transportation helps the socio-economic development of a nation. Air transportation is rated as the fastest means of transportation for humans. Singh and Sharma (2016: 11) noted the following challenges associated with air transportation: high rate of fuel consumption, the increasing price of fuel, stiff competition, global economic crises, pollution emission and difficult operational structure. Gualandi and Mantecchini (2008: 141) submit that the high noise level emitted from air transportation is a major challenge in the aviation industry. They further stated that the amount of noise pollution generated by an air craft depends on the type of air craft and the time of operation. Osueke and Ofundu (2011: 4) recommend the use of aircraft that emit less sound, insulation of buildings around the airports, proper site selection to locate airports and the adoption of decent methods of landing. Furthermore, Nojoumi *et al.* (2009: 1363) believe that the combustion process in an aircraft engine pollutes the environment by releasing greenhouse gases and the formation of cirrus clouds in the atmosphere.

Chapman (2007: 356) noted that the aviation sector is the greatest environmental polluter, because aircraft release greenhouse gases directly into the atmosphere during flights.

4.6.1.3 Rail transportation

Rail transportation is one of the oldest methods used to move goods and services. Wenxing and Shuai (2012: 9) believed that rail transportation boasts of unique characteristics not limited to: speed, safety, energy efficiency. Par (2009: 6) noted that the negative externalities of rail transportation are: noise pollution, greenhouse gases emission and climate change. Fuglestvedt *et al.* (2010: 4777) argued that rail transportation is the lowest greenhouse emitter, when compared with other methods of transportation. They further illustrated this in Table 4.11.

Table 4.11: Emission of CO_2 in the Transportation Sector 1900-2000

	2000		Cumulative 1900–2000	
	Emissions Tg CO_2	Share [%]	Emissions Tg CO_2	Share [%]
Road	4282	72.3	114,494	55.1
Rail	124	2.1	20,913	10.1
Maritime shipping	626	10.6	31,940	15.4
Aviation	688	11.6	16,890	8.1

Source: Fuglestvedt *et al.* (2010: 4773)

The drawbacks for rail transportation are: project costs, technicalities involved in constructing and maintaining trains (Litman, 2007: 96).

4.6.1.4 Water transportation

Water transportation is often used to transport large and heavy materials from one point to another. Ng and Song (2010: 309) noted that pollution generated in this sector can affect the environment; and it can also cause economic loss. Liao *et al.* (2011: 727) studied the impact of road and sea transportation on the emission of greenhouse gases in Taiwan; and they submitted that water transportation emits less greenhouse gases than road transportation. Again, Fuglestvedt *et al.* (2010: 4778) further stated that, water transportation emits 1% less greenhouse gases compared to road transportation. Liao *et al.* (2009: 496) concluded that the reason why water transportation emits less greenhouse gases compared to road transportation was solely because of the fuel used to power their engines. They further noted that ships utilise heavy oil; while vehicles utilise diesel and petrol.

Geerlings and van Duin (2011: 665) conducted a study on the reduction of CO_2 emissions in the Rotterdam terminal. They advocated that the design and construction of terminals, the substitution of diesel-powered terminal operation with electric-powered equipment and the mixing of bio fuel with diesel would reduce the emission levels.

4.7. Material Production

A large amount of energy is needed to power production – from product design to packaging. Anand *et al.* (2006: 383) claim that the production of cement contributes an additional 20% CO_2 to the already heavily polluted atmosphere, resulting in a 10% risk increase in man-made global warming.

Ali *et al.* (2011: 2254) noted that CO_2 emissions during cement production largely emanate from fossil-fuel combustion, and also during the calcination process of limestone into Calcium Oxide. They further stated that this process also releases gases such as NO_2, SO_2 and O_2 into the atmosphere.

Ali (2015: 3) contends that due to the increase in population, the manufacturing industries will need more raw materials for production. He further noted that this will impact negatively on the environment. Adewale *et al.* (2016: 2) proposed the need for a symbiotic relationship between humans and nature, where human activity would not exhaust the available resources. Fard *et al.* (2016: 76) noted that the cement production process contributes about 7% of CO_2 to the atmosphere. They put forward the need for cement production organisations to adopt sustainability measures, in order to minimise the impact of their operation on the environment.

Olusegun *et al.* (2009: 1) pointed to the negative impact of granite production on biodiversity to include: contamination of ground water, release of obnoxious gases and fumes during stone crushing.

Azapagic (2004: 640) noted that calls from their stakeholders have compelled organisations operating in the quarry sector to adopt corporate-sustainability measures to reduce the negative impact of activities on the environment. Again, the benefits derived from adopting corporate sustainability include:

- The provision of a safe and healthy working environment;
- Adoption of cleaner technology for production;
- Boosting of financial status to access financial services;
- Reduction of closure and post-closure costs;

Olusegun *et al.* (2009: 1) suggested the adoption of cleaner technology, such as scrubbers, precipitators and filters to minimize the amount of pollution released to the atmosphere during crushing operations in quarry sites. Gilham (2010: 19) points out that natural resources should be well thought-out, as a partner to the manner in which financial capital and human capital are valued, as the key components of production.

The negative impact of sand mining and production was observed by Mathanda and Kori (2012: 135) in the Limpopo Province in South Africa where, sand mining pollutes the surface and ground water due to the pit created as a result of mining and abandonment after sand collection, and this is likely to permanently damage the environment.

Manap and Voulvoulis (2015: 341) added that the mining of sand, by using dredging technology cause damage to the environment that may be irreparable or difficult to remedy, such as: the spread of pollutants into water; disturbance to seabed; displacement of fauna and flora, as well as other organisms inhabiting the water.

4.7.1 Combined Impacts of material transportation and production on the environment

Sourcing, transportation and production have negative impacts on the environment. According to Calkins (2009: 25), material sourcing, transportation and production affect the environment negatively, as shown in Table 4.10.

Table 4.10: Impacts of material transportation and production on the environment

S/no	Stages	Impacts
1.	Material transportation	Transport fuel uses non-renewable resources and releases by-products (VOCs, CO_2, CO, particulates, and sulfur and nitrogen compounds) from internal combustion engines, substantially contributing to air pollution, human respiratory problems, and global climate change.
		Transport emissions of trucks, ships and boats, and trains accounted for 53% of the total. Most fuels used in transport were petroleum-based products such as gasoline for cars and light trucks, diesel fuel for heavy trucks, or jet fuel for airplanes.
		A transport distance is an important consideration because materials/products used in site construction are often heavy and bulky. Energy used in transport, especially by less efficient trucks and airplanes, can be greater than energy used in production if the manufacturer is located too far from the site.
2.	Materials production	This phase can be very waste intensive, as large amounts of material are handled and a good portion of it discarded prior to reaching the manufacturing stage. For example, metal mining produces ore waste to metal ratios of 3:1 for iron and aluminum and far greater for copper.
		Emissions, effluents, and solid wastes, some of which are toxic, are generated. Fugitive emissions, those not contained, are released to air, water, and soil. Emissions and waste that are contained are disposed of in controlled releases or recycled.
		Toxic waste types and quantities vary widely by industry, with the metals sector producing relatively large amounts. The stone industry produces large amounts of waste in the form of overburden, but with minimal toxicity.
		A large environmental and human health concern in the manufacturing phase is the use of cleaning fluids and coatings. Solvents are used for cleaning and preparation of surfaces and as carriers for coatings. Many oil-based solvents contain toxic constituents and release volatile organic compounds (VOCs), impacting human health and

		air quality.
		Some manufacturers take steps toward minimizing the environmental and human health impacts of their materials/products by incorporating recycled materials and by-products into their products; minimizing energy and water use in manufacturing processes; using organic and water-based solvents; using mechanical cleaning methods; burning waste as fuel; using alternative energy sources; and capturing, recycling, or safely disposing of toxic emissions and wastes.

Adapted from Calkins (2009: 25)

The previous section discussed the research theoretical framework. This section discusses the conceptual framework of the research that emerged from the theoretical framework (sections 4.2 - 4.7) and literature review carried out in previous chapters.

4.8 Conceptual Framework of the Research

A concept is a mental picture for the course of an action; and it also provides a platform from which to commence research. The conceptual framework comprises a minimum of two interconnected plans, in order to elucidate an event systematically. It states the researcher's view with respect to the research problems. Ogan *et.al.* (2016: 164) argue that a conceptual framework centres on developing and improving the existing measures, standards, practices and guidelines. The conceptual framework also shows the correlation that exists between the key variables related to the research. Again, the conceptual framework is a pointer to the research-methodology process.

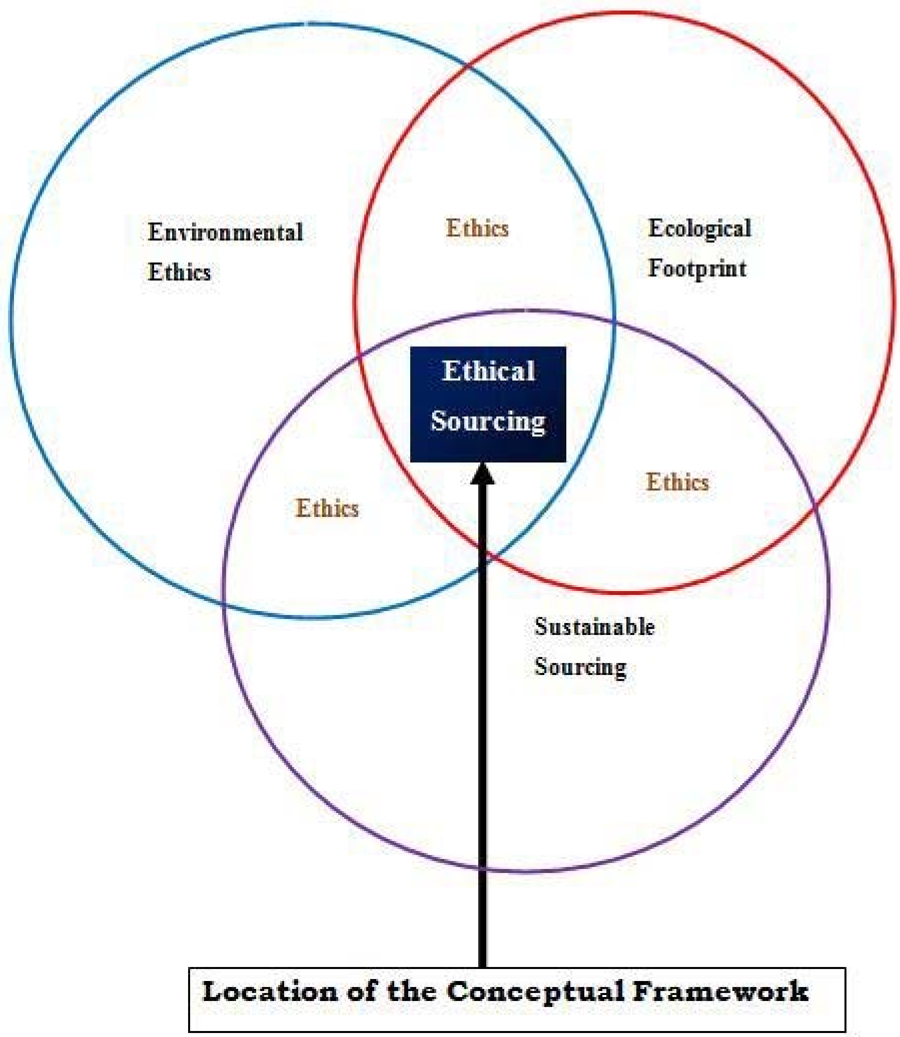


Figure 4.11: Research conceptual framework

Source: Researcher's own construct, 2017

The interrelation between the constructs used for the development of the conceptual framework are explained in Figure 4.11.

In the conceptual framework, there is a relationship between environmental ethics and sustainable sourcing. This relationship focuses on the ethical sourcing of construction materials. A relationship also exists between environmental ethics and ecological footprint. This relationship also focuses on the ethical sourcing of construction materials.

A further relationship also occurs between ecological footprint and sustainable sourcing, which also focuses on the ethical sourcing of construction materials.

4.9 Sustainable Sourcing

The abundance of natural resources in developing countries has brought about an unhelpful impact on the ecosystem. Ebohon and Rwelamia (2001: 3) opined that resource consumption and production pollutes the rivers and other water bodies; and it also affects the carbon credit due to deforestation and bush burning. Lawal (2011: 193) predicted the increase in environmental degradation due to the demand from suppliers for building materials, such as granite and sand.

According to Madyise (2013: 26), the commonly available method for sourcing sand and granite are open pits, along the river beds and large bodies of rock in both developed and developing countries, where the materials sourcing stages include: the cutting down of trees and plants; mining operations; production/processing and the land reclamation of explored mine sites.

Halliday (2008: 121) argues that the materials extraction process affects the environment negatively by destroying the flora and fauna, the landscape character, the pollution of ground and surface water, and a reduced water table. Campbell (2012: 142) reports that companies that are operating in the mineral-rich countries of sub-Saharan Africa have not been able to make significant impacts socially, ecologically and economically, to their host communities. Slack (2012: 197) highlights the non-compliance of business entities with the stipulated laws of the host government, mainly in the developing countries; and he attributed it to poor government oversight.

This has resulted in serious damage to the flora and fauna around the mining sites (Aigbedion and Iyayi, 2007: 33). Szablowsk (2007: 60) claims that corporations operating in the Global South countries, both locally and internationally, are often criticized for their inability to operate sustainably under the arm of the law in the host countries and regions. This was attributed to the weak laws and legislation, as well as the inability of government to prosecute erring corporations.

Bahrami *et al.* (2010:1) maintain that land degradation is the most severe challenge affecting most nations, which has had a devastating impact on human activities, including agriculture and the landscape.

Aigbedion and Iyayi (2007: 33) noted severe environmental damage from the mining of materials, with the manual method of quarrying, such as: landscape degradation and the emission of radiation hazard. Furthermore, Lawal (2011: 197) reported the physical and ecological impacts of mining. He noted the physical impact of sand mining, which ranges from the disintegration of the river bank, upstream and downstream erosion, due to the changed increase in water flow. Destruction of vegetation and plants around the water body and the displacement of marine bodies are ecological impacts of sand mining.

Asabonga *et al.* (2016: 2) reported the impact of sand mining on the environment around the OR Tambo district in South Africa to include: washing away of the top and subsoil, landslides, and invasion of the area by strange vegetation.

County and Nthambi (2015: 95) studied the outcome of sand mining on the environment in Kathiani division Kenya. The study showed that sand mining has intensively affected the environment by reducing the water availability, damage to the infrastructure, due to the methods adopted for sand mining; and noise disturbance from the hauling of sand to different locations. Sarkodie *et al.* (2014: 43) in their study on clay mining in Kwahu West Municipality of the Eastern Region of Ghana for construction materials, revealed that the inhabitants in this area extract clay for their livelihood, However, this is unchecked thereby polluting the environment and the destruction of vast land areas used for agricultural purposes.

Activities in the construction industry have increased the demand for timber from the project-initiation stage to the completion stage, which has had a detrimental effect on the ecosystem. Hansen and Treue (2008: 575) observed that 70% of timber in Ghana is illegally sourced; and this is done manually with a chainsaw, having a negative impact on the environment, such as: noise pollution, the leakage of oil from the chainsaw, the destruction of other adjourning trees and plants during the felling process.

Kirchoff (2011: 20) points out that those organisations that identify with the environment would operate in a sustainable manner, so as to minimize the negative impact the organisations might have on the environment. Cragg and Greenbaum (2002: 320) maintain that companies have realized that they are often the centre of referencing; and they need to change by developing an ethical code for better behaviour, as well as developing environmental strategies that would outline their social and environmental obligations. This has attracted attention from the advocacy for environmental and social justice assembly, tasked with the responsibility to monitor and observe compliance in the extractive industry (Cragg and Greenbaum, 2002: 320).

Azapagic (2004: 640) recommends that to have a break even in material sourcing, there is the need to maintain a balance among the triple-bottom line of sustainability by:

- Categorizing issues related to sustainability and the various stakeholders involved;
- Identification of key items involved, together with their action plan;
- The selection of relevant sustainability pointers that would allow benchmarking;
- Performance evaluation for improvement and continuity;
- Collection and dissemination of relevant information sharing with the relevant stakeholders;
- The promotion of entrepreneurship skills to group representatives and other stakeholders to boost their investment opportunities.

Ebohon and Rwelamia (2001: 4) in their study, found that the production of construction materials, such as Zinc, timber, tiles, glass and quarry products, which consume a lot of resources – from the extraction to the production – dissipate large quantities of toxic gases into the atmosphere in the form of Carbon dioxide (CO_2), Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2) as pollutants; and these gases cause global warming. Furthermore, Mojarradi *et al.* (2016: 58) *and* Lawal (2011: 194) observed that environmental degradation resulting from sand and gravel sourcing includes: distortion of the landscape and the topography, the creation of breeding grounds for insects and pollution of the air and the water.

Haney (2010: 19) identified two (2) major sources of materials for the construction industry, as follows:

1. **Material sourcing from rivers**

River bodies provide a base for building materials. These bodies include: riverbeds, winding rivers and estuaries. All these bodies supply distinct materials, such as coarse gravel, which is found where the water pressure transporting the materials has great pressure; but it does not have much impact on gravel.

Materials accumulate, due to changes in the water pressure, thereby allowing materials to become available. Winding rivers, due to their nature, provide silt and sand for construction activities. The extraction process takes advantage of low water pressure to transport these materials from one point to another.

Materials sourced from the river bed might not have direct physical impacts on the environment; but they might have a direct impact on the flora and the fauna.

2. **Material sourcing from rocks**

Material sourcing here requires planning, tools and equipment for extraction. The process usually entails displacement of layers to unearth the bodies of rock, which are usually granites. Blasting and drilling are the most common methods used for sourcing large rock bodies; and these methods usually affect the environment.

4.9.1 Methods adopted for sourcing construction materials

The construction industry relies on huge supplies of materials, such as stone, sand and timber, among others. These materials usually occur in their natural state; and they must be extracted from the earth`s crust; and this is usually done by mining, quarrying and logging for timber products.

4.9.1.1 Mining and quarrying

Mining is often carried out where natural resources occur: either in small or large quantities. In Nigeria, there are abundant natural resources lying across the length and breadth of the country. Vintró *et al.* (2012: 118) assert that the mining sector is important for countries with minerals; since it can provide raw materials for industries, such as building, electronics and others. According to Chindo (2011: 164), minerals such as gold, iron, diamond, marble and granite exist in large quantities in Nigeria.

Mining and quarrying exert pressure on the environment, along with the sourcing, transportation and production stages. Careddu and Siotto (2011: 305) examined marble production in Eastern Sardinia and reported that during quarrying, noise emanates from: compressed air equipment for drilling, carbide chain-saws and diamond-wire saws, air compressors and diesel generators, the movement of vehicles for transporting materials sourced and the utilization of detonating cord during materials sourcing. They further submit that noise from the production process emanates from the machines used during cutting, grinding and polishing and bush-hammering, movement along the production line, and the use of motor vehicles for transporting raw materials, semi-finished materials and finished materials.

4.9.1.2 Timber sourcing

Timber is sourced from the forest after the cutting of trees, transporting and processing in the mill. Sist and Ferreira (2007: 199) argue that the overexploitation of forest products for various uses mainly construction, has necessitated the need for the conservation of forest resources; this has encouraged better methods for harvesting, with little or no impact on the environment. This is called low-impact' or 'reduced-impact' logging (RIL). Putz *et al.* (2008: 1428) defined reduced-impact' logging "as *intensively planned and carefully controlled timber harvesting conducted by trained workers in ways that minimize the deleterious impacts of logging".*

The reduced-impact logging process reduces canopy damage and increases the forest's ability to regenerate rapidly after sourcing has been completed, which is dependent on the logging techniques employed for sourcing (Sist and Ferreira, 2007: 199). Rockwel *et al.* (2007: 371) also affirmed that the reduced-impact logging process is very environmentally friendly, when adopted in timber sourcing, compared to the conventional logging process.

Zimmerman and Kormos (2012: 484) observed that large-scale timber logging increases the amount of the anthropogenic carbon dioxide in the ecosystem. The implication here is that, the release of carbon dioxide into the ecosystem would contribute to climate change.

4.9.2 Methods adopted for mitigating the impact of sourcing construction materials

Construction materials' extraction, transportation and production have negative impacts on the environment. However, methods do exist for mitigating these negative impacts on the environment. In the opinion of Chen and Li (2006: 49), material sourcing impacts on the environment can be mitigated by:

Technology: Pollution resulting from dust, harmful gases, noise and wastes during sourcing operation can be mitigated by the use of modern technology, such as hydraulic machines instead of impact machines. A significant amount of pollution reduction would be thereby achieved.

Management: The management of an organisation can drastically reduce the negative impact of sourcing materials. Such management practices include, high priorities for matters relating to mitigating the environmental impact.

- Planning: Adequate planning should reduce the negative impact of materials on the environment. The reversal and re-arrangement of schedules, such as carpooling, and limiting operations during unfavourable weather conditions would significantly reduce the impact on the environment.

Shen and Tam (2002: 540) assert that the following measures could mitigate the impact of material sourcing on the environment:

- The reuse and recycling of the waste generated.
- Making environmental management plans a top priority.
- The deployment of environmental technology during the extraction, transportation and production.
- Training and retraining of staff members in the organisation.
- Training and retraining of staff members on minimising the negative impact on the environment.
- Establishing measures for managing the environment.

Roberts (2003: 160) mentions that the standard practice in the construction industry is to outsource the materials needed from various suppliers, which would necessitate that organisations should know the source and means by which these materials are delivered. Roberts (2003: 160-161) believes that deploring ethical sourcing initiatives when dealing with material-procurement issues has a lot of merit for organisations; but unfortunately, organisations have not been able to leverage on the following reputable opportunities:

i. Service-level agreement between the organisation and the supplier is guaranteed;
ii. Improving the organisation's bargaining ability for the best quality and price;
iii. The risks associated with the suppliers are reduced;
iv. The provision of opportunities for the organisation to choose from a pool of supplies;
v. Innovation and development enhancement in the supply network;

vi. Attraction of the best prospective employees; and,

vii. Guarantees that the services and products offered by the organisation are of the best standard.

4.9.2.1 Reputation and the supply chain

Recently, the utilisation of reputation as a barometer for responsibility has become the hallmark for business ethics. Roberts (2003: 160) argues that for business entities to survive in the present business climate, organisational reputation is the key to brand image and public perception. Non-governmental organisations (NGO) have been measuring organisations' business character by their success recorded from the perspectives of ecology and humanity (Roberts, 2003: 160).

4.9.2.2 Risk assessment

The present business terrain makes it imperative to take into cognizance social, environmental and economic factors, when taking key decisions to source inputs sustainably. Epstein *et al.* (2015: 105) assert that globalization has compelled business entities to integrate political instability, corruption, terrorism, the use of child labour, as well as pollution into strategic management resolutions. Loosemore and Phua (2011: 93) note that frequently, activities in the construction industry have attracted scrutiny by various stakeholders regarding their ecological impacts, bribery and the workers' conditions of service.

Carter and Rogers (2008: 365) recommend that organisations manage the risks emanating from suppliers, workers, environment and products, due to their ability to hinder growth and stability.

Systemic evaluation of the business climate, planning for alternatives and innovative policy help to minimize risks and uncertainty (Epstein *et al.,* 2015: 105). Epstein *et al.* (2015: 105) suggest three steps for risk management; and they submit that it is paramount to identify the probable risks that an organisation might face; and they must incorporate such steps into the main risk-management plan. The steps are:

- Determination of initial sources of risks, such as social, environmental and political. These sources will not be the same, due to the nature of the sector, the products, the employees and the customers.
- Categorization of real risk sources against perceived risks would enable better risk assessment. The impact of the real risks and the perceived risks may vary in the organisation. Real risks include: social, environmental and political issues. The perceived risks are the stakeholders, such as customers, employees, communities and others to whom the organisation is responsible.
- Grouping of the related risks into sustainability and other related risks. Organisations usually deal with financial risks exclusively; but they tackle social, environmental and political risks as single entities; since these usually require early attention; because they become more difficult to resolve when such issues arise.

4.9.3 Sustainability indicators in the extractive Industry

The need to assess the impact of various activities in the extractive industry arose due to various stakeholders. Azapagic (2004: 641) highlights stakeholders in the quarry industry, who are impacted by mining activities:

- **Employees**

These are the livewires of the quarry industry; since their input ensures continuous operation of the mining site. Their immediate needs range from a good salary structure, a safe and healthy area to perform their duties, training and retraining, in order to achieve their future goals.

- **Trade unions**

Trade unions are the representatives of the employees. They often struggle for the welfare and the rights of the workers, whom they represent. Usually, the management of the mining organisations and trade unions` are at loggerheads, due to the trade unions position on matters relating to the workers. Their demand usually is that the management adhere strictly to International Labour Organisation Conventions on the rights of workers.

- **Local communities**

Local communities are usually the hosts of the mining corporations. They are the most severely affected stakeholders, in terms of economic viability, opportunities, pollution of the environment and the provision of social amenities.

- **Government**

They are often the regulators, who determine the modalities and plans for mineral exploration, tax and revenue. Again, issues relating to pollution prevention and remediation are key areas they often focus on. Government`s ultimate goal is to ensure that the mining sector operates sustainably.

- **Non-Governmental Organisations**

The mining sector usually attracts attention of non- governmental organization due to the activities in the sector. They are often concerned with the social and environmental impact of mining companies, and bring these issues to the notice of the general populace. These issues comprise both local and international challenges impacting humans and the environment.

The production process in mining involves: extraction, processing, production and waste management; and this process has continually impacted negatively on stakeholders in the mining sector (Azapagic, 2004: 643). According to Ahmed and Oruonye (2016: 9), accidents resulting in the loss of life or disabilities have been reported in Taraba State, Nigeria due to the caving in of pits and large holes during mining. Mining operations have raised a lot of sustainability and environmental issues relating to: air pollution, water pollution, landscape damage, as well as harm to flora and fauna.

Chindo (2011: 245) unveils the negative environmental impact of sourcing materials on humans and the environment in Table 4.9.

Table 4.9: Negative impacts of material sourcing

Concerns	Consequences
Water availability and quality	Pollution of fishing water, and impact on other aquatic organisms, such as crabs.
	Diversion of communal sources of water.
	Long distance travel to access water because of pollution of proximal water sources.
	Flooding caused by barriers placed on natural-flow canals.
	Contamination of surface and underground water making it unsafe for drinking and cooking.
	Reliance on unclean water causes diarrhoea and dysentery.
Loss of biodiversity and destruction of habitats	Cutting of forests and plantation at varying operational scales limits local opportunities for employment, food and income.
	Reduction in the availability of arable land.
	Loss of primary sources of protein and medicine.
	Extinction of certain animal and plant species.
Pollution-noise, dust and gas emissions	Pollution of air in the surrounding environment.
	Cause of variation in rainfall pattern.
	Contraction of airborne diseases such as those affecting the lungs.
	Long-term hearing problems.
	Machinery noise and movement upset domestic animals and children.

Source: Chindo (2011: 245)

Fard *et al*. (2016: 76) observe that the environmental challenges associated with cement production include:

- Emission of greenhouse gases, such as CO_2, NOx, SO_2;
- Reduced visibility, noise and vibration;
- Consumption of non-renewable earth resources;
- Distortion of both soil profile and water level;
- Distortion of landscape and general site conditions, such as the flora and fauna;
- Pollution due to various methods of material logistics; and

- Environmental deformation during the planning and construction phases.

Sreebha and Padmalal (2011: 137) contend that sand mining, using the in-stream and flood-mining techniques, negatively affects: land stability, land use, soil, land form, river bed, aesthetics of the land, air, water and flora and fauna in India. They suggested the following, in order to improve the environment:

- Ethics should be introduced for sand mining;
- Specific laws regarding sand mining should be passed;
- Other sources that would be able to provide environmentally friendly sand for construction should be explored; and
- Remediation measures should be carried out for abandoned pits;

Sensitisation should be carried on the adverse impact of sand mining on the environment.

4.10 Ecological Footprint

The world has continued to record a higher growth rate even with the dwindling resources for survival. Lambert (2013: 1) reports that, the global resources consumption pattern is currently not sustainable due to continuous mineral exploration and believes that it will be disastrous if the current approach continues. Fiksel (2006: 15) argues that the negative impact of over exploitation of renewable resources is fast depleting the resources base.

Ecological footprint measures the amount of earth resources used by a person (Brandon and Lombardi, 2005: 33). Moran, Wackernagel, Kitzes, Goldfinger and Boutaud (2007: 471) viewed ecological footprint, as a means to measure the earth`s ability to rejuvenate from the continuous human resource depletion such as materials transportation. Wackernagel and Yount (2000: 23) assert that ecological footprint allows the assessment of resources consumed. For a break-even to be achieved in the pattern of resources utilised by people, there is the need to triple the land mass currently been utilised (Wackernagel and Yount , 2000: 23). Brandon and Lombardi (2005: 35) aver that for any infrastructure and building facility commissioned, it impacts negatively on nature due the vast amount of resources consumed as a result of moving materials from one point to another. Barrett and Scott (2001: 317) believe that the ecological footprint permits assessment, allows organisations to take account of their impact on the environment and will also assist them in determining their efforts towards achieving sustainability. Planning and implementation of sustainable resources system will ensure resource efficiency. Wackernagel and Yount (2000: 23) argue that development of framework for ecological footprint will uplift the current sustainable resources effort. Barrett and Scott (2001: 317) note that ecological footprint enables vivid description of organisation`s resource use to stakeholders such as land utilization assessment. Zhao and Li (2005: 66) posit that there is need to establish measures for ecological footprint, because it affects future generations. Brandon and Lombardi (2005: 35) contend that developing a mechanism for ecological footprint appraisal requires detailed planning, since the needed resources for project delivery do emanate from different sources and regions.

Zhao and Li (2005: 64) indicate that lately, the methods used for measuring sustainability have been changing from qualitative to quantitative method of assessment. They further submitted that the adoption of tool kits for evaluating ecological footprint and energy accounting is on the rise. These processes offer a novel way for stock taking of energy and other resources consumed (Zhao and Li, 2005: 64).

Demand for resources by humans is increasing as a result of population explosion. When the carrying capacity is exceeded it results into ecological overshoot, loss of biodiversity and increased carbon emissions among others (Lambert, 2013: 1; Bagliani *et.al.,*2008: 355). Ashby (2013: 7) argued that the current natural resources consumption pattern has depleted earth`s resources, which might threaten the survival the of coming generation. The transportation sector relies heavily on resources sourced from the earth`s crust for its operations.

A way out of these challenges was proposed by Lambert (2013: 1) and Zhao and Li (2005: 64), who advocate for the need to change resources consumption patterns and making provision for materials transportation that reduce the global ecological footprints from exceeding the present level. Brandon and Lombardi (2005: 33) indicate the need to take into cognizance the negative impact developments have on the ecosystem i.e ecological footprint.

Transportation of people and goods from one point to another is paramount for human survival. The commonly used means for materials transportation namely: roads; air and sea, utilize great amount of fuel for their operations.

To reduce ecological footprint for materials transportation, Echenique *et al.* (2012: 136) advocate for polices that would reduce resource consumption. Schwanen, *et al.* (2011: 1000) advocated for attitudinal change to reduce the amount of resources utilised for materials transportation.

The ecological footprint due to transportation is frequently higher across cities in developing countries. Cervero (2013: 14) noted that the ecological footprint, as a result of materials transportation differs between developed and developing countries due to population density. Adequate provision for transport planning and co-ordination are often challenges in developing countries (Cervero, 2013: 14).

Chi and Stone (2005: 179) predicted that the ecological footprint of materials transportation will rise in years to come due to a continuous increase in the human population. Amekudzi *et al.* (2009: 345) noted that an inappropriate method for transporting materials could have a negative impact on the quality of air, water and land available for human development. Mao (2012: 7) opines that materials' movement from one point to another constitutes a major polluter to the environment – ranging from visibility reduction, noise, congestion and the emission of toxic gases, which deplete the ozone layer. Gases emitted range from Carbon monoxide (CO), Lead (Pb), Hydrocarbons and Nitrogen oxides (NO). When released into the atmosphere, these pollutants acidify and cause acid rain, which leads to the rapid deterioration of building components and lowers the yield of the agricultural harvest (Mao, 2012: 8).

Chapman (2007: 354) argues that 26% of the world's CO_2 emission emerges from the transportation sector. Lin and Xu (2017: 980) attributed the high CO_2 emission in materials transportation to the large quantities of fossil fuel consumed by the sector. Shakantu (2004: 50) perceives the need to harmonize the sustainability objectives in materials' transportation in environmental management. Alvemo *et al.* (2010: 1) argue that the large quantities of materials for construction works and the need to transport such materials exerts pressure on the means of transportation – especially roads, which causes grid-locks and increases the down time for goods movement.

Similarly, Fiksel (2006: 18) noted that the transportation of materials has an impact on the socio-economic development. Furthermore, Georgakis and Chiristopher (2012: 198) noted that transportation often causes congestion, the use of large quantities of energy; and it pollutes the environment.

4.10.1 Guidelines for selecting methods for transportation

The adoption of sustainable transportation systems would reduce the negative impacts highlighted earlier. Kamakaté and Schipper (2009: 3751) submitted that the factors below should be considered when selecting a method for transporting materials:

- Fuel price;
- Energy usage during operation;
- Operator's experience;
- Capacity of vehicle;
- Laws and regulations; and,
- Serviceability and maintenance costs.

Dekker *et al.* (2012: 674) affirm that the following are paramount for selecting methods to be used when transporting materials from one point to another:

i. **Material sources:** The source of materials should determine the method to be used for transporting such materials. Some materials are sourced from points distant from where they are needed; and the distance might impact on the overall cost. It is thus recommended that consideration should be given to sourcing materials from the closest source, in order to reduce costs and conserve energy.
ii. **Production system:** The distance from source of raw materials to the production point should be as short as possible, in order to reduce externalities, such as time and cost
iii. **Characteristics of the facility:** Factors such as type, number and location should be considered when selecting the most suitable methods to transport materials. When these are considered; this should reduce cost and the gas emission level.
iv. **Means of transportation:** When the materials are sourced, the next process would be to transport these materials to various locations. Cost should determine the means; since some methods are more expensive than others; but they are often faster.

4.10.2 Renewable construction materials

Materials are usually utilised from project inception to the commissioning stage. These materials range from naturally occurring materials to finished or semi-finished materials. Ebohon and Rwelamia (2001: 5) note that the construction industry has been adjudged to be the major exploiter of resources, with 25% of world timber consumed, 16% of fresh water used, and 40% of energy utilised for construction activities. These materials utilised for construction processes are often difficult to replace (Ashby, 2013: 240).

The materials and resources have a common cycle root, such as Nitrogen (N), Carbon (C) and Hydrological cycles occurring naturally in the atmosphere (Ashby, 2013: 240). The following are examples of renewable construction materials, according to Ashby, (2013: 240-241).

i. **Rammed earth:** This is available in many areas; and it can be produced by a mixture of earth with straw and cement or lime. It can be used for most construction purposes; and it has the ability to withstand high temperatures.

ii. **Straw and reed:** These are by-products of agricultural products, which are used to construct walls with low thermal conductivity. The reeds are usually used for roofing purposes; and they can be very durable when well-constructed.

iii. **Stone and lime:** Stone in most cases is not renewable; and it is also infinite; but it is also durable and eco-friendly. The demand for stone, such as Portland stone and Carrera marble has pushed the prices up.

iv. **Quasi-sustainable materials:** These materials allow for continuous exploration without the risk of exhaustion. They occur in large quantities and include: Iron, Aluminium, Sodium and Silicon among others. They are used in the production of other materials.

4.11 Environmental Ethics

The environment is a major pillar of support for human survival, where it provides the necessary resources for human development. Even with heavy reliance for survival, man has often paid little attention to the environment. Tilley (2000: 31) attributes this human character to the selfish nature of human beings, not considering other living species. Fisk (1973: 25) posits that concern for the environment started only in 1970 after land degradation, atmospheric pollution and animal extinction started to manifest and had become bothersome. Furthermore, Kamanzi (2012: 5) believes that the archeological-fossil proof shows that unethical environmental practices started about 10, 000 years ago with the introduction of new agricultural techniques. Hens and Susanne (1998: 98) attributed environmental challenges to the development achieved in science and technology. That is why Phillips and Reichart (2000:194) uphold that humans need to hold a high value to nature to guarantee their continuous existence. However, Hens and Susanne (1998: 97) noted the divergent views among environmental ethicists concerning the environment. They noted that the environmental ethicists all believe that they have a duty towards handling environmental challenges, but they disagree on what entails environmental ethics, its achievability and the extent of its achievability. A way out of this debacle was offered by Fisk (1973: 24), who advocated for environmental ethics through materials sourcing, transportation, production and consumption patterns that limit the externalities on the environment. This is because disputes often occur among stakeholders regarding environmental issues notably environmental pollution and destruction (Kulkarni, 2000: 215). Kulkarni (2000: 215) added that organisations generally aim at maximising profit which often mostly goes against environmental preservation and protection.

Stewart (2013: 25) and Tilley (2000: 31) submitted that environmental ethics came forth early in the 1970`s with the dual purpose of questioning the moral belief of human superiority over other living species on the earth and making case for the environment and nonliving contents. According to Stewart (2013: 25) environmental ethics seeks to promote environmental protection and remediation thereby guaranteeing justice to the environment and intergenerational equality.

Schilizzi (2000: 6) identified the following processes for ensuring intergenerational equality and preventing intertemporal externalities:

- Promulgation of relevant laws and regulations to protect the environment
- Imposition of tax to promote equity
- Organisations holding back harmful activities during operations.

4.11.1 Approaches to Environmental Ethics

Common approaches to environmental ethics are the ecocentric theory, biocentric theory, anthropocentrism, Gaia theory and sustainable development. The common environmental ethics theories are examined in the following sections.

4.11.1.1 Ecocentric theory

The ecocentric theory promotes environmental sustenance and values all the species in the environment (Stewart, 2013: 25). Tilley (2000: 31) noted that the ecocentric theory promotes environmental sustainability, where the environment is seen as a major stakeholder. Adequate attention should be paid to persons or individuals that intend to disrupt the environment (Tilley, 2000: 31). Stewart (2013: 24) noted that majority of business organisations have often adopted the ecocentric viewpoint, however some continue to run their businesses at a detriment to the environment. That might be the reason why Stone (1975: 457) suggested that living things in the environment including forests, rivers and oceans should be held with value and appropriate attention and care should also be accorded to them.

4.11.1.2 The Biocentric theory

The biocentric theory is widely accepted and used in various fields including conservation of biodiversity, management of natural resources, environmental accounting and business development (Kant: 260). According to Stewart (2013: 24), the biocentric theory promotes the rights and our responsibility to living things including plants and animals. Furthermore, Lamp (1996: 477) noted that the biocentric theory does not believe that human beings are superior over other living species; rather attaches value to all living things. It advocates for a balance in resources consumption patterns among living species in the environment (Goldsmith, 2008: 33)

4.11.1.3 Anthropocentrism

Tilley (2000: 31) noted that anthropocentrism ethical theory treasures humans only without considering other biotic species. Stewart (2013: 24) submitted that the anthropocentric theory holds human beings with high esteem, such that humans need to protected at the expense of nonhumans. A shortcoming observed in the anthropocentrism viewpoint is rigidity. Norton (1984: 132) noted that the anthropocentrism ethical theory places humans above other nonhuman species even as both human and nonhumans depend on each other.

4.11.1.4 Gaia theory

Hens and Susanne (1998: 111) noted that the Gaia theory was first developed by James Lovelock; a British scientist and researcher in the early seventies. According to Lovelock (2003: 770), the Gaia theory seeks to extend the frontiers of knowledge and does not go against the earlier theory of evolution. Hens and Susanne (1998: 111) aver that the earth is central to the growth and development of all living species. Furthermore, Hens and Susanne (1998: 112) noted that the Gaia theory promotes and upholds collaboration and partnership amongst the species living on the earth.

4.11.1.5 Sustainable development

There is no internationally accepted definition of sustainability other than the idea prescribed by the Brundtland report on sustainability, which took cognizance of the present and upcoming generations. The general worldview of the environment and the ecology calls for a critical discourse with regard to socio-economic development in society. Diverse views call for a contemporary model that is relevant, with a current development pattern tagged "sustainable development". Such views are expressed at conferences and symposia. These include: The United Nations Conference on Environment and Development and the Kyoto Conference (Hague, 2000:4). Hill and Bowen (1997: 224) maintain that sustainable development is a type of developmental initiative that provides for the infrastructural needs of the society; but at the same time ensuring a limited negative environmental impact of such development.

There are reservations regarding the Brundtland report. But Oladapo and Olotuah (2007: 335) argued for the need for sustainable development strategies; since the relationships between nature and the environment are symbiotic; and they frequently depend on one another for their ongoing survival. According to du Plessis (2009: 36), sustainable development seeks to uplift the living conditions of humans, guaranteeing the continuous survival of humanity.

Kibert (2016: 43) believes that for sustainable development to be achieved there is a need for the present generation to introduce and embrace ethical standards for the benefit of current and coming generations. du Plessis (2007: 5) indicates that sustainable development centres on balancing connections between the environment and humans, thereby ensuring that the environmental carrying capacity is not surpassed and ensures impartiality, as well as an equal opportunity to develop, thereby guaranteeing the continuous development of the humanity.

Robinson (2004: 373) points out that the literature is rife with diverse positions on the sustainable developmental approach. Some support their assertion by using social, ecological and economic dimensions in their approach; while others view it from the human and nature perspective.

In the view of Mosaku (2015: 184), sustainable development should focus on ensuring an equilibrium between human wants, needs and the environment, so as to guarantee the survival of the coming generation. Edum-Fotwe and Price (2009: 314) posit that sustainability covers economic, social and environmental factors, as the first order of sustainability. The second order is the commonality with the first. An interrelationship between all these components makes up the third order, which is then termed sustainable development. This is illustrated in Figure 4.4

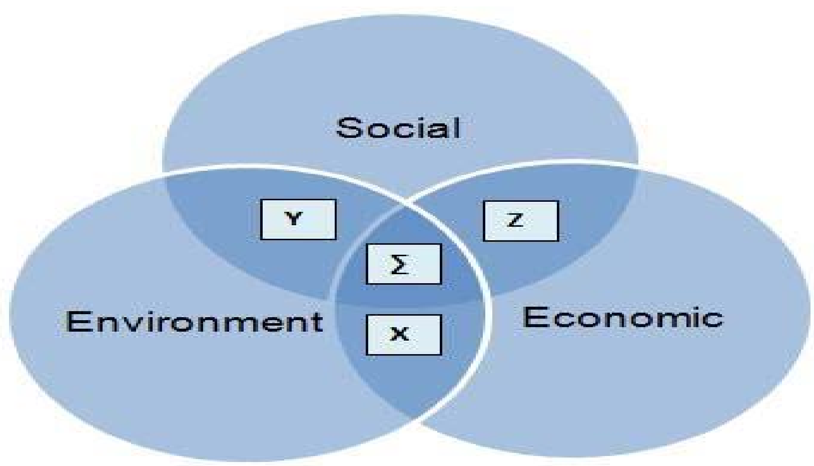


Figure 4.4: Sustainable development concept
"X", "Y" and "Z" represent the 2nd order of sustainability

"∑" represents sustainable development

Adapted from Edum-Fotwe and Price (2009: 314)

Gilham (2010: 8) maintains that sustainable development is a procedure that ensures an equilibrium between the economic, environmental and social issues for the survival of both the current and coming generations. Ruparathna and Hewage (2015: 306) point out that the integration of procurement with sustainability would greatly enhance sustainable development. Hill and Bowen (1997: 222) contend that sustainable construction should aspire to minimise the effect of the construction process on the health of citizens and the environment.

These divergent views on the concept of sustainable development could be attributed to dissimilar beliefs and understanding of the much-coveted Brundtland report, which first popularized the concept of sustainable development.

Humans rely entirely on nature for the provision of the resources for survival and development; and these resources range from land, materials and enabling weather. However, various human activities have adverse effects on the ecosystem; even though their entire activities depend on the stability of the ecosystem.

4.12 Conclusive remarks

In this chapter, sustainability and sustainable development were examined. The chapter also extensively discussed the theoretical and conceptual frameworks. The constructs considered in the theoretical framework were: environmental sustainability; sustainable reporting; materials production and materials transportation. The conceptual framework discussed extensively the interrelationship between sustainable sourcing; ecological footprint and environmental ethics. The next chapter presents the research methodology and the techniques used to evaluate the research objectives.

Chapter 5: Research Methodology and Techniques

5.1 Introduction

The previous chapter focused on the theoretical and conceptual frameworks. This chapter discusses the research methodology used for the study. It begins with a discussion of the research design.

5.2 The research design

A research design illustrates the research strategies for the study, including the nature of what the result would evolve into (Babbie, 2007: 107). Cohen *et al.* (2007: 44) asserted that research designs are the steps taken in the research for the collection of the data, which can be used for making inferences, explanations and predictions of the findings. Thus, the research design involves the use of specific methods to analyse the data (Cassim, 2017: 63). It aids the researcher in stating the process used in the collection and analysis of the data for the study (Zikmund and Babin 2010: 66). Ultimately, a research design should clearly state what the study entails (Sinkovics and Alfoldi (2012: 899).

Research design provides a framework on how to carry out the study. Leung (2013: 71) and Creswell (2012: 121) noted that research design also involves theoretical, methodological, philosophical, and ethical considerations that determine the aim of the research. Aigbavboa (2013: 253) argued that research design should consider ontology, epistemology, methodology, designs and instruments for the research, as illustrated in Figure 5.1.

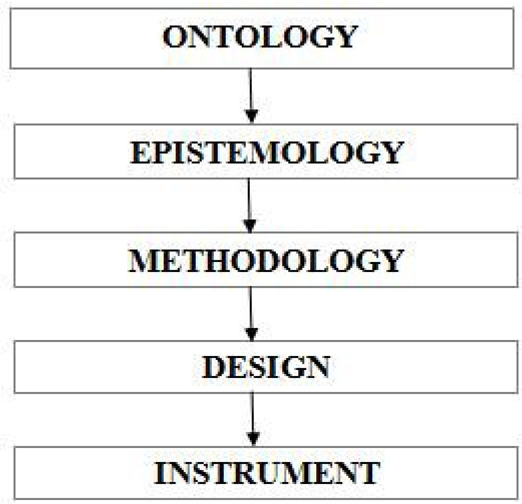


Figure 5.1: Research-design process
Source: Aigbavboa (2013: 253)

Wahyuni (2012: 69) asserted that research design is what the researcher does; and involves development of knowledge. Research design helps to give a clear guide on how the research should be carried out. This research began with a general background on the issues relating to sustainability and the ethical sourcing of materials in the construction industry. The outcome guided the formulation of theoretical, as well as the related conceptual framework for the ethical sourcing of construction materials.

Philosophical approaches and paradigms dictate how the research design is set out; and these should be in tandem with the manner in which a researcher makes assumptions, as well as their conviction and view of the research. This gives direction to the method on which the research philosophy is based, including the research paradigm.

5.3 The Research Philosophy

Research philosophy largely focuses on the creation, the control and the strengthening of the techniques for the investigation in all the research endeavours (Shakantu, 2014: 54). The philosophical stance determines the research design and the method employed for a research; and it is frequently based on the researcher's background and sociological perception. Shakantu (2014: 56) posits that bias should be avoided in the choice of the philosophical position and the tools selected for the research; rather the nature of the research should be paramount in determining the choices.

The importance of grasping the research, according to Easterby-Smith *et al.* (2008: 27) is that:

i. It guides the researcher in selecting the appropriate research design;
ii. It aids in the identification and creation of designs;
iii. It acts as a pointer for the researcher to know the obstacles to completion of the research.

When determining the philosophical position, there is need to look at the sociological, epistemological, and ontological backgrounds, which guide the research study (Shakantu, 2014: 47 ; Pathirage *et al.,* 2008: 5). These factors strongly influence the research reasoning, the data requirement, as well as the method adopted for the data analysis.

5.4 Ontology

Fellows and Liu (2015: 70) and Bothman *et al.* (2010: 40) argue that, ontology is concerned with reality; and how the world is observed. In ontology, the research question guides the direction of the study (Bothman *et al.,* 2010: 40). According to Tracy (2013: 38), ontology deals with the questions of reality. Researchers can base their position on either the Parmenidean, or the Heraclitean ontologies. Shakantu (2014: 53) contends that the two key ontological perspectives are paramount when selecting a methodology. He further believes that they give credence to the methodology used for the study. The Heraclitean ontology views nature as deeply rooted in a fluxing, changeable and emergent world; while the Parmenidean ontology promotes the view that reality is permanent and unchangeable (Shakantu, 2014: 53).

It should be noted that all humans make individual ontological assumptions, which determine what they attribute their existence to, either a particular item or other items.

5.5 Epistemology

Epistemology is concerned with the nature in which knowledge exists (Fellows and Liu, 2015: 70 and Bothman *et al.,* 2010: 40). Fellows and Liu (2015: 70) and Bothman *et al.,* 2010: 40) further revealed that epistemology :

i. Centres on the composition of the knowledge we posses;
ii. Deals with how we can understand and describe the situation;
iii. Is related to the methods, theories, law and how they all apply;
iv. Is related to theories that state the way the social phenomena can be understood.

Shakantu (2014: 55) explains that epistemology focuses on the authentication of knowledge. It clarifies the way the knowlege came about (Bothman *et al.,* 2010: 40). According to Tracy (2013: 38), epistemology deals with the nature of knowledge. Again, epistemology focuses on how knowledge can be gained and confirmed (Sutrisna 2009: 8). Thiroux and Krasemann (2012: 2) argued that epistemology seeks to answer questions such as:

- What does knowledge entail?
- What are the differences between the truth and falsehood?
- What is the basic knowledge to be known by people?
- What information does perception give; and is perception trustworthy?
- What constitutes knowledge and belief?
- Does “certain knowledge” really exist?

Two opposing epistemologies are objectivist and subjectivist. The objectivist presupposes that any source of knowledge on the external world can be verified without any ambiguity (Shakantu, 2014: 55). The subjectivist presumes that knowledge of the external world can be obtained by assessing and inferring meaning to the result obtained from a scientific process (Eriksson and Kovalainen, 2008: 14).

5.6 The research paradigm

Creswell (2012: 6) views the research paradigm as the manner, in which an event is observed and analysed. Babbie (2007: 31) points out that the research paradigm depicts how reasoning and observation are carried out. According to Tracy (2013: 38), the research paradigm helps to understand a phenomenon, to develop knowledge, and to collect vital information. Fellows and Liu (2015:19) point out that research paradigm is the lens a researcher uses to view a research problem. The research paradigm illustrates the position taken by the researcher in visualising the problem the study seeks to address (Dainty *et al.*, 2008: 9).

5.6.1 Positivism

Positivism is a distinct research paradigm that is concerned with the facts that can be understood and widely accepted (Bothman *et al.,* 2010: 42). Fellows and Liu (2015:19) claim that the positivist paradigm believes that the facts exist; but they must be measured or observed to lay claim of their existence.

Tracy (2013: 39) and Bothman *et al.* (2010: 42) argue that since the earth exists and is also real, it is believed that study can be carried out and make some remarkable inferences from this existence. Ritchie and Lewis (2013: 79) associate the following characteristics with positivism:

i. Positivism has its roots in the natural sciences; and it is also suitable for research in the social science;
ii. Inductive study of an event is carried out, so as to have the facts confirmed;
iii. Assumptions are made deductively from systematic hypotheses, which can be confirmed with scientific study in resolving the hypotheses;
iv. Positivism relies on facts and values.

5.6.2 Post-positivism

The Post-positivism theory is similar to positivism; since they both aim at unravelling reality (Tavakoli, 2012: 477). Tracy (2013: 39) argues that the post-positivism theory is similar to the Positivism theory; but it is different in the belief that the human understanding of reality is biased. According to Tracy (2013: 39-40), the following are the characteristics of the Post-positivism theory:

- Post-positivism believes that reality is truly real; and it should be understood;
- For reality to be known and understood by humans, there are barriers, which have to be overcome.

5.6.3 Interpretivism

Interpretivism relies entirely on internal opinions for inferences to be made (Fellows and Liu, 2015: 23). Sutrisna (2009: 8) argues that the interpretivist accepts the interpretation of reality. Tracy (2013: 39) avows that Interpretivists believe reality is a fallacy that could be easily understood; but there is a strong relationship between reality and knowledge. . Interpretivism believes knowledge is gained through social interaction with people (Tracy, 2013: 41). This is because, peoples' inputs are dependable for a situation to be fully understood (Bothman *et al.,* 2010: 42).

Fellows and Liu (2015:19) submit that interpretivism believes that reality is comparative; and it can exist in various forms, which need to be clearly defined and understood. Phenomenology, ethnomethodology and ground-breaking theories are qualitative approaches that are promoted by Interpretivism (Bothman*et al.,* 2010: 42). Ritchie and Lewis (2013: 79) associate the following characteristics with interpretivism:

- There is a clear distinction between scientific experience and traditional experience;
- The background understanding of a situation is a necessity;
- Brainstorming over an event provides a solution; and
- Human understanding is determined by one's level of understanding.

5.7 The Critical theory

This is based on critical thinking. There must be critical analyses and examination of a particular event thoroughly, before conclusions are drawn; and individual opinions and experience would help to determine the reliability of the result (Bothman *et al.,* 2010: 43). In critical thinking, there is the belief that serious philosophical thinking helps in understanding a situation better (Bothman *et al.,* 2010: 43). Saidu (2016: 124) holds that critical theory believes in the historical and the rational perspective as the basis for analysis in critical thinking. According to Tracy (2013: 44), critical theory focuses on examining wrongdoings, such as: misuse, abuse and misrepresentation, and how people seek redress.

5.8 Postmodern/ poststructuralist

Postmodern/ poststructuralist theories share the same view as the critical theory. Tracy (2013:44) affirms that the postmodern/poststructuralist believe that all humans, irrespective of their race, prefer to explore all the various options available. Furthermore, the postmodern/poststructuralist sees reality and knowledge as separate; hence, it will be a Herculean task to understand and prove that knowledge exists (Tracy, 2013: 44).

Table 5.1 presents the logic of the research approach/paradigms and their interrelationships with each other.

Table 5.1: Post-Positivist, interpretive, critical, postmodern/post structural assumptions

S/No	Post-positivist	Interpretive	Critical	Postmodern/post structural
Ontology (nature of reality)	Single, true, apprehensible Socially	Socially constructed	Constructed through power relations and shaped over history	Multiple, fragmented, layered, fluid, and multi-faceted
Epistemology (nature of knowledge)	Discovered; a priori, true, objective	Produced; dependent and value-laden; subjective, co-	Mediated, hidden, distorted, and produced	Relative, skeptical, “truth” is a myth; knowledge is as much fantasy as it is reality

		created	through power relations	
Goal of research	To measure, predict, control; to be formally generalizable, reliable, and a mirroring representation	To understand why and how; to be useful and interesting; to provide opportunities for participant voice	To ask "what should be?" to improve and transform; to disrupt power relations	To highlight chaos, show multiple points of view, and examine absence and the relativism of meaning
A good researcher	Expertly uses research and measurement devices; brackets out background and biases so they do not taint research findings	Is a self-reflexive research instrument, aware of biases and subjectivities; background is imperative for understanding the research method	Considers social class and powerful structures such as "isms" (sexism, homophobia, racism, ageism); asks how the scene is affected by, and constructs, power relations	Acknowledges the crisis of representation, writes stories that open up multiple themes, examines the appropriation and layering of reality
Method (strategies for gathering, collecting and analyzing data)	Viewed as value-free; multiple methods (often quantitative and experimental) triangulated to ensure accuracy and validity building	A value choice with ethical and political ramifications; multiple methods show the contexts' layered and partial nature; hermeneutical	Qualitative methods often coupled with historical considerations of power and class	Qualitative methods often coupled with considerations of various and overlapping mediated representations of the scene
Focus	Building knowledge through analysis of objective behavior (behavior that can be measured, counted, or coded)	"Making sense" of scene from the participants' point of view – examining not only behaviors but intentions and emotions	Pointing out domination; aiming toward emancipation and transformation	Highlighting absence, pastiche, hyper-reality, simulacra and rhizomatic meaning
Theory creation	Deductive and incremental; researchers systematically propose and test scientific explanations on the basis of	Inductive, expansionistic and iterative. Researchers hold on loosely to tentative explanations, compare them with emergent data, revise their claims, go back to the data and repeat. As a result, the study may solve a problem, attend to a given controversy, critique an existing school of thought, strengthen a fledgling theory, or construct a new one		

	existing knowledge	

Source: Tracy (2013: 48-49)

5.8 Phenomenology

Phenomenological views are based on the knowledge of events, happenings and experiences witnessed (Fellows and Liu, 2015: 72). The phenomenologist relies on the knowledge gained from a process or incident that occurs; and it does not seek to know just how it occurred (Shakantu, 2014: 58).

5.9 The Research philosophical position

This research is situated in the built environment; it aims to enhance sustainability practice in the construction industry by taking these philosophical positions:

- In epistemology, the research is subjectivist in nature. The issues were addressed from the observation of processes and events, as they unfolded, which is based on rationalist assumptions.
- For the ontology, the research is Heraclitean in nature. It believes human actions flux and change.
- Paradigmically, the research is phenomenological, because the issue that the research sets to study is subjective.

5.10 Research reasoning

Research reasoning refers to the sense employed to undertake research work. It also implies the tactics deployed to ensure that the research is completed (Tracy ,2013: 52). Sutrisna (2009: 8) points out that, research reasoning centres on the sense deployed for the research, the use of existing literature, the data collection and the analytical method. The two basic research reasoning approaches are inductive research and deductive research.

5.10.1 Inductive reasoning

Inductive reasoning relies on the evidence gathered. Ritchie and Lewis (2013: 79) indicate that inductive reasoning uses facts as a guide to reach conclusions. Inductive reasoning is closely related to qualitative research; but they are not the same (Ritchie and Lewis, 2013: 79). Sutrisna (2009: 8) points out that in inductive reasoning, it is imperative to make references to the existing knowledge, to collect the data, to analyse the data collected to produce the findings. According to Tracy (2013: 22), the processes for inductive reasoning are:

- Inductive reasoning commences by the observation of an event;
- The development of thought from the observation made;
- The production of results from the observation carried out; and,
- To draw a conclusion that contributes to knowledge.

5.10.2 Deductive reasoning

According to Ritchie and Lewis (2013: 79), deductive reasoning relies on the available evidence to buttress its position. Ikediashi (2014: 91) points out that deductive reasoning involves collection of the relevant data, so as to check the relationships from the data collected, grouping of the relevant data together; and formulation of the data. Deductive reasoning formulates the hypothesis, guided by the review of the relevant literature, the gathered data and also the analysis of the data to check whether a relationship exists (Sutrisna, 2009: 9). Fellows and Liu (2015:17) note that accurate reasoning guarantees accurate results and conclusions in deductive reasoning. The difference between inductive and deductive reasoning is presented in table 5.2.

Table 5.2: Differences between Inductive reasoning and deductive reasoning

S/no	Inductive reasoning	Deductive reasoning
1.	Commences by the observation of an event	Commences with the building of general theory
2.	Thoughts are developed through observation	Theory helps to develop hypothesis
3.	Results are produced after observation	Developed hypothesis are tested after carrying out research
4.	Draws conclusions that add to knowledge	Final result either proofs or disproof's the hypothesis

Adapted fromTracy (2013: 22)

5.10.3 Research reasoning adopted

The peculiarity of the research study makes it imperative to focus more on investigating ethical behaviours in material sourcing, transportation and production in the construction industry; and there after developing a framework for the ethical sourcing of construction materials. Inductive research reasoning was adopted in the study in order to provide a better understanding on the subject and the area studied by using an observation template. The inductive research reasoning adopted, allowed the researcher to have an open mind in finding possible results that will enable the fulfilment of the research aim and objectives.

The next section discusses the types of research methods that exist.

5.11 The research methods

These are steps used to carry a research work to its conclusion. The methods/ approaches mostly used are the qualitative and quantitative method. Sutrisna (2009: 6) views the research methods as tools deployed to achieve the stated aim and objectives.

5.11.1 The Quantitative method

Sale *et al.* (2002: 49) view the quantitative method as expressing the truth without any ambiguity and devoid of the investigator's influence. Creswell (2009: 13) and Amaratunga *et al.* (2002: 21) maintain that qualitative methods can be used for testing theories and checking whether relationships exist between the data collected. Ikediashi (2014: 95) claims that the quantitative method has its base in the natural scientific system; and it is not concerned with the social reality. Cooper and Schindler (2014: 146) noted that the quantitative method focuses on quantification in research, such as: behaviour, knowledge, opinions, or attitudes. Fellows and Liu (2015: 9) and Cooper and Schindler (2014: 146) observe that quantitative methods often respond to questions, such as: What? How much? How many? Creswell (2012: 13) highlights the following characteristics of the quantitative method:

I. Unravelling of problems and ambiguity clearly and directly, so that they can be easily understood;
II. The literature review gives a guide on the body of research;
III. It relies on the amount of data collected and also the sources of the data;
IV. Making inferences on the type of data collected; and
V. The need for the study, the research question and hypotheses are confirmed.

5.11.2 The Qualitative method

Amaratunga *et al.* (2002: 19) note that the qualitative method draws the data from words and observations of the samples in the natural setting. Bryman (2012: 36) adds that, the qualitative method is concerned with the respondents' contents of expression rather than numbers. The Qualitative method focuses on the dynamic nature of the results, which usually manifests from the perception and interaction for the study between the observer and the observed (Sale *et al.,* 2002: 49). Creswell (2012: 16) pinpoints the following characteristics of the qualitative method:

i. Carrying out a detailed study on a problem observed;
ii. The review of past works provides a basis to understand the research problem;
iii. The data collected are usually few; but they are detailed;
iv. The need for the study and the research question are comprehensively stated;
v. The data analysis is usually descriptive.

Tracy (2013: 5) affirms that the qualitative method offers the following advantages:

- It exposes the salient research problems;
- It critically analyses the research problems;
- It provides details of the connection between the subjects; and,
- It describes the relationship between the groups and the various organisations in detail.

Table 5.3 presents the differences between the quantitative and qualitative research methods.

Table 5.3: Differences between the qualitative and the quantitative methods

	Qualitative method	Quantitative method
Focus of research	Understand and interpret.	Describe, explain, and predict.
Researcher involvement	High—researcher is participant or catalyst.	Limited, controlled to prevent bias.
Research purpose	In-depth understanding, theory building.	Describe or predict, build and test theory.
Sample design	Non probability, purposive.	Probability.
Sample size	Small.	Large
Research design	May evolve or adjust during the course of the project	Determined before commencing the project
	Often uses multiple methods simultaneously or sequentially	Uses single method or mixed methods
	Consistency is not expected	Consistency is critical
	Involves longitudinal approach	Involves either a cross-sectional or a longitudinal approach
Participant preparation	Pre-tasking is common	No preparation desired to avoid biasing the participant
Data type and preparation	Verbal or pictorial descriptions	Verbal descriptions
	Reduced to verbal codes (sometimes with computer assistance)	Reduced to numerical codes for computerized analysis
Data Analysis	Human analysis following computer or human coding; primarily non quantitative	Computerized analysis—statistical and mathematical methods dominate
	Forces researcher to see the contextual framework of the phenomenon being measured—distinction between facts and judgments less clear	Analysis may be ongoing during the project
	Always ongoing during the project	Maintains clear distinction between facts and judgments
Insights and meaning	Deeper level of understanding is the norm; determined by type and quantity of free-response questions	Limited by the opportunity to probe respondents and the quality of the original data collection instrument
	Researcher participation in data collection allows insights to form and be tested during the process	Insights follow data collection and data entry, with limited ability to re-interview participants
Research sponsor	May participate by observing	Rarely has either direct or indirect contact

Involvement	research in real time or via taped interviews	with participant
Feedback turnaround	Smaller sample sizes make data collection faster for shorter possible turnaround	Larger sample sizes lengthen data collection, Internet methodologies are shortening turnaround but inappropriate for many studies
	Insights are developed as the research progresses, shortening data analysis	Insight development follows data collection and entry, lengthening research process, interviewing software permits some tallying of responses as data collection progresses
Data security	More absolute given use of restricted access facilities and smaller sample sizes	Act of research in progress is often known by competitors, insights may be gleaned by competitors for some visible, field-based studies

Source: Cooper and Schindler (2014: 147)

5.11.3 The mixed method

This method applies at least one type of research method (Bergman, 2008: 53). Creswell (2012: 22) argues that the data from the research findings are presented better using the mixed method than either the qualitative or the quantitative research method. Furthermore, Fellows and Liu (2015: 29) and Amaratunga *et al.* (2002: 23) aver that the mixed method helps to offset any of the shortcomings in the qualitative and quantitative methods.

5.12 Methods adopted for the research

Data collected for the research were mainly qualitative in nature. However, some the data collected were presented in numerical format to demonstrate parameters under scrutiny. Furthermore, relevant information was sought from the archival records of the organisations used for the case studies. This approach enabled a clear understanding of phenomena, without any predetermined expectations.

5.13 The data

The data describe the responses collected from a research or study. Wahyuni (2012: 73) claims that the data collected may be primary data or secondary data. The data are the findings emanating from a study carried out from a research (Cooper and Schindler 2014: 86).

5.13.1 The primary data

The primary data are raw and unrefined data gathered by a researcher (Wahyuni, 2012: 72). The primary data were collected with the aid of an observation template by the researcher. The observation process covered the material sourcing, transportation and the material production.

5.13.2 The secondary data

These are the data that are already processed, published as a result after the research has been carried out; and they are also accessible publicly (Wahyuni, 2012: 73). The secondary data for the research were collected from the sustainability reports of organisations, journals and conference proceedings.

5.14 The data-collection procedure

For this research, the following methods were used to collect data:

5.14.1 Observation of object

The observation of the object allows the true capture of the data in a real-life setting; since the object being observed would not be altered by the observer in the natural setting (Struwig and Stead, 2013: 104). Cooper and Schindler (2014: 179) highlighted the merits associated with the use of observation as a means of data collection as: (1) Peculiarity of the research areas, such as ethics and behaviours; (2) Actual data needed will be gathered as events unfold; (3) Elimination of forgetfulness of important information by the respondents; (3) Exposes hidden information and data; (4) Data and information can be captured in a normal environment; and (5) The bias is less compared with other methods.

According to Jackson (2010: 96-97) and Nieuwenhuis (2007: 85), the types of observation methods are:

- Complete participant: the researcher is completely immersed in the process and those being observed at not aware of the researcher`s presence;

- Participant as observer: the researcher is immersed in the process and the researcher's presence could alter the situation/action;
- Observer as participant: the researcher is actively involved in the process, but does not alter the situation/action; and,
- Complete observer: the researcher is not involved in the process, but keenly observes.

For this study, complete observer method was adopted for the study. The research instrument developed for the study, contains the parameters for the study, for example:

i. Site location;
ii. Distance of resource-extraction site from the buildings;
iii. The mode of sensitisation before extraction;
iv. The time of operation;
v. The method of resource extraction;
vi. The types of plant and equipment;
vii. The mode of plant and equipment operation;
viii. The types of materials involved;
ix. The method of material loading and offloading;
x. The method of material transportation/ haulage;
xi. The method of material production/ processing;
xii. The impact of material sourcing on the environment; and,
xiii. The methods adopted to mitigate the material sourcing, transportation and production impact, were rated to produce evidence about the various behaviours that were observed.

Two rating scales were used in the study to achieve the aim of research. Regarding the impact of materials sourcing, transportation and production on the environment, the rating scales used were:

a) Very high;
b) High;

c) Moderate;
d) Neutral; and,
e) No impact.

For the efforts adopted to mitigate the impact of materials sourcing, transportation and production on the environment, the rating scales used were:

- Applied; and,
- Not applied.

5.14.2 Archival record

Archival record describes an organization`s composition and also contains a large amount of information that is useful to a researcher (Salkind, 2012: 214).

The sustainability reports prepared by the organisations selected for the study, were examined to obtain information on the efforts, plans and provisions that organisations make to improve their sustainability practices. The reports also reveal the various impacts of the material sourcing, transportation and the production of air pollution, noise pollution and vibration, water pollution, landscape destruction and energy use.

5.15 Population and sample of the study

The population, sample size and the sampling approach are stated in the sections.

5.15.1 Population

Bothman *et al.* (2010: 43) explain that the population of a study comprises all the participants. These could be individuals and objects, from which the researcher intends to extract reliable information. Creswell (2012: 142) asserts that the population of the study is the entity in a group that completes the group. Salkind (2012: 33) notes that the population is the larger group from, which the sample is drawn. Babbie (2014: 207) believes that the population is the total number of elements, from which a sample is drawn.

5.15.2 Sample size

Cassim (2017: 73) declares that the sample size is the representative of a group or objects, from which the information needed on the group can be extracted. According to Creswell (2012: 142), the sample size comprises those members of a group; that the researcher intends to use as a representation of the target population. The sample size is a smaller group selected from the entire population (Salkind, 2012: 33). According to Babbie (2014: 105), after a sample size has been drawn, it is imperative to understand both the units of study/observation and those of analysis in carrying out a research.

I. **Unit of observation:**The unit of observation speaks to what is studied in the research (Babbie, 2014: 101).
II. **Unit of analysis:** According Babbie (2014:101), the unit of analysis is the phenomenon or incident to which attention is given in the research.

For this research, the **unit of observation** was: the material extraction, the material transportation and the material production; and the **unit of analysis** was the construction materials' ethics of the companies being studied.

5.15.3 Sampling approach/strategies

Sampling is how an observation is chosen (Babbie, 2014: 197). Tracy (2013: 134) notes that the sampling approach gives a guide on how to select a sample. Salkind (2012: 33) believes that the two sampling approaches include: the probability and the non-probability sampling. For probability sampling, the probability of any associate of the population being selected for a study is known; while for non-probability sampling, the probability of any associate being selected is unknown (Babbie, 2014: 199 and Salkind, 2012: 96).

Probability sampling approaches are:

i. **Simple random sampling technique:** The random sampling technique is the most popular and common technique used for sampling. Salkind (2012: 98) believes that the random sampling technique gives each associate the same and an independent opportunity to be involved in the study. According to Babbie (2014: 220), each member in the population is considered by assigning a randomly produced number; and each member that has their number picked is be selected for the study. Tracy (2013: 134) declares that the random sampling technique is unpopular among qualitative researchers, who prefer an in-depth study.

ii. **Systematic sampling technique**: In the systematic sampling technique, the chances of an associate to be involved in the research is minimal (Salkind, 2012: 98). Babbie (2014: 220) opines that the Nth unit in the list is chosen for the research.

iii. **Cluster-sampling technique:** This sampling technique is fast. Here, individuals are grouped into units; and these are then selected, rather than the individuals (Salkind, 2012: 102). Babbie (2014: 220) explains that in cluster sampling, the population is grouped into units; and each unit is then further sampled.

The non-probability sampling technique includes:

i. **Purposive/judgemental sampling technique:** The purposive/judgemental sampling is a non-probability sampling technique. According to Babbie (2014: 200), information, characteristics and justification are paramount, when using the purposive/judgemental sampling technique.

ii. **Snowball/ accidental sampling technique:** Fellows and Liu (2015: 34) claim that snowball sampling can be used when the population for the study is concealed. In the snowball/accidental sampling technique, a respondent for the research is often asked to recommend who can give valuable information for the research (Babbie, 2014: 200). This technique is used when it is difficult to get respondents, due to the complexity and sensitivity of the research, such as undocumented settlers and drug cartels.

iii. **The Quota-sampling technique:** Quota sampling is very similar to probability sampling. Babbie (2014: 201) maintains that in quota sampling, the units selected are distributed into various groups, so that every group would have a representative. Salkind (2012: 103) maintains that quota sampling helps to take care of the shortcomings in the stratified-sampling technique.

iv. **Convenience/ unrestricted sampling technique:** The Convenience/ unrestricted sampling technique is often the most inexpensive and the least stressful sampling technique. Cooper and Schindler (2014: 359) noted that the researcher uses his/her discretion to select who the respondents will be, as well as the number of respondents. Table 5.4 presents the differences between the types of sampling strategies.

Table 5.4: Snapshot of the differences and types of probability sampling and non-probability sampling strategies

S/no	Types of sampling	When to use it	Advantages	Disadvantages
		Probability sampling strategies		
1.	Simple random sampling	When the population members are similar to one another on important variables	Ensures a high degree of representativeness	Time consuming and tedious
2.	Systematic sampling	When the population members are similar to one another on important variables	Ensures a high degree of representativeness and no need to use a table of random numbers	Less random than simple random sampling
3.	Stratified random sampling	When the population is heterogeneous and contains several different groups, some of which are related to the topic of study	Ensures a high degree of representativeness of all the strata or layers in the population	Time consuming and tedious
4.	Cluster sampling	When the population consists of units rather than individuals	Easy and convenient	Possibly members of units are different from one another, decreasing the technique's effectiveness
		Non-probability sampling strategies		
1.	Convenience sampling	When the members of the population are convenient to sample	Convenient and inexpensive	Degree of generalizaability is questionable
2.	Quota sampling	When strata are present and stratified sampling is not	Ensures some degree of representativeness	Degree of generalizability is questionable

		possible	of all the strata in the population	

Source: Salkind (2012: 104)

5.16 The research population sample used for the study

The sampling approach adopted for the research is the non-probability method with special emphasis on the purposive-sampling techniques. The purposive-sampling technique was adopted because it enabled the researcher to choose organisation that meet some primary criteria, such as: the selection of organisations that are involved in sourcing, transportation and production of materials used for construction in Nigeria; and the organisations selected are fully operational. A total of eight (8) materials were considered, comprising: Tiles, Clay, Limestone, Sand, Granite, Laterite, Marble and Timber. The considered materials are the major materials produced in Nigeria. The multiple-case studies approach was adopted, such that two organisations were selected for each of the materials considered in the study.

5.17 The data analysis

The data collected from the study were presented in tables and on plates.

5.18 Data validity and reliability

Sutrisna (2009: 6) contends that the data validity is the extent to which the data generated can be referred to as authentic; and it is also the level at which the findings from the research can be comprehensively applied to a similar situation. Salkind (2012: 115) and Cohen *et al.* (2007: 133) posit that validity determines the level at which the research instrument achieves the set targets. According to Tracy (2013: 58), threats to validity are: incorrect sample, use of wrong instrument for research. Fellows and Liu (2015:147) claim that internal and external validity are threats to the research reliability. They further noted that a slight change in the independent variable would cause the dependent variable to also change, which would have an impact on the results.

The threats to internal validity are: History, instruments, maturation, morality and selection. The study employed the purposive-sampling technique, which means the likely threat here is history; hence, the other threats would probably not occur. To forestall any threat that might emerge from the history, relevant and significant data were not omitted in the study. Again, history was addressed by choosing organisations that are fully operational, and use relevant technology and methods. Hence; all the threats relating to validity were well taken care of in the research.

In the words of Babbie (2014: 152),“reliability is the guarantee that the exact data would be obtained when the research is repeated without changing the methodology". Reliability refers to the level at which the data gathered are deemed to be dependable (Salkind, 2012: 235 and Sutrisna, 2009: 6). Not only that, but Amaratunga *et al.* (2002: 29) believe that planning ahead for how reliable a study will be, helps to reduce any mistakes and prejudice that might occur in a research project.

For this research, the reliability of the data was ensured via the correct selection of unit to draw samples, increasing the numbers of observations carried out, thereby ensuring that only the researcher does the observation by maintaining a consistent scoring procedure, minimizing the effect of external events and limiting the range and scope, so that the results could be replicated in similar studies. A summary of the research design outline is presented in Figure 5.2.

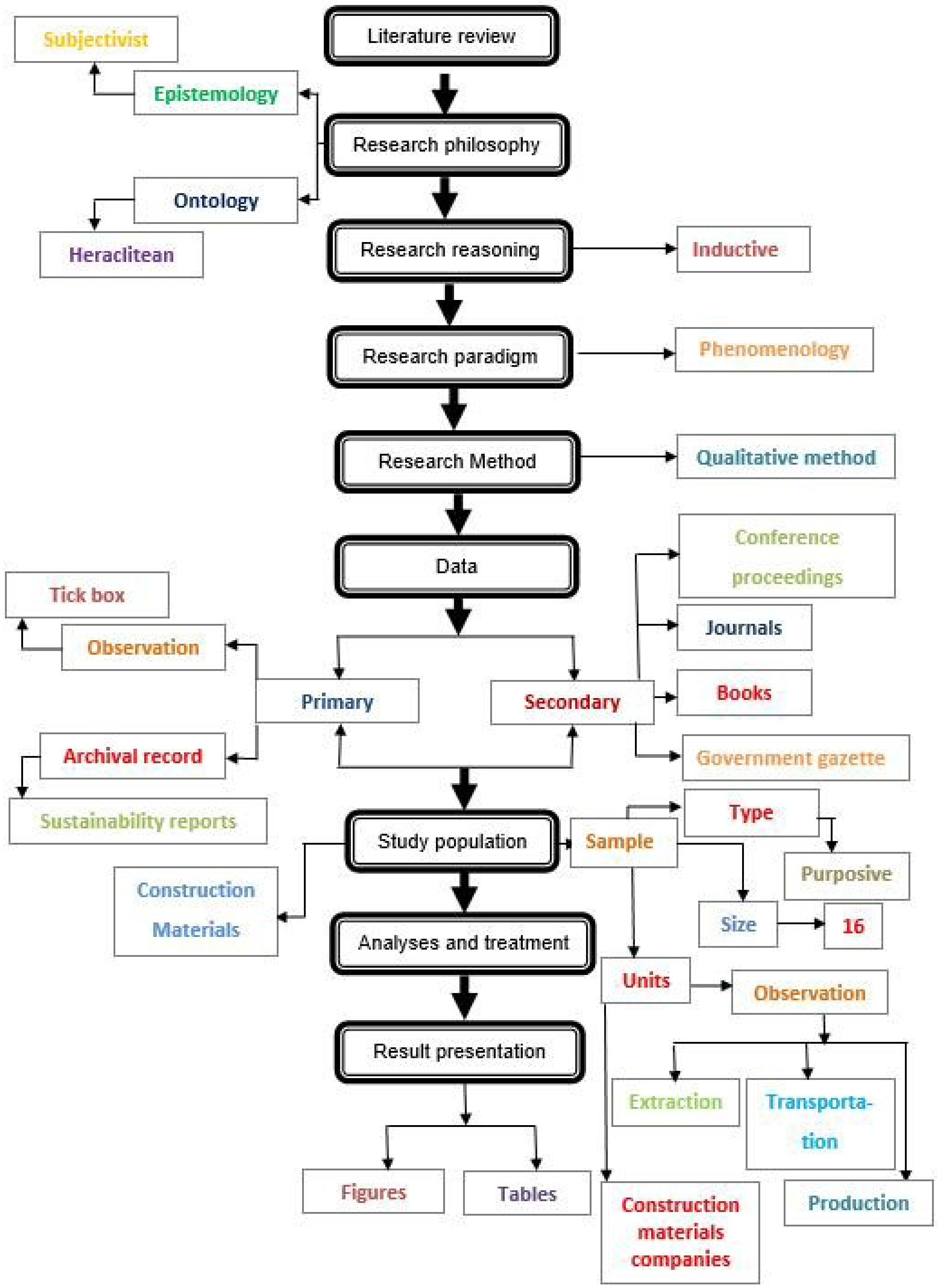


Figure 5.2: The research design outline

Source: Researcher's own construct, 2017

5.19 Ethical considerations

Ethical considerations such as: protection of participants, obtaining participants consent; and confidentiality are to be appraised when conducting a research.
The research considered the following ethical issues:

Plagiarism: The research recognised the existing materials and the data already published, which were all acknowledged and referenced appropriately;

Confidentiality: The names and addresses of the organisations studied were not revealed. The data from the study were used for academic purposes alone;

Compliance with the law and standards: The study was carried out under the rules and regulation tenets of the Nelson Mandela University pertaining to research;

Honesty and trustworthiness: The report was done with a high sense of moral conviction, thereby upholding the truth and the honest opinions of the respondents;

Neutrality: The study was unbiased during the data collection, the analyses and the conclusion and the recommendation; and,

Informed consent: Participating organisations consent was obtained.

5.20 Conclusive Remarks

This chapter has discussed the research design, the approach/paradigm, the philosophy and the method adopted for this study. It has further examined the research population, the sample, the types of data and the sources, as well as the methods of analysis. The data collected were analysed; and they are presented in the subsequent chapter.

Chapter 6: Data Presentation and Discussion

6.1 Introduction

Chapter Four presented an overview of the research design and the methodology used for the study. This chapter presents the results of the case studies carried out for the research on organisations' processes of sourcing, transporting and the production of construction materials.

The empirical data were obtained by direct observation.

The results of the case studies are presented both individually first and then in combined form. Also, pictorial descriptions of the various processes of sourcing, transportation and production of building materials are provided for better understanding. Permission was requested from the host organisations to carry out research. For this purpose, a covering letter was compiled to seek permission to carry out the study, to which the selected organisations gave their consent to be included in the case studies.

6.2 Case study 1 - Ceramic Materials

Case study 1 is of an organisation that is involved in the sourcing, transportation and production of ceramic materials in Nigeria. The company in case study 1 is located in the South-South geopolitical region of Nigeria; and it sources the majority of its raw materials around its vicinity. The products from the company are ceramic tiles used on walls, floors and countertops.

Figure 6.1 Factory view in Case study 1

6.2.1 Material sourcing in Case study 1

The organisation sources its raw materials from open pits with the use of plant and equipment, such as mobile excavators, bulldozers and tippers, as seen in Figure 6.2. Clay and laterite are both available in large quantities around the factory. Material sourcing commences from 7:00 am and stops at 6:00 pm. The pictures in Figures 6.2-6.3 reveal the material-sourcing process. The site for material sourcing is not located around an ecology-sensitive zone. However, no sensitization is made through public campaign awareness, communiqués to the public, media briefing and others. The mode of plant and equipment loading and offloading are mechanically operated. Furthermore, the materials are transported and moved from the points of extraction by road.

(a) Material-sourcing process (b) Trucks awaiting loading

Figure 6.2: The material-sourcing process in Case study 1

Plant and equipment used for sourcing materials

Figure 6.3: Plant and equipment for material sourcing and loading in Case study 1

6.2.1.1 The impact of material sourcing on the environment in Case study 1

Material-sourcing impacts on the environment are presented in Figure 6.4. The observation technique used showed that material sourcing is destroying the flora and the fauna; and it is damaging the landscape.

Destruction of flora and fauna

Damage to landscape

Figure 6.4: Landscape damage due to material-sourcing activities in Case study 1

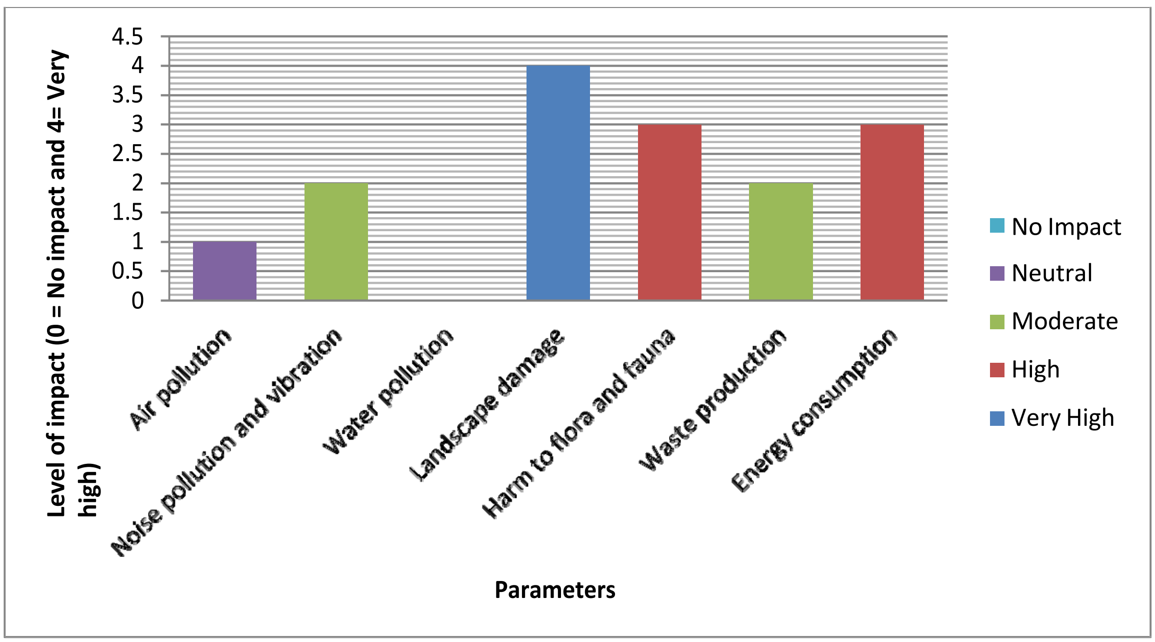
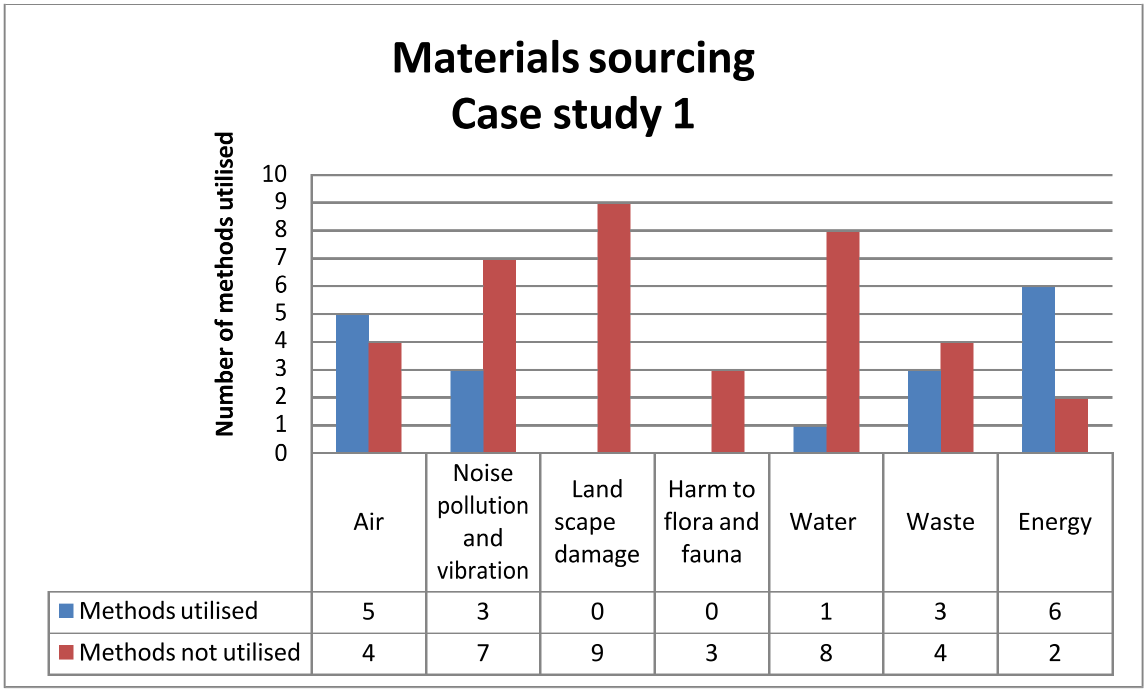


Figure 6.5: The impact of material sourcing on the environment (Case study 1)

From Figure 6.5, it can be seen that air pollution has neutral (1) impact rating on the environment during the sourcing of materials. Then, there is noise pollution, vibration and waste production with a moderate (2) impact. Water pollution follows, with no impact (0). Landscape damage comes next with very high (4) impact and harm to flora and fauna; and energy consumption followed closely with high (3) impact.

6.2.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 1



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	5	3	0	0	1	3	6
Methods not utilised	4	7	9	3	8	4	2

Figure 6.6: Methods utilised to mitigate the impact of material sourcing in Case study 1

Figure 6.6 shows that the organization in case study 1 utilised five methods (minimising operations during windy periods, increasing distance from nearest building, maintenance of plant and equipment, tapping of drilled holes before blasting and procurement of plant and equipment with less emission) regarding air, six methods (transport pooling/ limiting hauling, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts, regular energy audits and maintenance, optimisation of plant and equipment, reducing fuel spills and educating employees regarding plant and equipment idling) were utilised regarding energy to mitigate the impact of material sourcing. Few methods were utilised regarding noise pollution and vibration (maintenance of plant and equipment, limiting working time to day light hours and use of modern equipment), water (design of mining approaches that exclude water) and waste (use of modern plant and equipment for sourcing/ extraction, training of employees and recycling of waste). None of the proposed methods (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes, and use of gasification ash to land fill) were utilised to mitigate the impact of material sourcing on landscape damage, as well as harm to flora and fauna (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings, continuous monitoring to maintain pH levels).

6.2.2 Material transportation for Case study 1

Raw materials excavated from pits are transported by road with the use of tippers only. Excavators and bulldozers are used for the gathering and loading of the excavated raw materials into tippers. This operation usually begins around 7:00 am; and it lasts until 7:00 pm in the evening.

(a) Materials loading process (b) Materials transportation process

Figure 6.7: Materials transportation process in Case study 1

6.2.2.1 The impact of material transportation on the environment in Case study 1

(a) Air pollution (b) Landscape damage

Figure 6.8: Air pollution and landscape damage in Case study 1

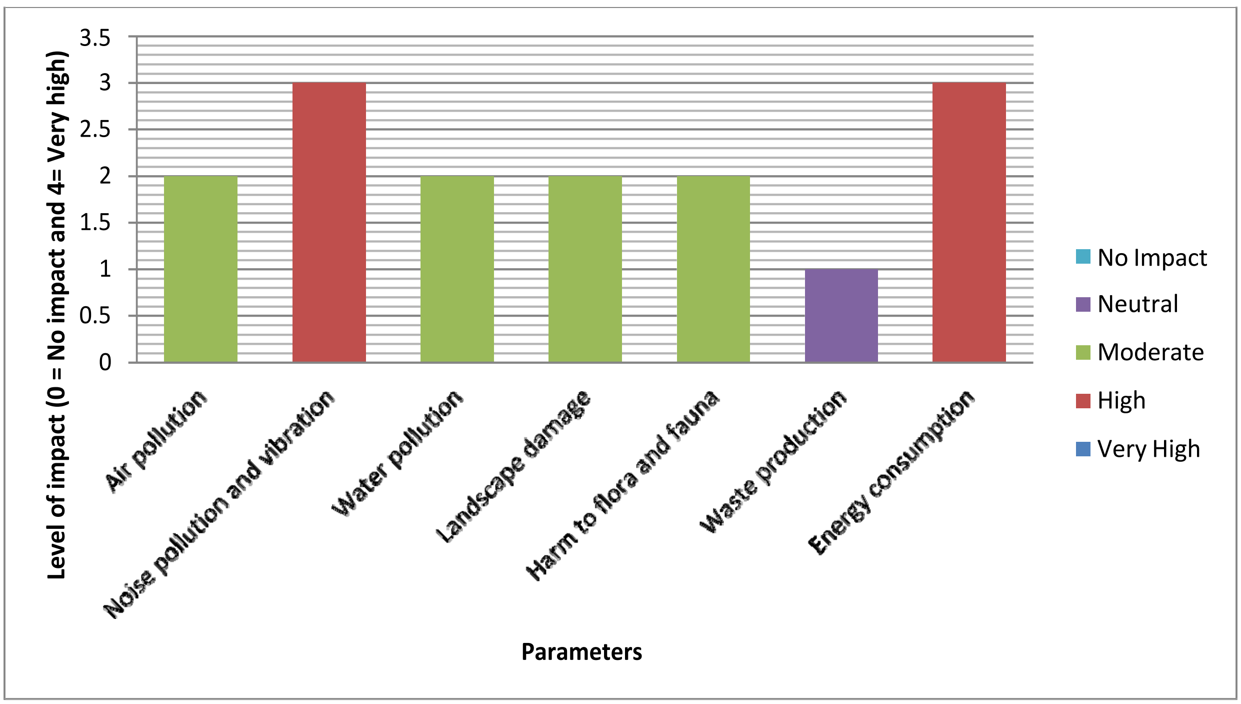
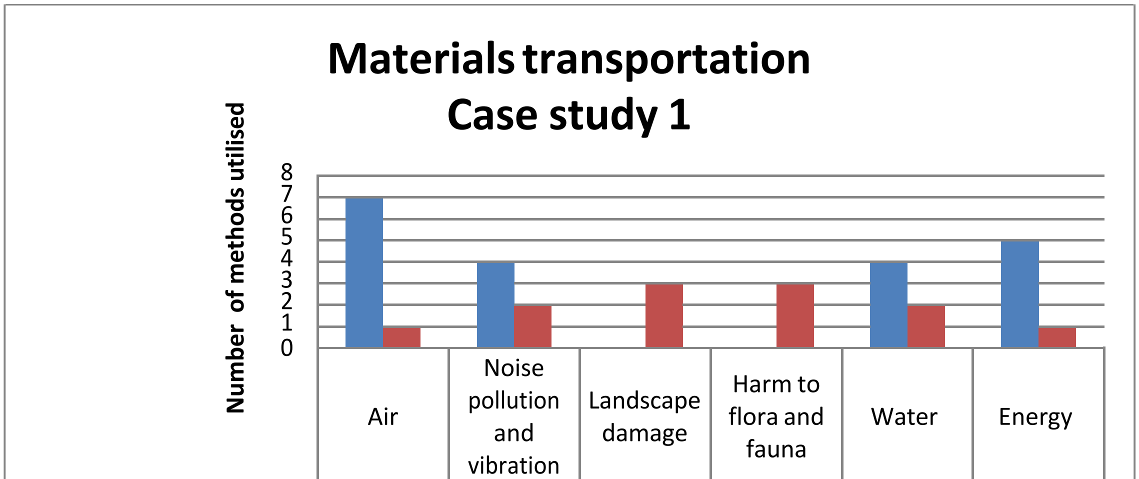


Figure 6.9: The impact of material transportation on the environment (Case study 1)

From Figure 6.9, air pollution, water pollution, landscape damage and harm to the flora and fauna have moderate (2) impact on the environment during the transportation of materials. Next to this, there is noise pollution and vibration and energy consumption with high (3) impact; and waste production follows with neutral (1) impact.

6.2.1.2 Methods utilised to mitigate the impact of material transportation in Case study 1



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Energy
Methods utilised	7	4	0	0	4	5
Methods not utilised	1	2	3	3	2	1

Figure 6.10: Methods utilised to mitigate the impact of material transportation in Case study 1

Figure 6.10 shows that case study 1 utilised seven methods (covering of transported materials, procurement of plant and equipment with less emission, selection of suitable routes, transport pooling/ Limiting hauling, maintenance of plant and equipment, partial enclosure of transferring and conveying equipments and process and partial enclosure of unloading area) to mitigate the impact of material transportation regarding air. Four methods (transport pooling/ Limiting hauling, selection of suitable routes, maintenance of plant and equipment, use of plant and equipment with less emission) were utilised regarding noise pollution and vibration; five methods each were utilised regarding water (maintenance of plant and equipment, proper training of drivers, procurement of plant and equipment with less emission, reducing fuel spills and continuous motoring of ground water) and energy (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, regular energy audits and maintenance, transport pooling/ Limiting hauling and Optimising pit and mine design). None of the proposed methods were utilised to mitigate the impact of material transportation regarding landscape damage (re-contouring of slopes, use of alternative routes and covering of transported materials) and harm to flora and fauna, (wetting of soil, covering of transported materials and buffer strips)

6.2.3 Material production for Case study 1

After the raw materials have been extracted and transported by road to the production plant, various processes commence for the raw materials to be converted into finished products. The production line works 24 hours un-interrupted. The majority of the operations are carried out with plant and equipment.

(a) Raw materials movement process (b) Raw materials processing process

Figure 6.11: Production process

(a) Stagnant waste water (b) Waste water movement

Figure 6.12 Waste water from the production process

6.2.3.1 The impact of materials production on the environment in Case study 1

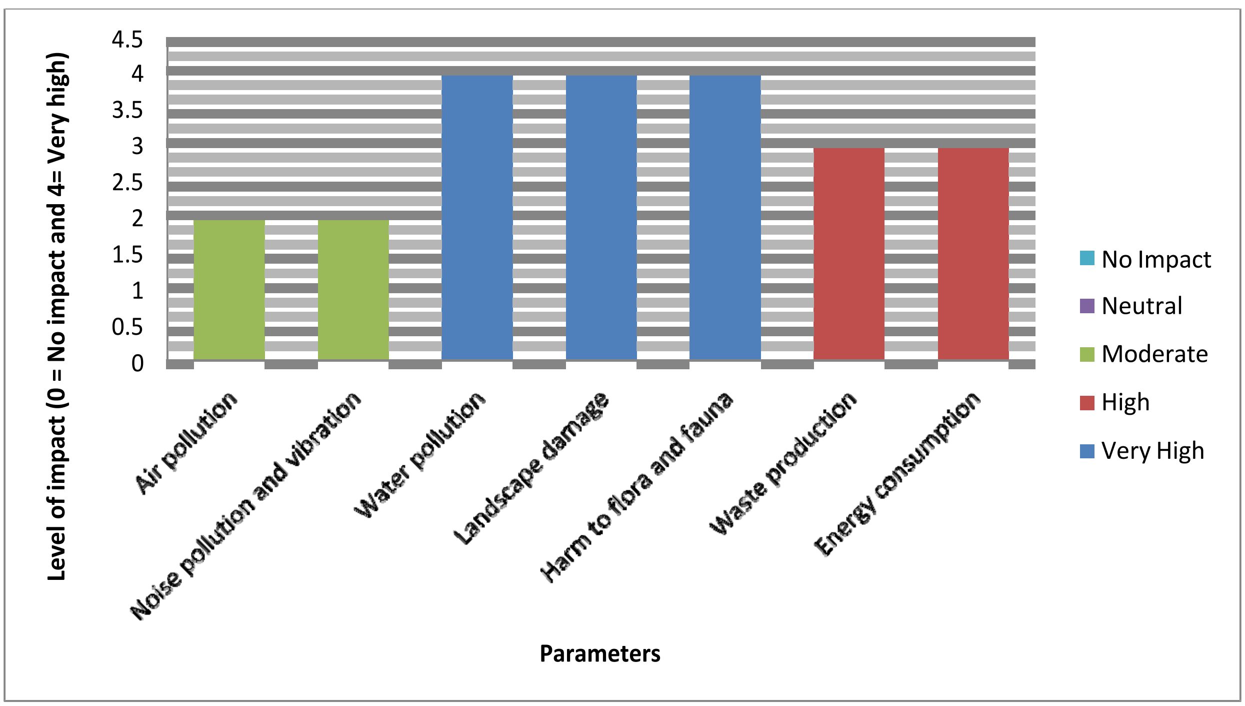
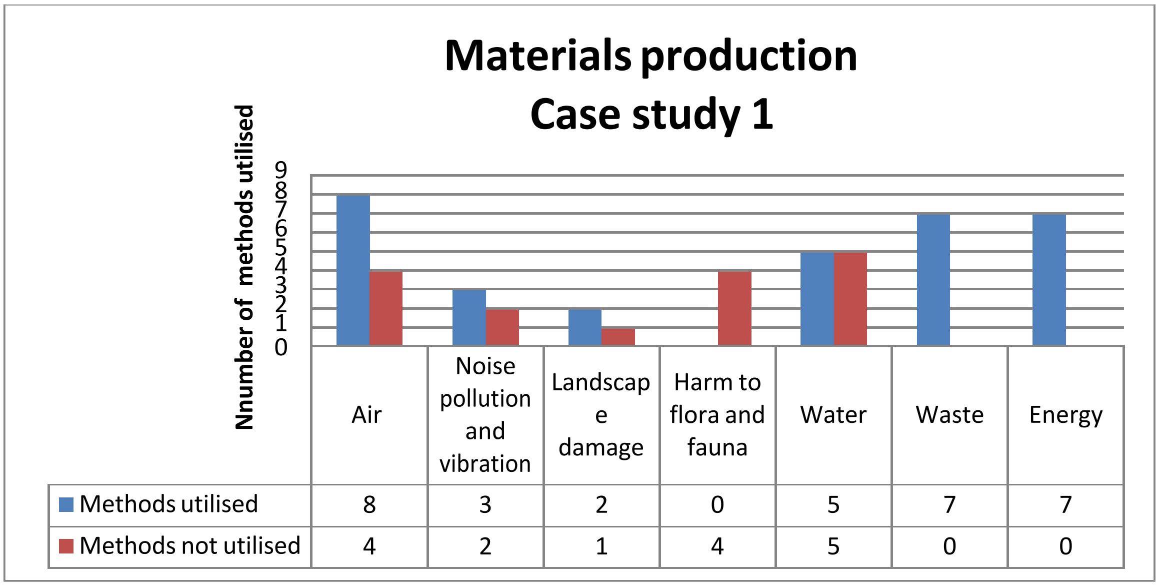


Figure 6.13: The impact of material production on the environment (Case study 1)

From Figure 6.13, air pollution, noise pollution and vibration have a moderate (2) impact rating on the environment during the production of materials. Thereafter, there is water pollution, landscape damage and harm to flora and fauna with a very high (4) impact rating. Waste production and energy consumption follow closely with high impact.

6.2.3.2 Methods utilised to mitigate the impact of material production in Case study 1



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	8	3	2	0	5	7	7
Methods not utilised	4	2	1	4	5	0	0

Figure 6.14: Methods utilised to mitigate the impact of material production in Case study 1

Figure 6.14 shows that the organisation in case study 1 utilised many methods (procurement of plant and equipment with less emission, mechanical ventilation, increasing distance from nearest building, maintenance of plant and equipment, using water-cooled tools, use of bag houses, use of dust suppressants and use of high temperature filters within gasification process) to mitigate the impact of material production in regard to air, waste (use of innovative cutting tools, use of carbon dioxide emission and storage technology, use of modern plant and equipment, treatment of solid reject, re-use of fine grained solid rejects for further production, segregation of fine grained solid rejects and re-crushing to form aggregate) and energy (implementation of energy saving/ conservation measures for plant and equipment e.g catalysts, use of renewable energy sources for production and operation, reducing fuel spills, regular energy audits and maintenance, minimisation of non- utilised power, educating employees regarding plant and equipment idling and turning off lights and installation of more efficient lighting). Three methods (maintenance of plant and equipment, use of Baffling silencer and construction of barrier walls), were utilised for noise pollution and vibration two methods (enclosure of fuel and chemical and better design and planning) were utilised regarding landscape damage, and six methods (collection in sumps, better design, control of site drainage, management of surface water and buffer strips) were utilised regarding water to mitigate the impact of material production. None of the proposed methods (application of fertilizer, lime, tillage and re-vegetation, addition of buffering agents to mitigate acidic seeps from mining, continuous monitoring to maintain pH levels and top soil substitution) were utilised to mitigate the impact of material production regarding the harm to flora and fauna.

6.2.4 Sustainability report in Case study 1

The sustainability report provides organisations with the opportunity to showcase the various impacts of their operation on the environment, humans and animals – and methods adopted to mitigate such impact. Enquiry was made on sustainability reporting for case study 1, which they admitted not having.

6.3 Case study 2 - Ceramic materials

Case study 2 source, transport and produce ceramic materials in Nigeria. The company, as in case study 2, is situated in the North central geopolitical region of Nigeria; and it sources the majority of raw materials around its vicinity. Products from the company includes: plain, coated and polished granite and unpolished ceramic tiles used for walls, floors, countertops, kitchens, bathrooms and toilets.

Figure 6.15: View of the factory in Case study 2

6.3.1 Material sourcing for Case study 2

Raw materials are sourced from a site close to the production plant via the open-pit method. Equipment and plant used for excavation are: mechanical compressor, tippers and head pans. Vesper, quartz and limestone exist in large quantities around the factory. Material sourcing is carried out from 7:00 am to 6:00 pm. The site for sourcing the material is not located around an ecologically sensitive area. No sensitization to the human population is made: either through public campaign awareness, communiqués to the public, media briefing before drilling and blasting operation. Loading is carried out manually; while the offloading is done with plant and equipment. Furthermore, all the materials are transported by road.

Drilling holes to load explosives before blasting

Figure 6.16 Material-sourcing process for Case study 2

Figure 6.17: The material loading for Case study 2

6.3.1.1 The impact of material sourcing on the environment in Case study 2

The study observed the impact of materials sourcing in case study 2; and this was presented in Figure 6.18.

Harm to flora

Landscape damage

Figure 6.18: Landscape degradation due to materials sourcing in Case study 2

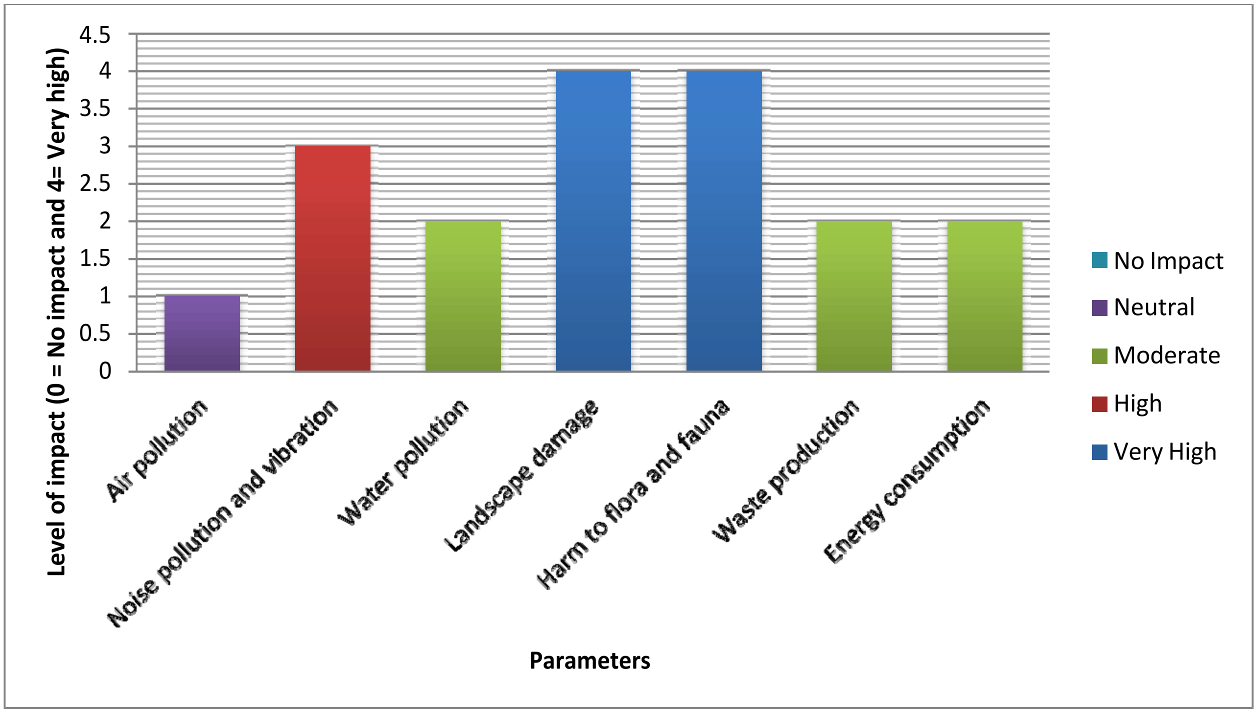
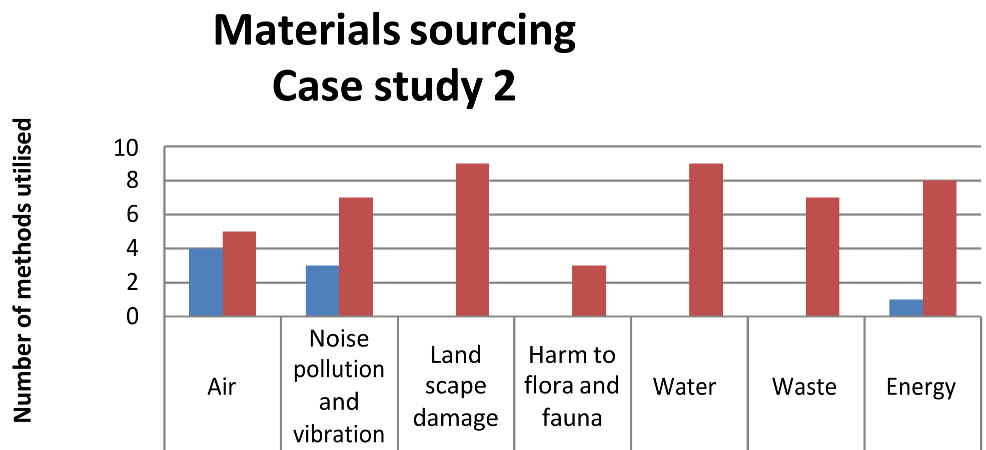


Figure 6.19: The impact of material sourcing on the environment (Case study 2)

From Figure 6.19, it can be seen that air pollution has a neutral (1) impact rating during the sourcing of materials. Next to this is noise pollution and vibration, with a high (3) impact. Water pollution, waste production and energy consumption follow closely thereafter, with a moderate (2) impact rating. Landscape damage and harm to flora and fauna comes next with a very high (4) impact.

6.3.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 2



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	4	3	0	0	0	0	1
Methods not utilised	5	7	9	3	9	7	8

Figure 6.20: Methods utilised to mitigate the impact of material sourcing in Case study 2

Figure 6.20 shows that the organisation in case study 2 utilised a few methods to mitigate the impact of material sourcing regarding air (tapping of drilled holes before blasting, procurement of plant and equipment with less emission, increasing distance from nearest building and minimise operations during windy periods), noise pollution, vibration (limiting working time to day light hours, maintenance of plant and equipment and use of modern equipment) and energy (transport pooling/ limiting hauling). None of the proposed methods were utilised to mitigate the impact of material sourcing regarding landscape damage (use of gasification ash to land fill, re-contouring of slopes, skid trailing, reduced-impact logging, application of fertilizer, lime, tillage and re-vegetation, top soil substitution, re - use of stockpiled soil removed during clearance operation, use of rip-rap and slope stabilisation through vegetation planning), harm to flora and fauna (continuous monitoring to maintain pH levels , replacement with saplings and addition of buffering agents to mitigate acidic seepage from mining), water (recycling of water, collection and treatment of waste water, protection plan, management of surface water, design of mining approaches that exclude water, use of leak detection systems, monitoring of ground water, contingency planning and buffer strips) and waste (use of modern plant and equipment for sourcing/ extraction, proper planning and efficient management, training of employees, use of Ground Penetrating Radars (GPR), installation of a mobile crushing/ grinder- pulverisation unit at quarry site and recycling of waste).

6.3.2 Material transportation for Case study 2

The raw materials excavated from pits are transported by road with the use of tippers only. Excavators and bulldozers are used for gathering and loading of the excavated raw materials into tippers. This operation usually begins around 7:00 am and lasts until 7:00 pm in the evening.

(a) Material-loading process (b) Material-movement process

Figure 6.21 Material transportation in Case study 2

6.3.2.1 The impact of material transportation on the environment in Case study 2

Figure 6.22: Landscape damage due to material transportation in Case study 2

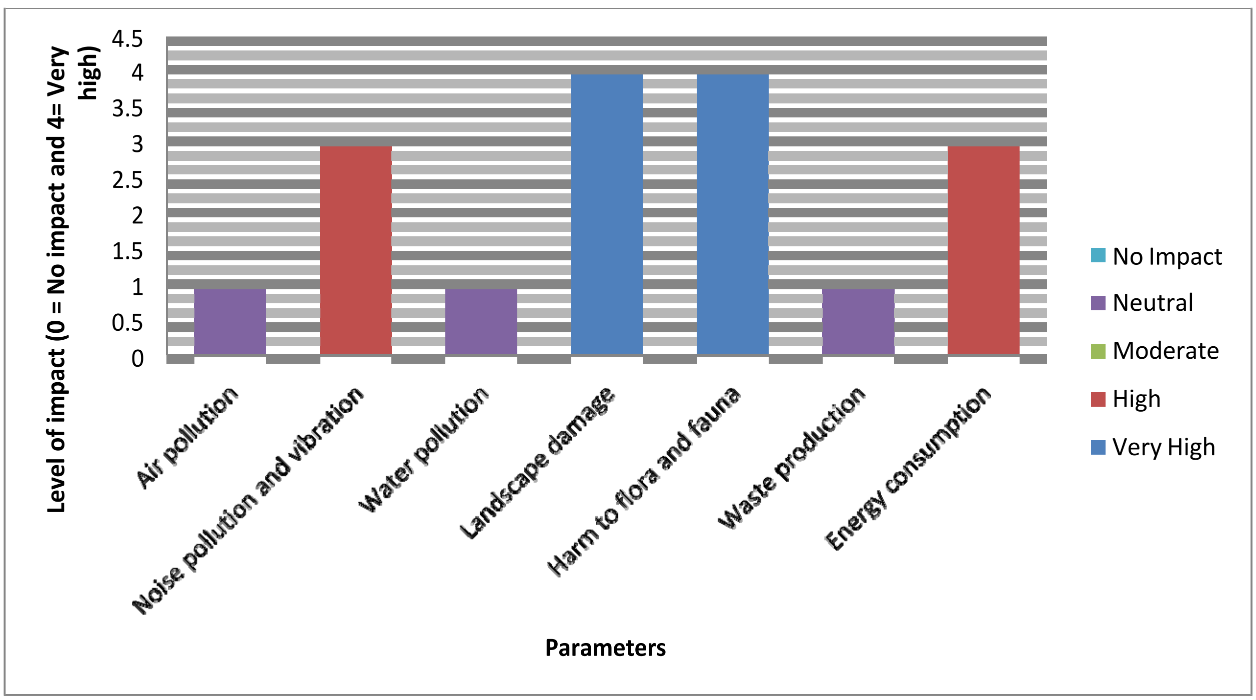


Figure 6.23: Impact of material transportation on the environment (Case study 2)

From Figure 6.23, air pollution, water pollution and waste production have neutral (1) impact rating on the environment during the transportation of these materials. Next to these, there are noise pollution, vibration and energy consumption with high (3) impact. Landscape damage and energy consumption comes next with high (4) impact rating.

6.3.3.3 Methods utilised to mitigate the impact of materials transportation in Case study 2

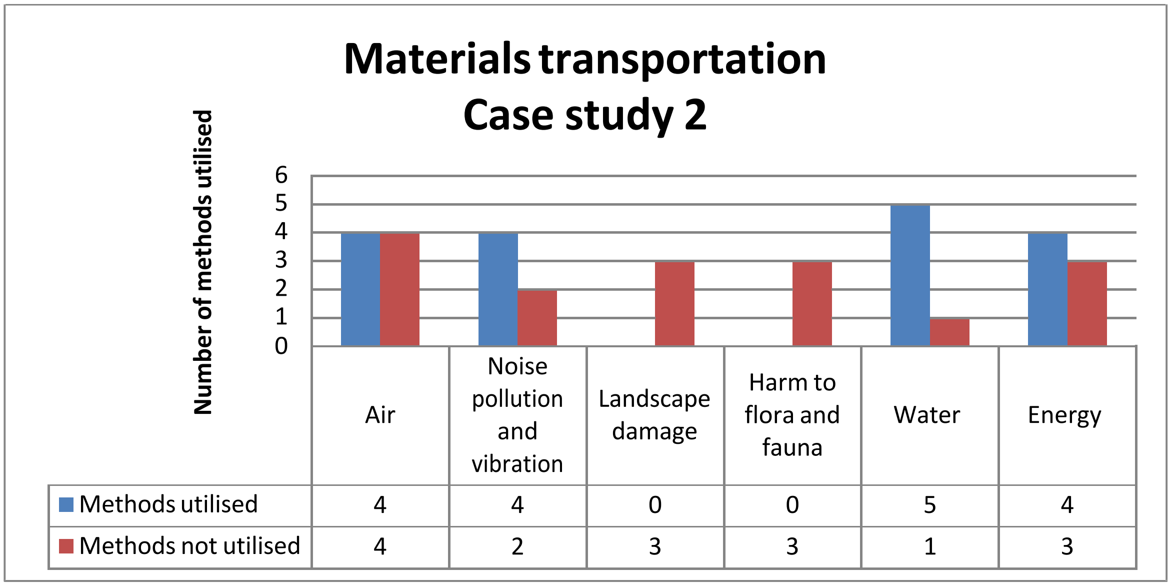


Figure 6.24: Methods utilised to mitigate the impact of materials transportation in Case study 2

Figure 6.24 depicts that case study 2 utilised four methods each regarding air (procurement of plant and equipment with less emission, maintenance of plant and equipment, selection of suitable routes and transport pooling/ Limiting hauling), noise pollution vibration (selection of suitable routes, transport pooling/ limiting hauling, use of plant and equipment with less emission and maintenance of plant and equipment) and energy (transport pooling/ limiting hauling, reducing fuel spills, educating employees regarding plant and equipment idling and regular energy audits and maintenance). Five methods (procurement of plant and equipment with less emission, selection of suitable routes, reducing fuel spills, proper training of drivers and maintenance of plant and equipment) were utilised to mitigate the impact of material transportation regarding water. None of the proposed methods were utilised regarding landscape damage (covering of transported materials, use of alternative routes and re-contouring of slopes) and harm to the flora (wetting of soil, covering of transported materials and buffer strips).

6.3.3 Material production for Case study 2

Raw materials are transported by road in tippers to the production plant, where the production process is carried out. The organisation production process is for 24 hours. The production operation relies largely on machines.

6.3.3.1 Impact of material production on the environment for Case study 2

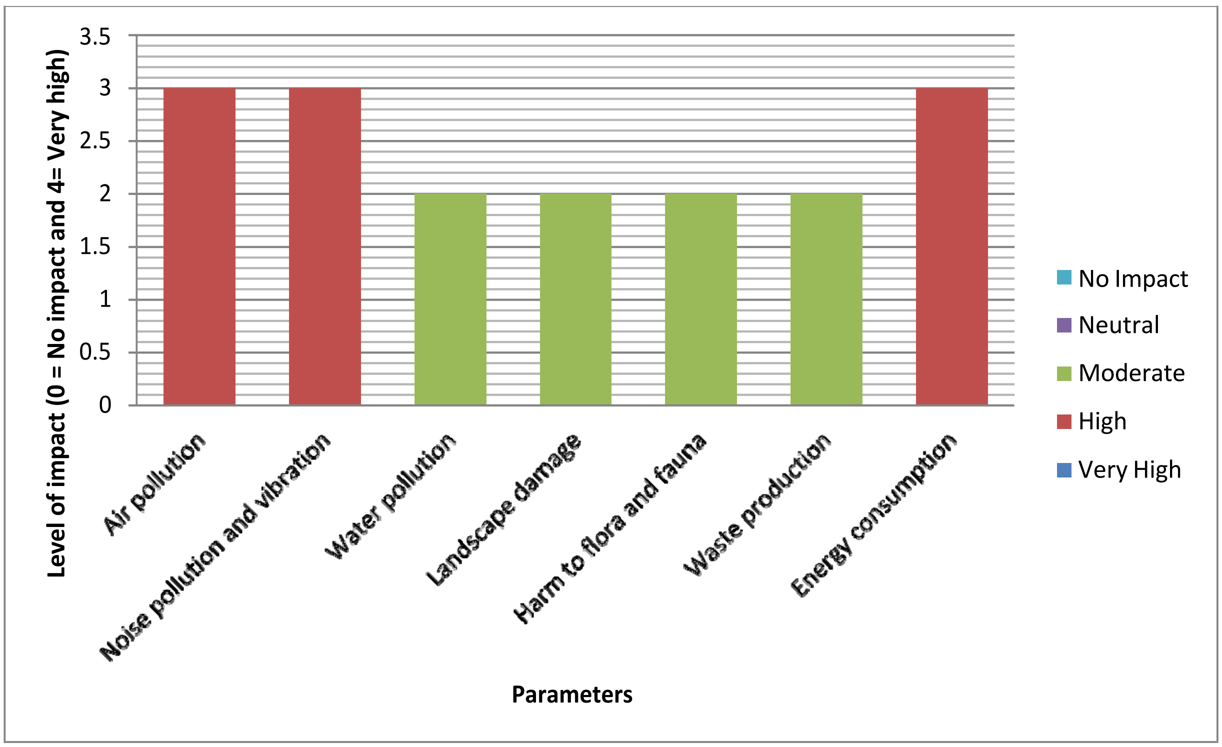
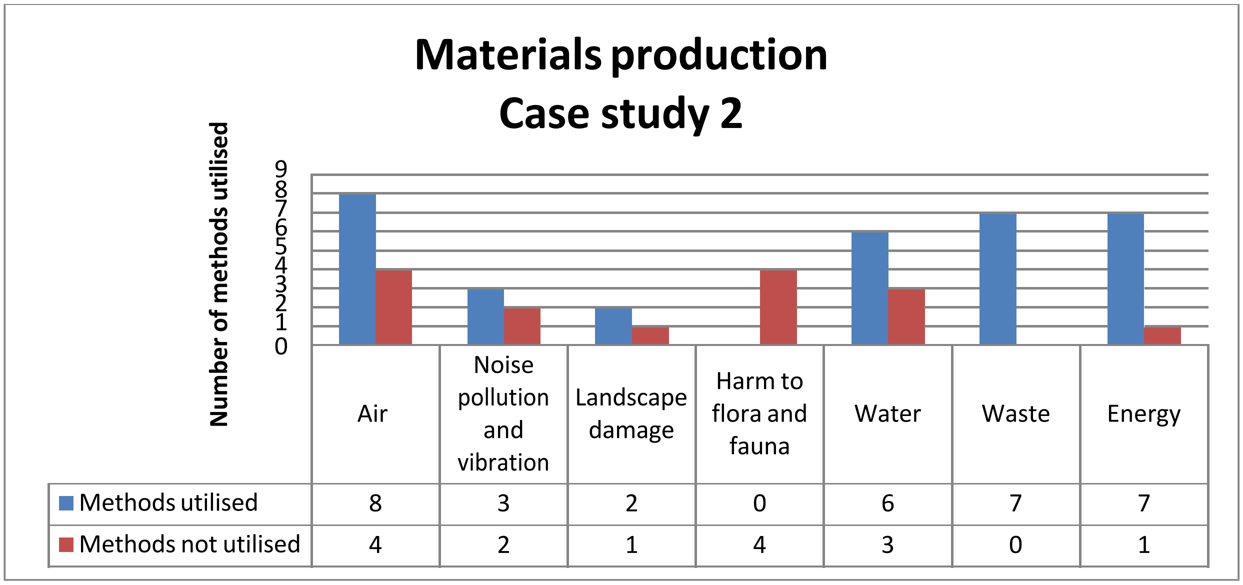


Figure 6.25: The impact of material production on the environment (Case study 2)

From Figure 6.25, air pollution, noise pollution and vibration and energy consumption have high (3) impact rating on the environment during the production of materials. Next to this, are water pollution, landscape damage and harm to flora, fauna and waste production with a moderate (2) impact.

6.3.3.2 Methods utilised to mitigate the impact of materials production in Case study 2



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	8	3	2	0	6	7	7
Methods not utilised	4	2	1	4	3	0	1

Figure 6.26: Methods utilised to mitigate the material production impact in Case study 2

Figure 6.26 shows that the organisation in case study 2 utilised many methods to mitigate the impact of material production regarding air (use of bag houses, increasing distance from nearest building, maintenance of plant and equipment, mechanical ventilation, procurement of plant and equipment with less emission, using water-cooled tools, use of high temperature filters within gasification process and initial and periodic compliance testing of pollutants emitted from production process), water (recycling of water, collection and treatment of waste water, management of surface water, control of site drainage, better design, collection in sumps and use of reclaimed effluent and other recycled water for cooling), waste (use of innovative cutting tools, use of modern plant and equipment, treatment of solid reject, re-use of fine grained solid rejects for further production, segregation of fine grained solid rejects, re-crushing to form aggregate) and energy (use of renewable energy sources for production and operation, implementation of energy saving/ conservation measures for plant and equipment e.g catalysts, regular energy audits and maintenance, reducing fuel spills, minimisation of non- utilised power, educating employees regarding plant and equipment idling and turning off lights and installation of more efficient lighting). Three methods (use of modern equipment, limiting working time to normal working hours and maintenance of plant and equipment) were utilised regarding noise pollution and vibration; and two methods (enclosure of fuel and chemical and better design and planning) were utilised regarding landscape damage to mitigate the impact of material production. However, none of the proposed methods (application of fertilizer, lime, tillage and re-vegetation, addition of buffering agents to mitigate acidic seeps from mining, top soil substitution and continuous monitoring to maintain pH levels) were utilised to mitigate the impact of material production regarding harm to flora and fauna.

6.3.5 Sustainability report for Case study 2

Sustainability reporting which was assessed in line with the research objectives and field work revealed that the organisation for case study 2 does not carry out any sustainability reporting.

6.4 Case study 3 - Cement production

Case study 3 is located in the North central geopolitical region in Nigeria; and it is involved in the production of cement. The organisations have a production capacity of about 10.25MMTPA, similar to the cement production plants in other countries. Case study 3 has a 135 MW captive gas power plant and a 94 kilometre gas pipeline. A limestone quarry is serviced by a 7.5km conveyor belt, a 130m dam services a reservoir with a storage capacity of 5.1 million m^3. The product from the company is largely 53 / 43 grade cement, which is needed by the customers in 50kg bags, or in silos.

Figure 6.27: Factory view of Case study 3

6.4.1 Material sourcing for Case study 3

The raw materials used for cement production are abundant around the factory; and they are sourced from open pits with plants and machines, such as mobile excavators, bulldozers and dumpers. Clay, laterite and limestone, which are readily available are sourced from 7:00 am to 6:00 pm daily. The pictures in Figures 6.27 and 6.28 illustrate how raw materials are sourced. The site where the raw materials are sourced is not in an ecologically sensitive area. Sensitization is made to the general public before starting with delicate sourcing operations. All the operations in the organization involve the use of plant and equipment for loading and offloading; these are all mechanically operated. A conveyor of four lines with a stretch of about eight kilometers is used to transport the raw materials from the point of sourcing to the production plant.

Material sourcing using an excavator, bulldozer and dump truck

Figure 6.28: Material sourcing and loading process for Case study 3

6.4.1.1 Impact of material sourcing on the environment for Case study 3

A detailed study of the material-sourcing process was carried out by direct observation of the impact of raw material sourcing in cement production by the organisation. From the study, the following impact of material sourcing on the environment was observed as shown in Figure 6.29.

(a) Flora destruction (b) Landscape destruction

Figure 6.29: Landscape degradation due to material-sourcing activities in Case study 3

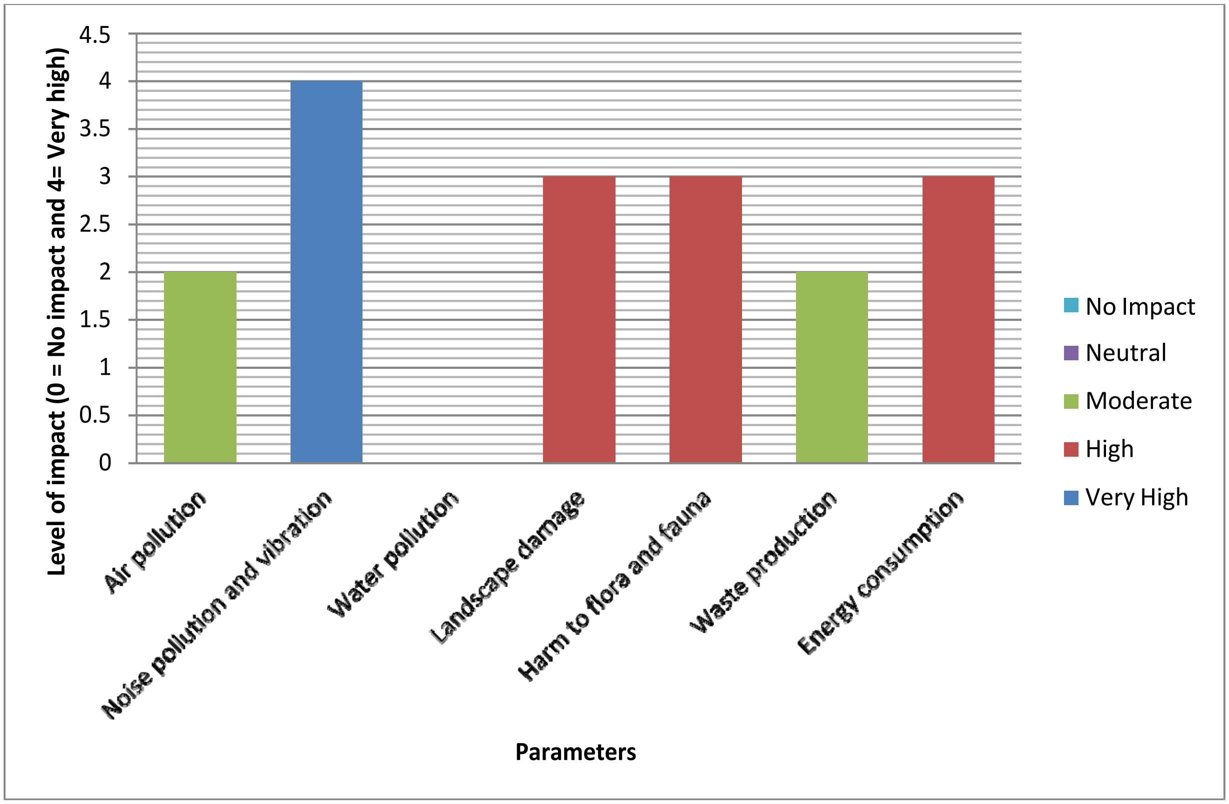
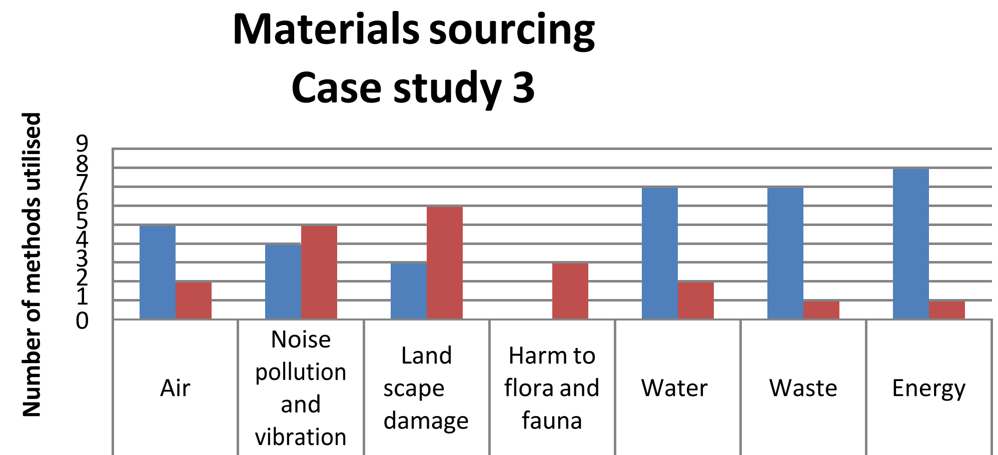


Figure 6.30: Impact of material sourcing on the environment (Case study 3)

From Figure 6.30, it can be seen that air pollution and waste pollution have moderate (2) impact ratings on the environment during the sourcing of materials. Next to this is noise pollution and vibration with very high (4) impact. Water pollution follows with no impact. Landscape damage, harm to flora and fauna and energy consumption follow thereafter with high (3) impact rating.

6.4.1.2 Methods utilised to mitigate material-sourcing Impact in Case study 3



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	5	4	3	0	7	7	8
Methods not utilised	2	5	6	3	2	1	1

Figure 6.31: Methods utilised to mitigate material-sourcing Impact in Case study 3

Figure 6.31 shows that the company in case study 3 utilised many methods to mitigate the impact of material sourcing regarding air (tapping of drilled holes before blasting, procurement of plant and equipment with less emission, maintenance of plant and equipment, wet of suppression and increasing distance from nearest building), water (contingency planning, monitoring of ground water, design of mining approaches that exclude water, management of surface water, protection plan, protection plan and recycling of water), waste (use of modern plant and equipment for sourcing/ extraction, proper planning and efficient management, training of employees, use of Ground Penetrating Radars (GPR), installation of a mobile crushing/ grinder- pulverisation unit at quarry site, recycling of waste and reduced-impact logging) and energy (transport pooling/ limiting hauling, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts, regular energy audits and maintenance, reducing fuel spills, minimisation of non- utilized power, optimisation of plant and equipment, educating employees regarding plant and equipment idling and altering processing parameter e.g. belt speed). Four methods (maintenance of plant and equipment, early public notification of extremely noisy operation, limiting working time to day light hours and use of modern equipment) were utilised regarding noise pollution and vibration; and three methods (slope stabilisation through vegetation planning, use of rip-rap and re-contouring of slopes) were utilised regarding landscape damage. None of the proposed methods (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels) were utilised to mitigate the impact of material sourcing regarding harm to flora and fauna.

6.4.2 Material transportation for Case study 3

Raw materials excavated from open pits are transported by a conveyor of five (5) lines. After the raw materials are excavated and ground into smaller sizes, they are fed into the conveyor and transported to the production plant.


(a)Truck dumping materials (b) Milling process of materials


Material-transportation process

Figure 6.32: Material transportation process for Case study 3

6.4.2.1 Impact of material transportation on the environment in Case study 3

Figure 6.33: Air pollution from material transportation in Case study 3

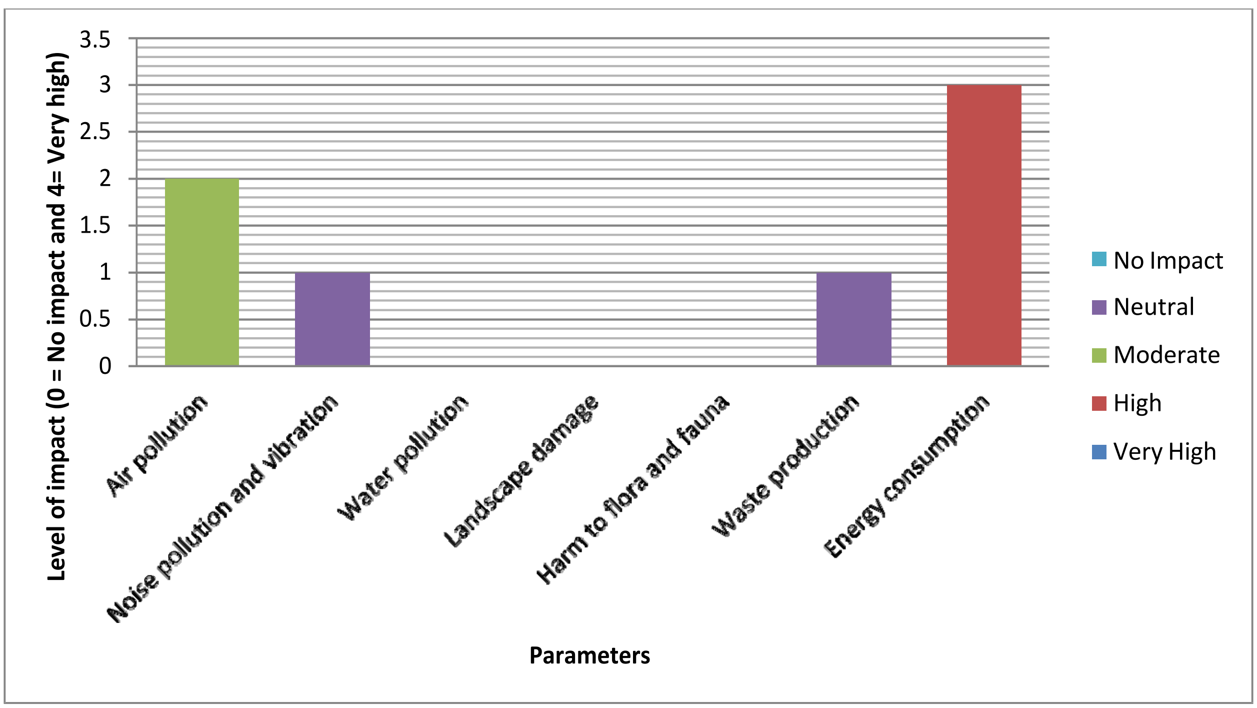


Figure 6.34 Impact of material transportation on the environment (Case study 3)

From Figure 6.34, air pollution has a moderate (2) impact rating on the environment during the transportation of materials. Then there follows noise pollution and vibration and waste production with neutral (1) impact. Water pollution, landscape and harm to flora and fauna follow closely thereafter with no impact (0); and the energy consumption comes next with high (3) impact.

6.4.2.2 Methods utilised to mitigate the impact of materials transportation in Case study 3

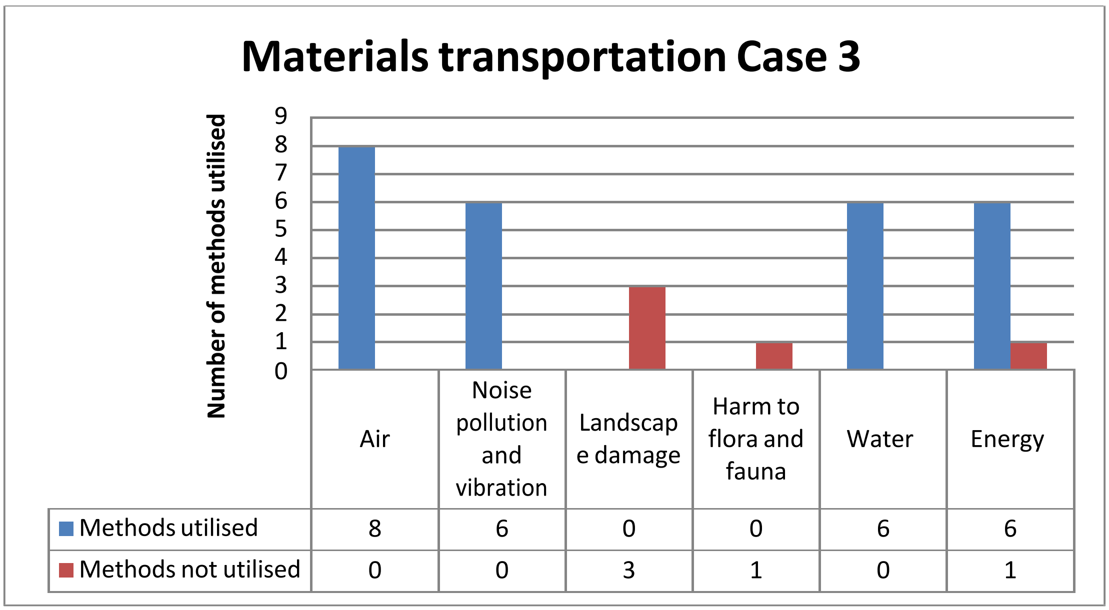


Figure 6.35: Methods utilised to mitigate the impact of materials transportation in Case study 3

Figure 6.35 shows that the company in case study 3 utilised many methods to mitigate the impact of material transportation regarding air (transport pooling/ limiting hauling, selection of suitable routes, wet suppression, maintenance of plant and equipment, partial enclosure of transferring and conveying equipments and process, partial enclosure of unloading area, covering of transported materials and procurement of plant and equipment with less emission), noise pollution and vibration (transport pooling/ Limiting hauling, selection of suitable routes, maintenance of plant and equipment, traffic diversion, working with relevant authority to prevent unnecessary traffic congestion and use of plant and equipment with less emission), water (continuous motoring of ground water, reducing fuel spills, selection of suitable routes, procurement of plant and equipment with less emission, covering of transported materials, proper training of drivers and maintenance of plant and equipment) and energy (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, optimising pit and mine design, regular energy audits and maintenance, transport pooling/ Limiting hauling and reducing fuel spills). None of the proposed methods were utilised to mitigate the impact of material transportation regarding landscape damage (re-contouring of slopes, use of alternative routes and covering of transported materials) and harm to the flora and fauna (wetting of soil, covering of transported materials and buffer strips).

6.4.3 Material production for Case study 3

In this stage, the conveyor transports the raw materials extracted to the production plant; where various operations are carried out to ensure that the finished product meets the required standards. The production operation works for 24hours involving grinding to produce a fine powder (raw meal), firing in the kiln at about 1,500°C, and the bagging of finished products.

Raw materials grinding process

(a) Material movement using conveyor (b) kiln plant for firing raw mill

Figure 6.36: The Cement production process

6.4.3.1 The impact of material production on the environment for Case study 3

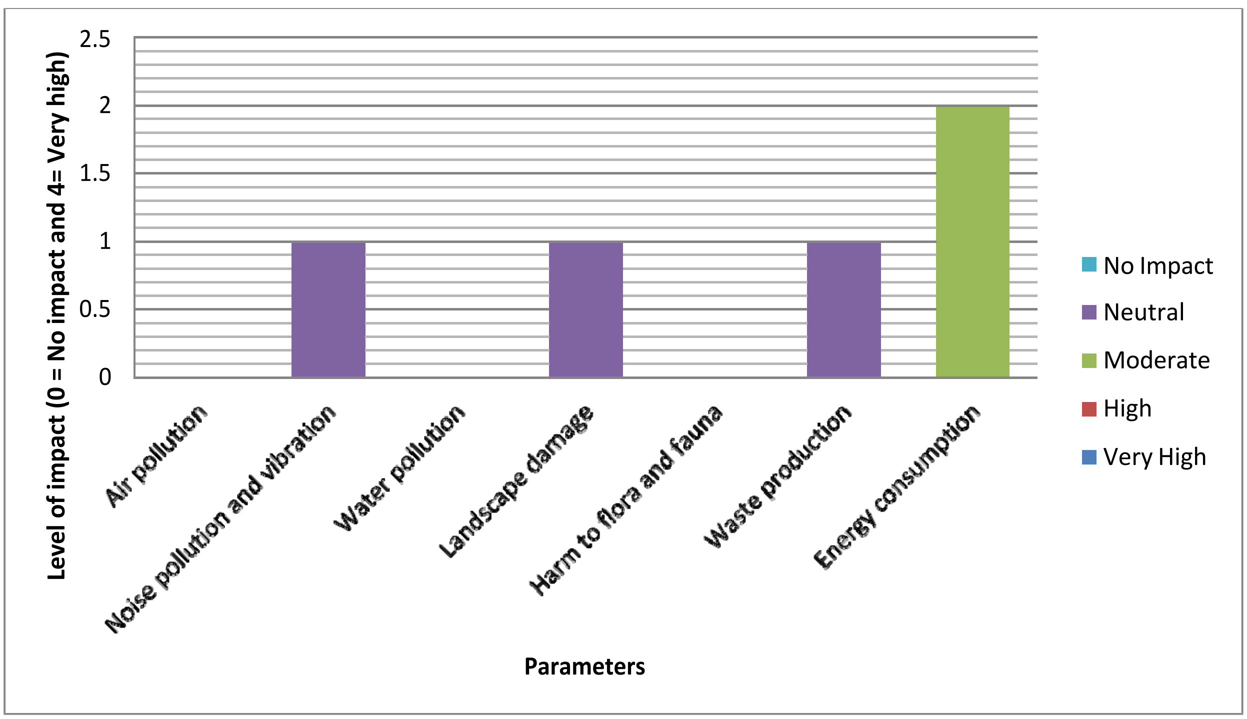


Figure 6.37: Impact of materials production on the environment (Case study 3)

From Figure 6.37, air pollution, water pollution and harm to flora and fauna have no impact (0) rating on the environment during the production of materials. Following this, there are noise pollution and vibration, landscape damage and waste production with neutral (1) impact rating. Energy consumption comes next with moderate (2) impact.

6.4.3.2 Methods utilised to mitigate the impact of material production in Case study 3

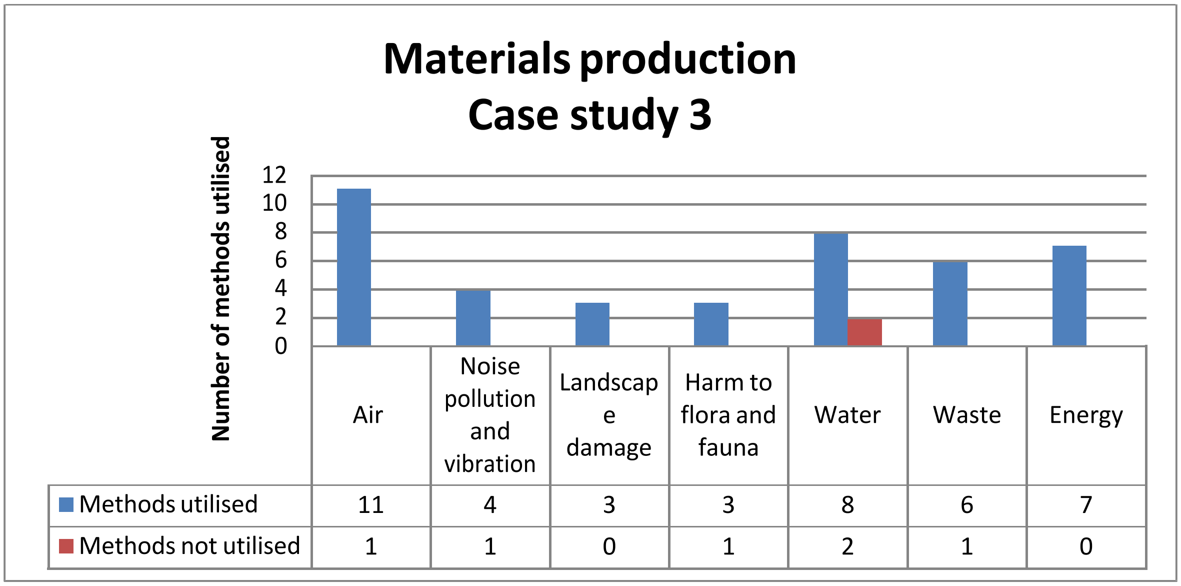


Figure 6.38: Methods utilised to mitigate the impact of material production in Case study 3

Figure 6.38 illustrates that the company in case study 3 utilised many methods to mitigate the impact of material production regarding air (increasing distance from nearest building, use of high temperature filters within gasification process, maintenance of plant and equipment, use of dust suppressants, mechanical ventilation, use of surfactants, procurement of plant and equipment with less emission, continuous monitoring and recording of emissions, use of bag houses, initial and periodic compliance testing of pollutants emitted from production process, continuous sampling to eliminate equipment leaks and using water-cooled tools), noise pollution and vibration (maintenance of plant and equipment, construction of barrier walls, limiting working time to normal working hours and use of modern equipment), landscape damage (enclosure of fuel and chemical, better design and planning and re-contouring of slopes) , harm to flora and fauna (continuous monitoring to maintain pH levels, application of fertilizer, lime, tillage and re-vegetation and top soil substitution), water (recycling of water, protection plan, collection and treatment of waste water, management of surface water, control of site drainage, use of leak detection systems, better design and collection in sumps), waste (use of innovative cutting tools, use of modern plant and equipment, treatment of solid reject, re-use of fine grained solid rejects for further production, segregation of fine grained solid rejects and re-crushing to form aggregate) and energy (use of renewable energy sources for production and operation, implementation of energy saving/ conservation measures for plant and equipment e.g catalysts, regular energy audits and maintenance, reducing fuel spills, minimisation of non- utilised power, educating employees regarding plant and equipment idling and turning off lights and installation of more efficient lighting).

6.4.4 Sustainability report for Case study 3

The sustainability report demonstrates an organisation's commitment to sustainability. The organisation in case study 3 prepares the sustainability report of the various activities that have been carried out.

6.5 Case study 4 - Cement production

Case study 4 is located in the South- South geopolitical region in Nigeria and the company is involved in the production of cement of varying quality, such as 42.5 and 52.5 texture grades.

Figure 6.39: Factory view of Case study 4

6.5.1 Material sourcing for Case study 4

Around the factory, there are huge deposits of raw materials used for cement production; and these are sourced from open pits with plants and machines, such as drillers, mobile excavators, bulldozers. Clay, laterite and limestone are readily available and are sourced between 8:00 am to 6:00 pm daily. The pictures in Figures 6.40 illustrate how raw materials are sourced. The site where the raw materials for cement production are sourced is not located in an ecologically sensitive area. Sensitization is not made to the general public before starting on delicate sourcing operations. The various operations carried out by the organization utilize plant and equipment for loading and offloading. Tippers are employed to transport the raw material from the point of sourcing to the production plant.

Figure 6.40 Materials sourcing process for Case study 4

6.5.1.1 Impact of material sourcing on the environment in Case study 4

A study of materials sourcing process was conducted using direct observation of the impact of sourcing raw material for cement production. The following impact of sourcing material for cement production on the environment was observed as shown in figure 6.41.

(a) Landscape destruction (b) Air pollution

Figure 6.41: Impact of material-sourcing activities in Case study 4

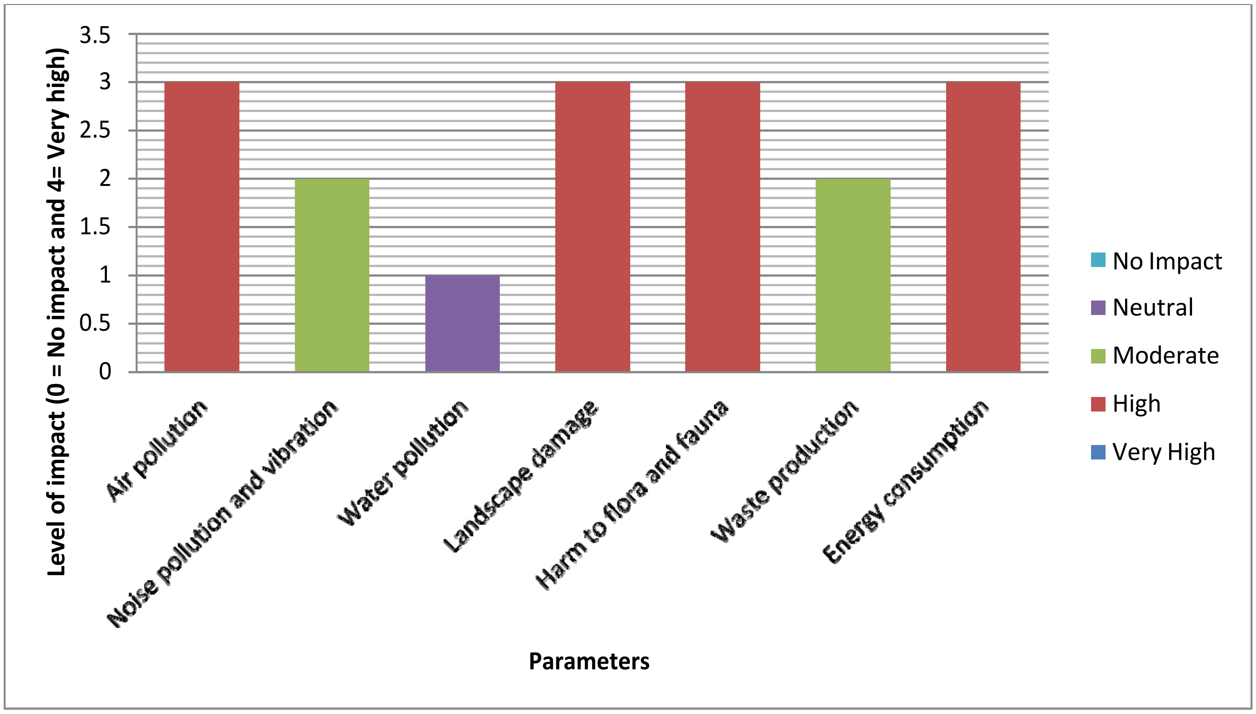
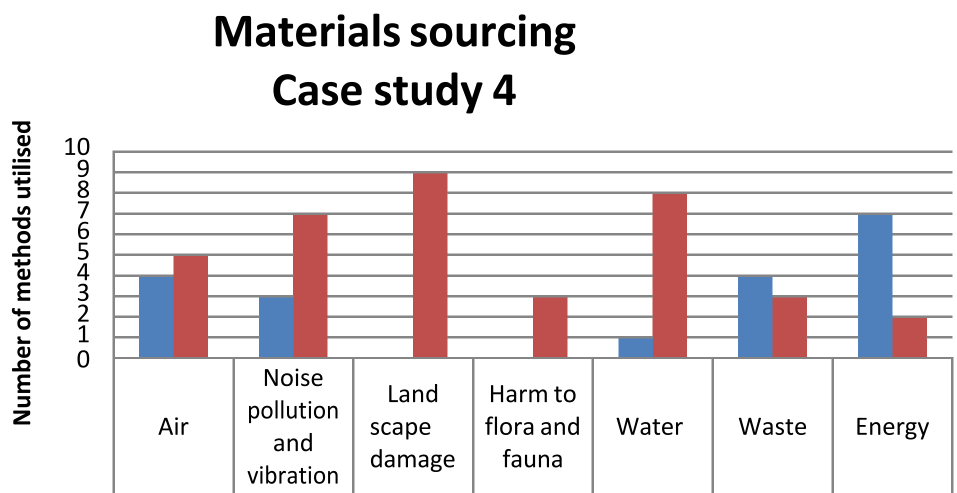


Figure 6.42: Impact of material sourcing on the environment (Case study 4)

From Figure 5.42, air pollution, the landscape damage, the harm to flora and fauna and energy consumption indicate high (3) impact rating on the environment during sourcing for materials. Following these are: noise pollution; vibration; and waste production with moderate (2) impact. Water pollution follows closely with neutral (1) impact rating.

6.5.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 4



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	4	3	0	0	1	4	7
Methods not utilised	5	7	9	3	8	3	2

Figure 6.43: Methods utilised to mitigate the impact of material sourcing in Case study 4

Figure 6.43 above indicates that the company in the case study utilised few methods to mitigate the impact of material sourcing regarding air (procurement of plant and equipment with less emission, maintenance of plant and equipment, increasing distance from nearest building and minimise operations during windy periods), noise pollution and vibration (maintenance of plant and equipment, early public notification of extremely noisy operation and use of modern equipment) and water (design of mining approaches that exclude water). Four methods (recycling of waste, installation of a mobile crushing/ grinder- pulverisation unit at quarry site, training of employees and use of modern plant and equipment for sourcing/ extraction) were utilised regarding waste. None of the proposed methods were utilised to mitigate the impact of material sourcing regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill) and harm to flora and to fauna (continuous monitoring to maintain pH levels, replacement with saplings and addition of buffering agents to mitigate acidic seepage from mining). Eight methods (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts and transport pooling/ limiting hauling) were available to mitigate the impact of materials sourcing regarding energy.

6.5.2 Raw material transportation for Case study 4

Raw materials sourced from open pits are transported by road across a highway by tippers.

Air pollution from trucks

Figure 6.44: Materials transportation process for Case study 4

6.5.2.1 Impact of material transportation on the environment for Case study 4

(a) Air pollution

(b) Landscape damage

Figure 6.45: Environmental impact due to material transportation in Case study 4

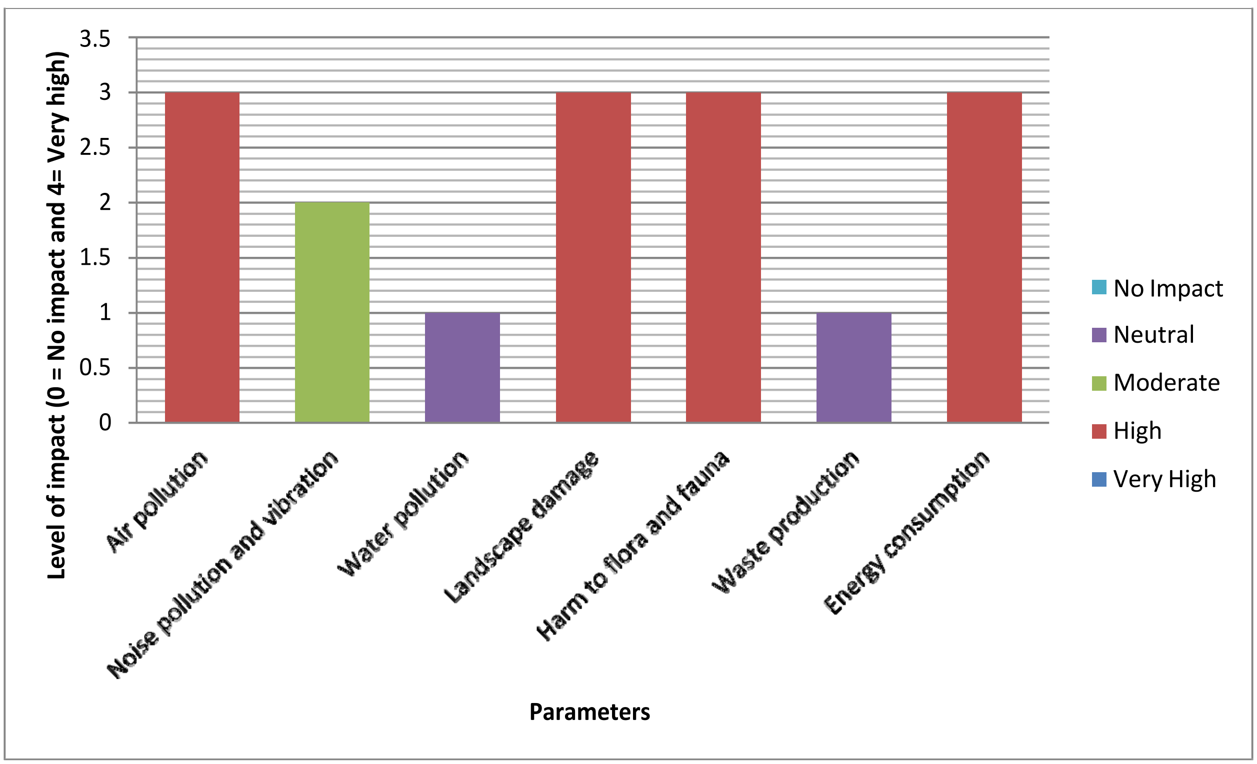


Figure 6.46: Impact of material transportation on the environment (Case study 4)

From Figure 6.46, air pollution, landscape damage, harm to flora and fauna, and energy consumption have high (3) impact ratings on the environment during the transportation of materials. Next to this is noise pollution and vibration with moderate (2) impact. Water pollution and waste production follows closely with neutral (1) impact ratings.

6.5.2.2 Methods utilised to mitigate the impact of material transportation in Case study 4

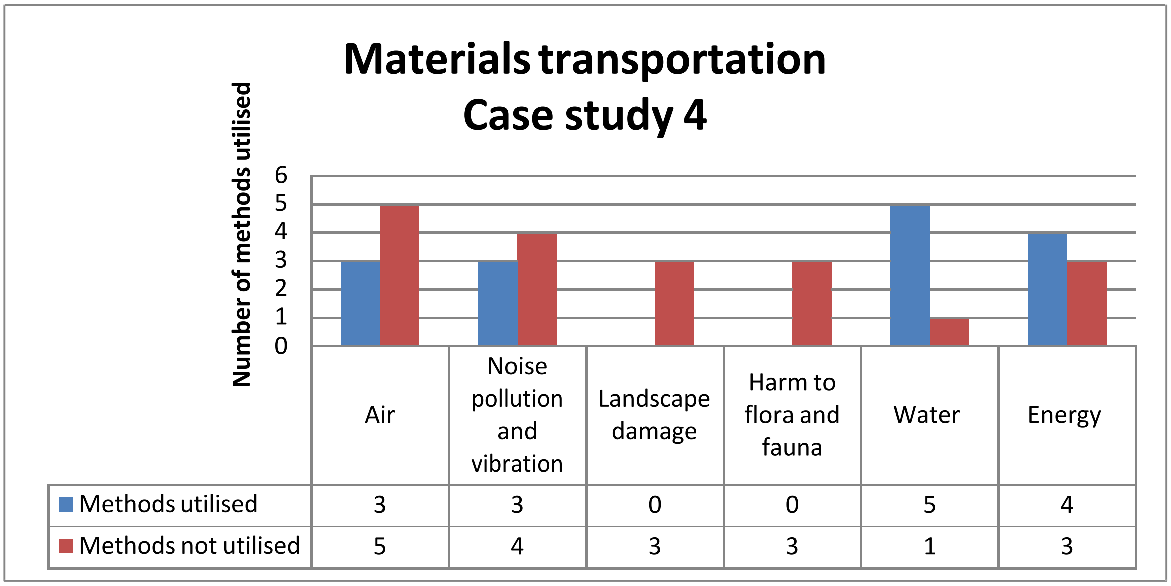


Figure 6.47: Methods utilised to mitigate the impact of material transportation in Case study 4

Figure 6.47 shows that five methods (maintenance of plant and equipment, proper training of drivers, procurement of plant and equipment with less emission, selection of suitable routes and reducing fuel spills) were utilised regarding water; and four methods (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, transport pooling/ limiting hauling and reducing fuel spills) were utilised regarding energy, in order to mitigate the impact of material transportation. Few methods were utilised regarding air (transport pooling/ limiting hauling, procurement of plant and equipment with less emission and maintenance of plant and equipment) and noise pollution and vibration (selection of suitable routes, use of plant and equipment with less emission and maintenance of plant and equipment) to mitigate the impact of material transportation in case study 4. None of the proposed methods were utilised to mitigate the impact of materials transportation regarding landscape damage (re-contouring of slopes, use of alternative routes and covering of transported materials) and harm to flora and fauna (wetting of soil, covering of transported materials, buffer strips).

6.5.3 Material production for Case study 4

The production process of cement involves the transportation of raw materials extracted from the point of sourcing to the production plant; where other operations are carried out to produce cement of the desired standard and quality. The processes for cement production are: grinding to produce a fine powder (raw meal); firing in the kiln at about 1,500°C, and bagging of the finished products.

6.5.3.1 Impact of material production on the environment for Case study 4

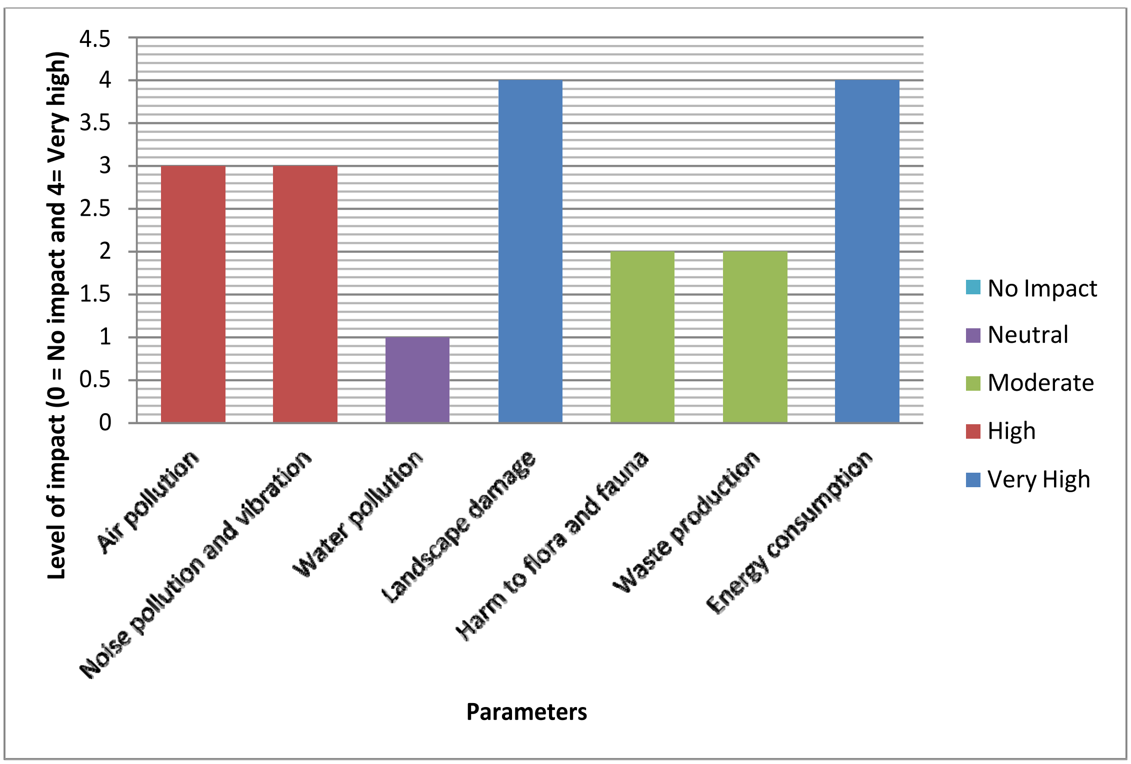
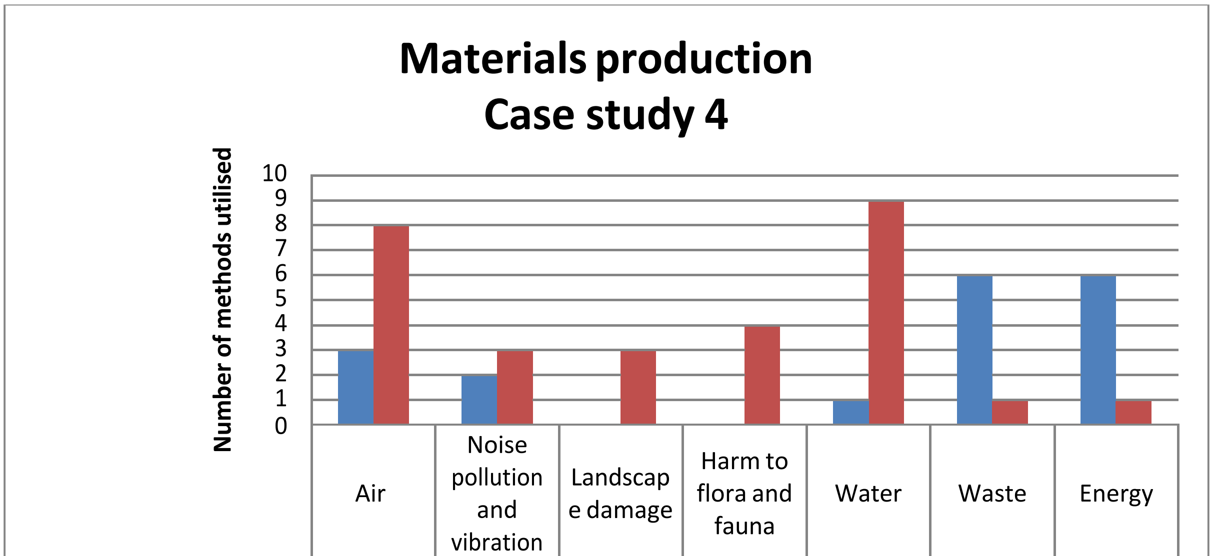


Figure 6.48: Impact of material production on the environment (Case study 4)

From Figure 6.48, air pollution, noise and vibration have high (3) impact ratings on the environment during the production of materials. Next, there is water pollution with a neutral (1) impact. Landscape damage and energy consumption follow with very high (4) impact. Harm to flora and fauna and waste production come next with moderate (3) impact ratings.

6.5.3. Methods utilised to mitigate the impact of materials production (Case study 4)



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	3	2	0	0	1	6	6
Methods not utilised	8	3	3	4	9	1	1

Figure 6.49: Methods utilised to mitigate the impact of materials production (Case study 4)

Figure 6.49 illustrates that the company in case study 4 utilised many methods to mitigate the impact of material production on waste (use of innovative cutting tools, use of modern plant and equipment, treatment of solid reject, re-use of fine grained solid rejects for further production, treatment of solid reject and use of modern plant and equipment) and energy (installation of more efficient lighting, educating employees regarding plant and equipment idling and turning off lights, minimisation of non- utilised power, reducing fuel spills, regular energy audits and maintenance and implementation of energy saving/ conservation measures for plant and equipment e.g catalysts). Few methods were utilised regarding air (increasing distance from nearest building, maintenance of plant and equipment and procurement of plant and equipment with less emission), noise pollution and vibration (use of modern equipment and limiting working time to normal working hours) and water (better design).None of the proposed methods were utilised to mitigate the impact of material production on landscape damage (re-contouring of slopes, better design and planning and enclosure of fuel and chemical) and harm to flora and fauna (application of fertilizer, lime, tillage and re-vegetation, addition of buffering agents to mitigate acidic seeps from mining, top soil substitution and continuous monitoring to maintain pH levels).

6.5.4 Sustainability report for Case study 4

Sustainability reporting depicts an organisation's obligation to implement sustainability. The study made enquiries on sustainability reports in case study 4. It was established that the organization does not have any sustainability reports.

6.6 Case study 5 0 - Granite production

The organisation in Case study 5 produces polished granite tiles and slabs in various forms, such as Ivory gold; Ivory elegance and Ivory white. Granite produced by the company can be applied on floor, wall (cladding), stairs, kitchen tops, counter tops and table tops. The company, which is cited in the South-South geopolitical zone of Nigeria, source, transports and produces ceramic materials.

Figure 6.50: View of the factory (Case study 5)

6.6.1 Material sourcing (Case study 5)

The raw materials used by the organization are located around the organization's production plant. The raw material is sourced through open pits. The organization relies heavily on plants and equipment for sourcing, such as: mechanical compressor, drill and diamond cutter. Raw materials are sourced between 8:00 am to 5:00 pm. The site where the raw materials are sourced is not located around an ecologically sensitive area. Before drilling and blasting operation, no sensitization is made either by public campaign awareness, communiqué to the public or media briefing. After sourcing, the loading and offloading of raw materials are carried out mechanically. Furthermore, the materials are transported by road.

Figure 6.51: Material-sourcing process (Case study 5)

6.6.1.1 The impact of material sourcing on the environment (Case study 5)

Landscape destruction

(a) Cracks due to blasting operation (b) Harm to flora and fauna

Figure 6.52: Degradation due to material sourcing

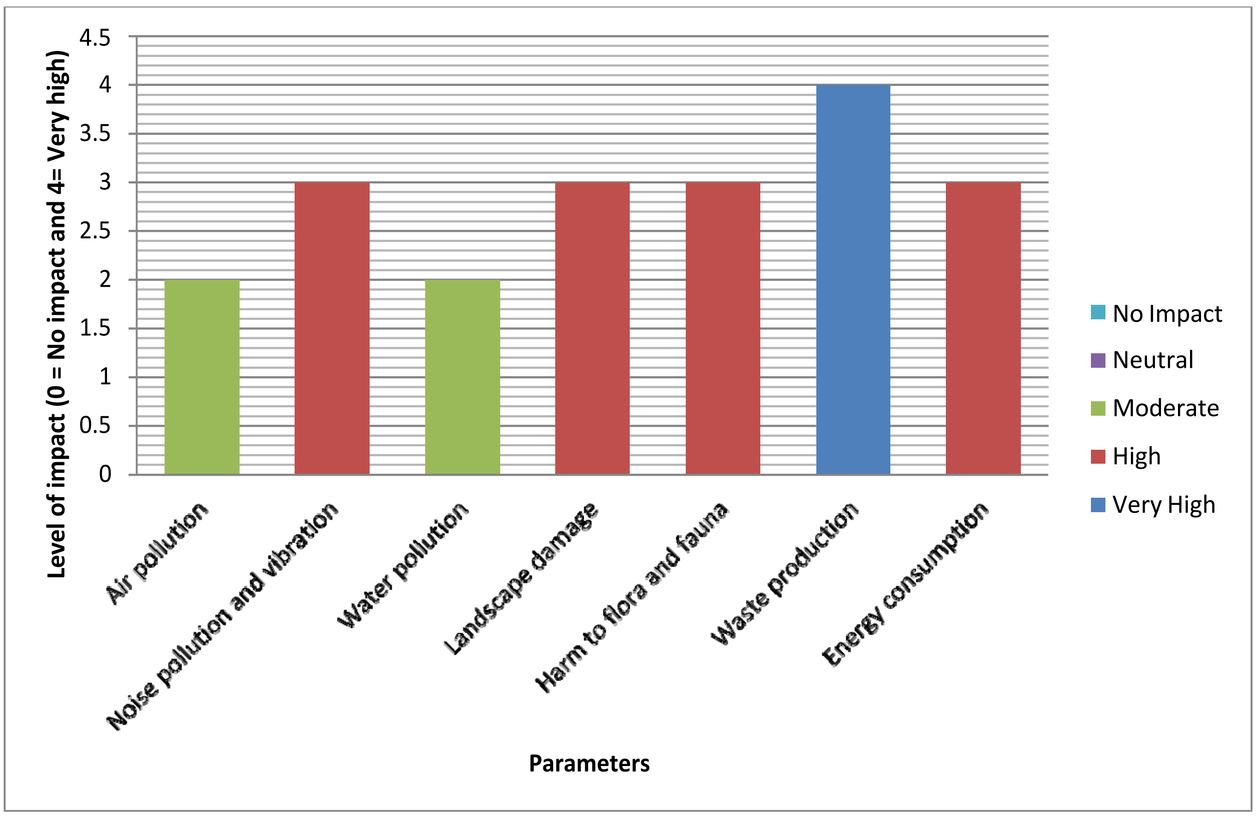


Figure 6.53: Impact of material sourcing on the environment (Case study 5)

From Figure 6.53, air pollution and water pollution have a moderate (2) impact rating on the environment during the material sourcing. Next to this are noise pollution and vibration, landscape damage, harm to flora and fauna, and energy consumption with high (3) impact. Waste production comes next with a very high (4) impact rating.

6.6.1.2 Methods utilised to mitigate the impact of materials sourcing (Case study 5)

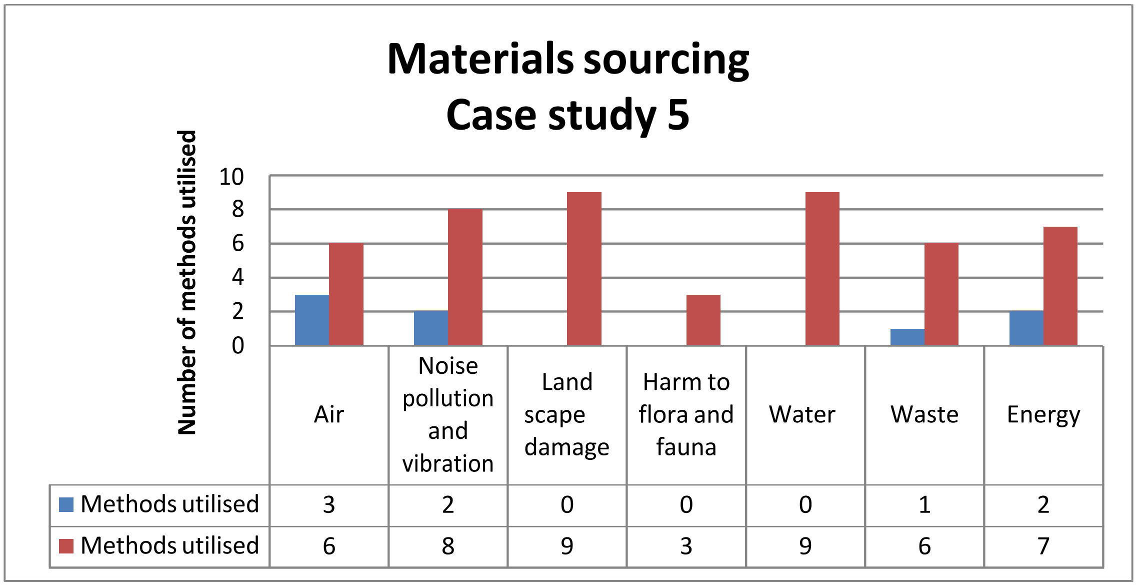


Figure 6.54: Methods utilised to mitigate the impact of materials sourcing (Case study 5)

Figure 6.54 shows above that the organisation in case study 5 utilised few methods to mitigate the impact of material sourcing regarding air (tapping of drilled holes before blasting, increasing distance from nearest building and minimise operations during windy periods), noise pollution and vibration (limiting working time to day light hours and early public notification of extremely noisy operation), waste (training of employees) and energy (transport pooling/ limiting hauling and educating employees regarding plant and equipment idling). None of the proposed methods were utilised to mitigate the impact of material sourcing regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill), harm to flora and fauna (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels) and water (recycling of water, collection and treatment of waste water, protection plan, management of surface water, design of mining approaches that exclude water, use of leak detection systems, monitoring of ground water, contingency planning and buffer strips).

6.6.2 Raw material transportation (Case study 5)

Raw materials excavated from pits for granite production are all transported by road with the use of lorries only. This operation usually begins around 8:00 am and it lasts until 5:00 pm in the afternoon.

(a) Lorries transporting loaded materials (b) Forklift lifting materials

Figure 6.55: Material transportation (Case study 5)

6.6.2.1 Impact of raw material transportation on the environment for Case study 5

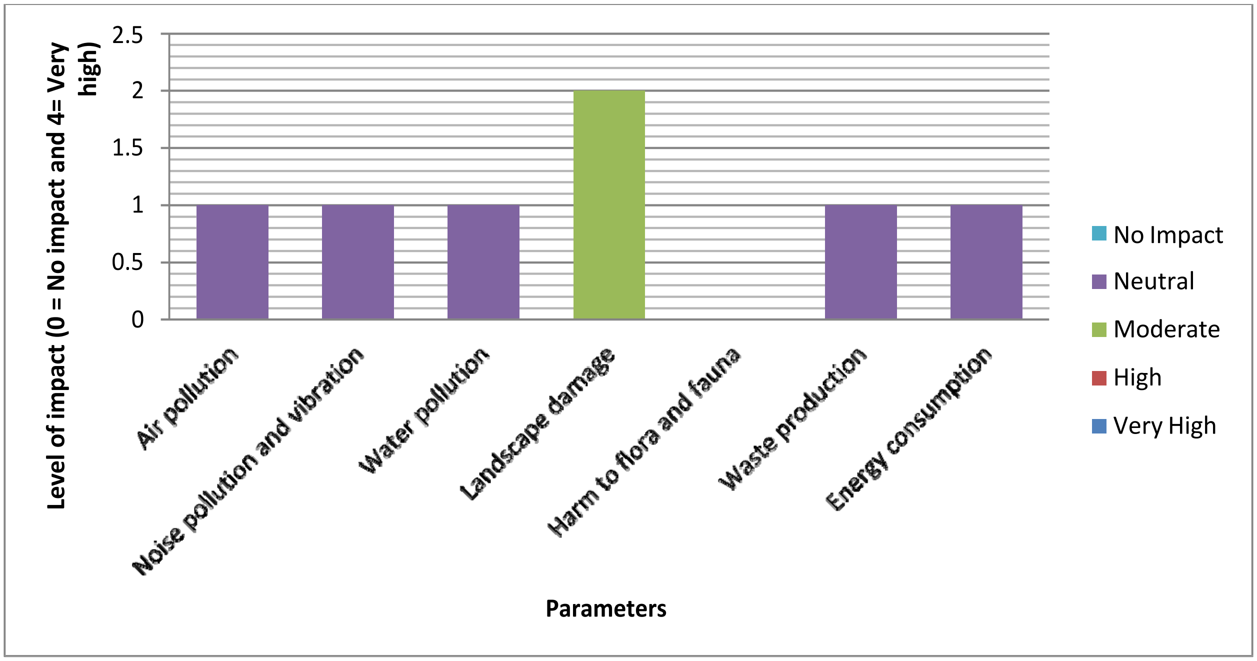
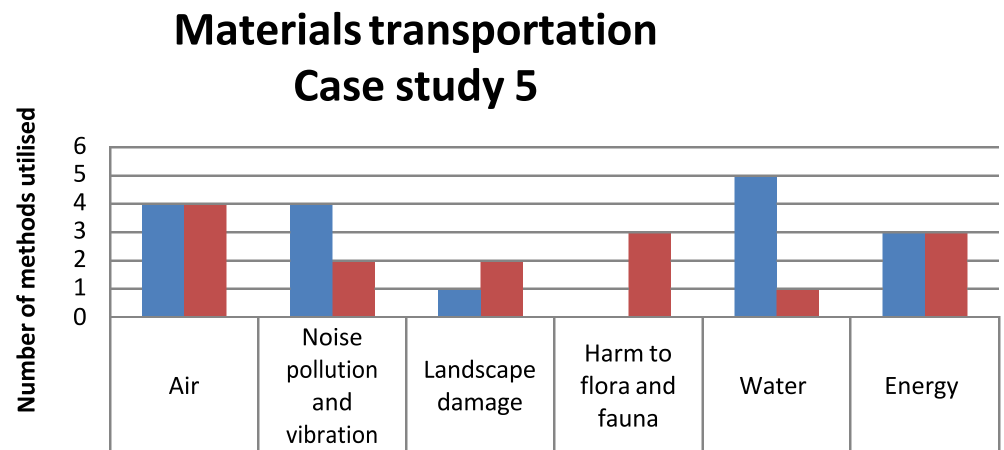


Figure 6.56: Impact of material transportation on the environment (Case study 5)

From Figure 6.56, air pollution, noise pollution, and vibration, water pollution, waste production and energy consumption have neutral (1) impact ratings on the environment during material transportation. Next to this is landscape damage, with a moderate (2) impact. There was no impact (0) on harm to flora and fauna due to material production.

6.6.2.2 Methods utilised to mitigate the impact of material transportation (Case study 5)



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Energy
Methods utilised	4	4	1	0	5	3
Methods not utilised	4	2	2	3	1	3

Figure 6.57: Methods utilised to mitigate the impact of material transportation (Case study 5)

Figure 6.57 shows that case study 5 utilised four methods (transport pooling/ limiting hauling, selection of suitable routes, procurement of plant and equipment with less emission and maintenance of plant and equipment) to mitigate the impact of material transportation regarding air. One method (use of alternative routes) was utilised regarding landscape damage. Many methods were utilised regarding noise pollution and vibration (transport pooling/ limiting hauling, selection of suitable routes, maintenance of plant and equipment and use of plant and equipment with less emission), water (maintenance of plant and equipment, proper training of drivers, procurement of plant and equipment with less emission and selection of suitable routes) and energy (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, transport pooling/ limiting hauling and optimising pit and mine design). None of the proposed methods (wetting of soil, covering of transported materials and buffer strips) were utilised to mitigate the impact of material transportation regarding harm to flora and fauna in case study 5.

6.6.3 Material production for Case study 5

The production process of granite involves the transportation of raw materials from the point of sourcing to the production plant; where other operations are carried out to produce granite of the desired standard and quality. The organisation uses a wet processing technique in the granite production process. The processes for granite production are: dressing, cutting, grinding and polishing of surfaces, as shown below.

Granite-sawing process using diamond cutter

Granite-polishing process

Figure 6.58: Material-production process (Case study 5)

Discharging of waste water into river and stream

(a) Water pollution (b) Destruction of economic trees

Figure 6.59: Environmental degradation in Case study 5

6.6.3.1: Impact of material production on the environment in Case study 5

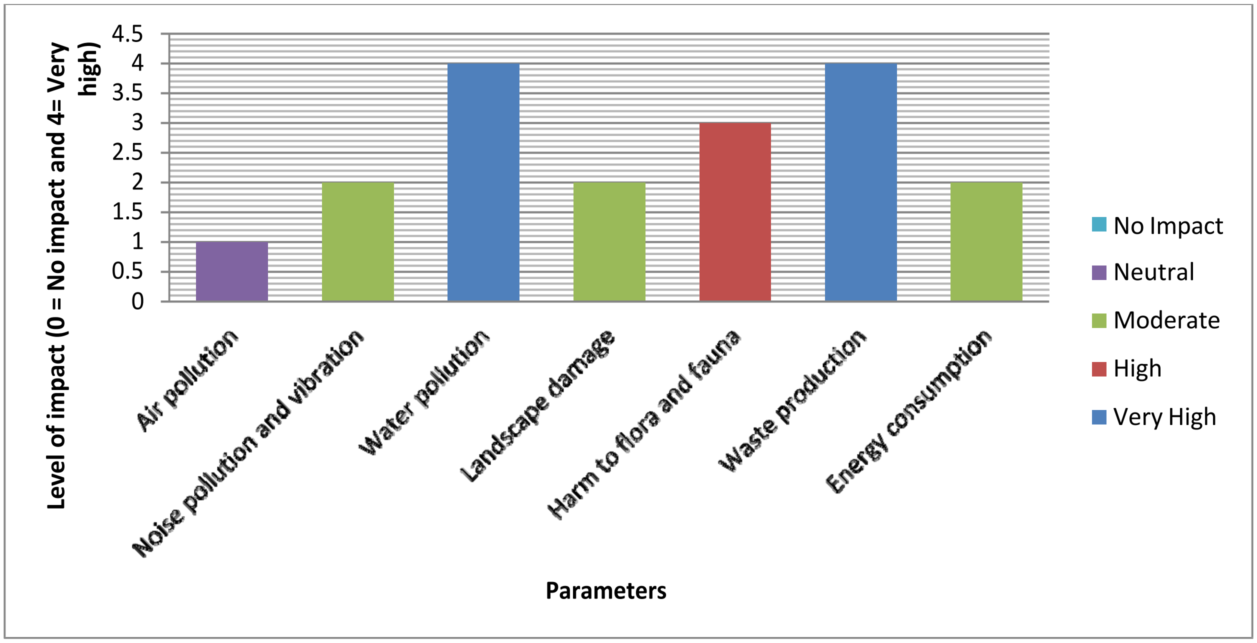
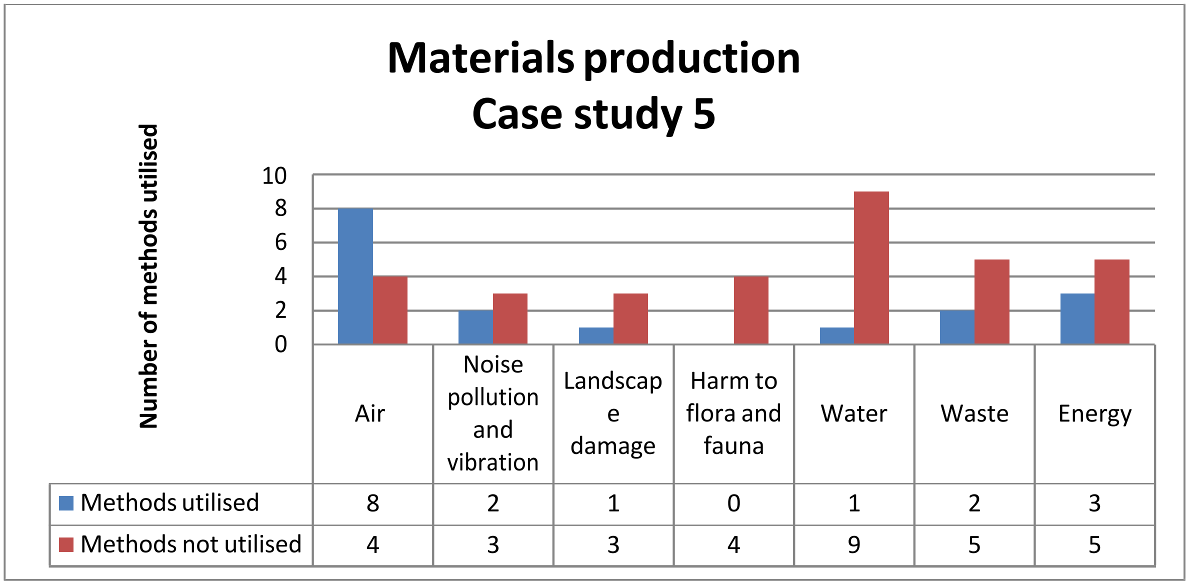


Figure 6.60: Impact of material production on the environment (Case study 5)

From Figure 6.60, air pollution, have neutral (1) impact ratings on the environment during the production of materials. Then follows noise pollution and vibration, landscape damage and energy consumption with moderate (2) impact. Water pollution and waste pollution follow thereafter with very high (4) impact ratings; and harm to flora and fauna comes next with high (3) impact.

6.6.3.2 Methods utilised to mitigate the impact of material production in Case study 5



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	8	2	1	0	1	2	3
Methods not utilised	4	3	3	4	9	5	5

Figure 6.61: Methods utilised to mitigate the impact of material production in Case study 5

Figure 6.61 illustrates that in case study 5, eight methods (using water-cooled tools, procurement of plant and equipment with less emission, mechanical ventilation, maintenance of plant and equipment, use of dust suppressants, use of high temperature filters within gasification process, increasing distance from nearest building and use of bag houses) were utilised to mitigate the impact of material production regarding air. Few methods were utilised regarding noise pollution and vibration (maintenance of plant and equipment and limiting working time to normal working hours), landscape damage (better design and planning), water (management of surface water), waste (segregation of fine grained solid rejects and re-use of fine grained solid rejects for further production) and energy (installation of more efficient lighting, educating employees regarding plant and equipment idling and turning off lights and reducing fuel spills). None of the proposed methods (application of fertilizer, lime, tillage and re-vegetation, addition of buffering agents to mitigate acidic seeps from mining, top soil substitution and continuous monitoring to maintain pH levels) were utilised regarding harm to flora.

6.6.4 Sustainability report for Case study 5

Sustainability reporting was assessed in line with the research objectives; and it was observed that the organisation in case study 5 does not have a sustainability report.

6.7 Case study 6 - Granite production

Case study 6 is among the early companies to venture into granite production in Nigeria, with over twenty-five years of operation. The factory is located in the North-central geopolitical region in Nigeria; and it is sited about 640m above sea level. The factory is situated in a watershed area surrounded by a large river. Case study 6 is involved in the production of granite finishes of varieties that are applied on floor, wall (cladding), stairs, kitchen tops, counter tops and dining room table tops.

Figure 6.62: View of Case study 6

6.7.1 Material sourcing in Case study 6

The raw materials used for granite production are sourced at sites far away from the production plant; and they are sourced from open pits with plants and machines, such as drillers, mobile excavators, and bulldozers. Sourcing operations are carried out between 8:00 am and 6:00 pm daily. The pictures in Figures 6.63 illustrate how raw materials are sourced. The site where the raw material is sourced for granite production is not located in an ecologically sensitive area. However, sensitization is carried out before sourcing operations commence. The various operations carried out by the organization utilize plant and equipment for loading and offloading. Lorries, crane, excavator and bulldozer are used in transporting raw materials from the point of sourcing to the production plant.

Drilling process

Figure 6.63: Material-sourcing process for Case study 6

6.7.2.1 Impact of material sourcing on the environment for Case study 6

The study observed the impact of the material-sourcing processes on the environment for granite production; and they are presented below.

Waste materials

Landscape destruction

Figure 6.64: Impact of material sourcing on the environment

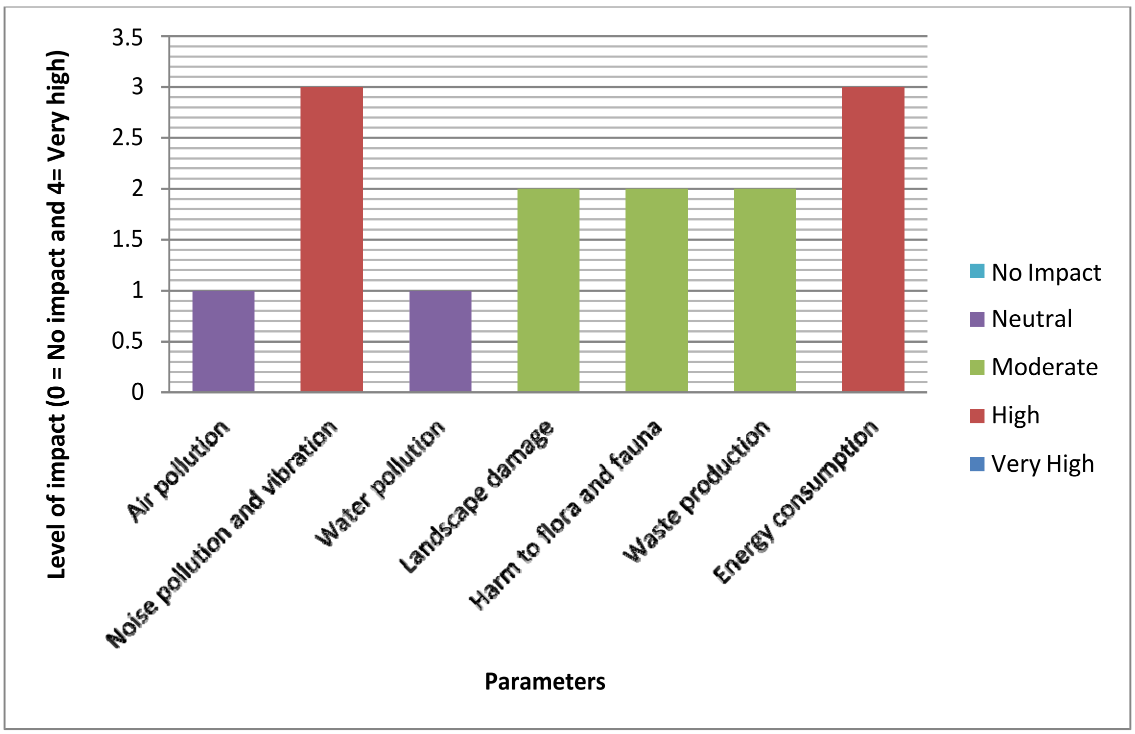
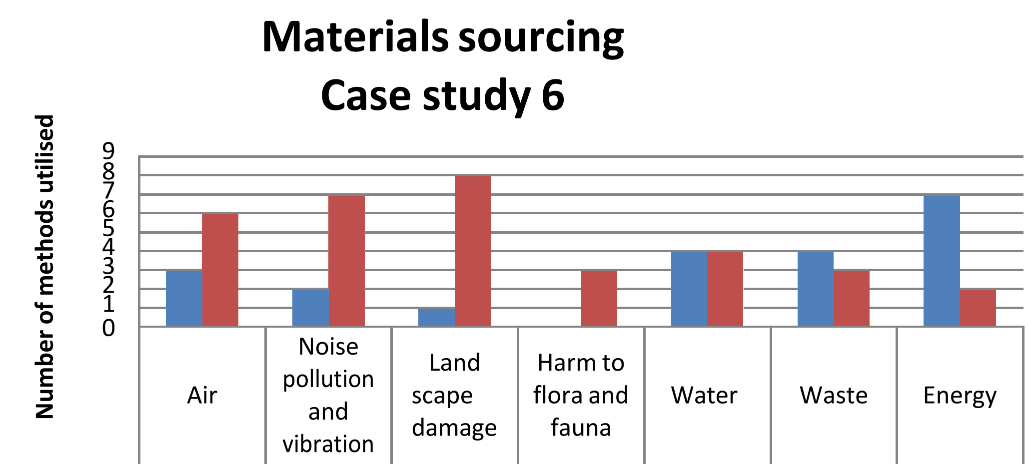


Figure 6.65: Impact of material sourcing on the environment (Case study 6)

From Figure 6.65, air pollution and water pollution have neutral (1) impact ratings on the environment during material sourcing. Next to these are: noise pollution and vibration and energy consumption with a high (3) impact. Landscape damage, harm to flora and fauna and waste production follow closely with a moderate (2) impact rating.

6.7.2.2 Methods utilised to mitigate the impact of material sourcing in Case study 6



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	3	2	1	0	4	4	7
Methods not utilised	6	7	8	3	4	3	2

Figure 6.66: Methods utilised to mitigate the impact of material sourcing in Case study 6

Figure 6.66 shows that five methods were utilised regarding water (collection and treatment of waste water, monitoring of ground water, contingency planning and management of surface water and design of mining approaches that exclude water); seven methods (educating employees regarding plant and equipment idling, altering processing parameter e.g. belt speed, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, regular energy audits and maintenance, and ransport pooling/ limiting hauling) were utilised regarding energy; and four methods (training of employees, recycling of waste, use of modern plant and equipment for sourcing/ extraction and proper planning and efficient management) were utilised regarding waste, in order to mitigate the impact of material sourcing. Few methods were utilised regarding air (minimise operations during windy periods, increasing distance from nearest building and procurement of plant and equipment with less emission), noise pollution and vibration (limiting working time to day light hours and use of modern equipment) and landscape damage (re-contouring of slopes). None of the proposed methods (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels) were utlised regarding harm to flora and fauna.

6.7.3 Material transportation for Case study 6

Raw materials for granite production are carried out with a crane and loaded onto the lorries that transport the raw materials to the production plant by road. The stone blocks are cut into 2 m^3/ 6m^3 and each m^3 has a weight of 3 tons.

(a) Crane lifting stone blocks (b) Lorries transporting loaded materials

Figure 6.67: Material transportation process for Case study 6

6.7.3.1 Impact of Material transportation on the environment for Case study 6

(a) Landscape destruction (b) Destruction of fauna

Figure 6.68 Impacts from Materials transportation in Case study 6

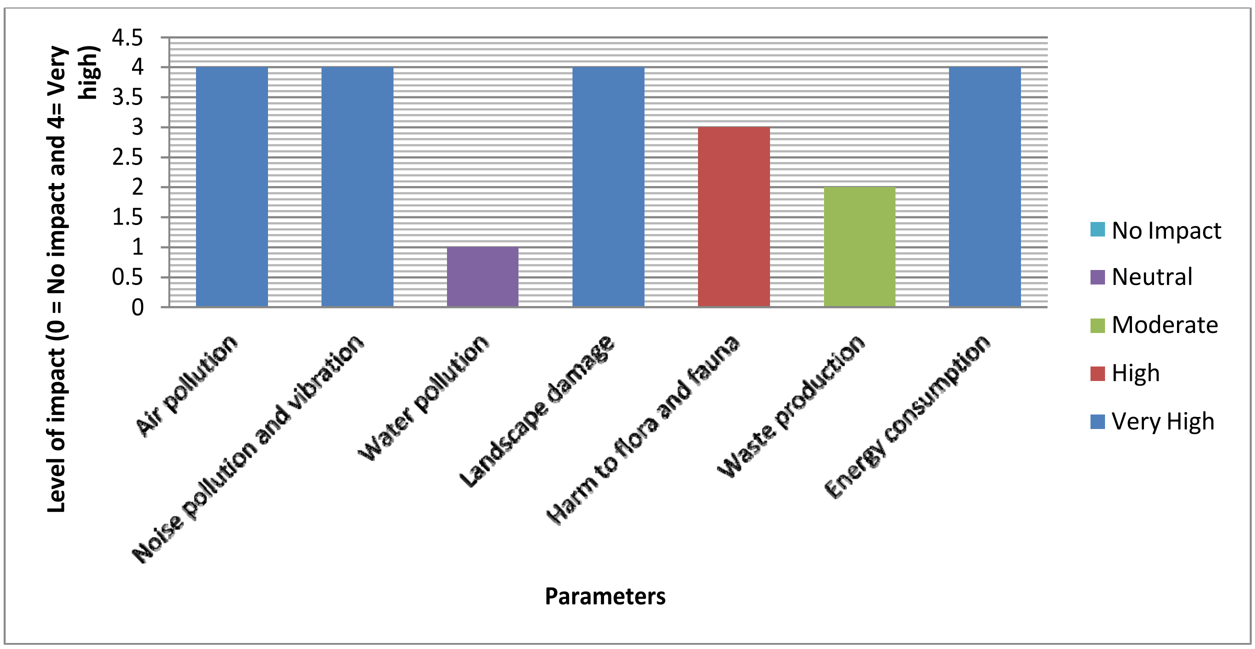


Figure 6.69: Impact of material transportation on the environment (Case study 6)

From Figure 6.69, air pollution, noise pollution and vibration, landscape damage and energy consumption have very high (4) impact ratings on the environment during the transportation of materials. Next to this is harm to flora and fauna with a high (3) impact.

Waste production follows closely with moderate (2) impact rating and water pollution comes next with neutral (1) rating.

6.7.3.2 Methods utilised to mitigate the impact of material transportation in Case study 6

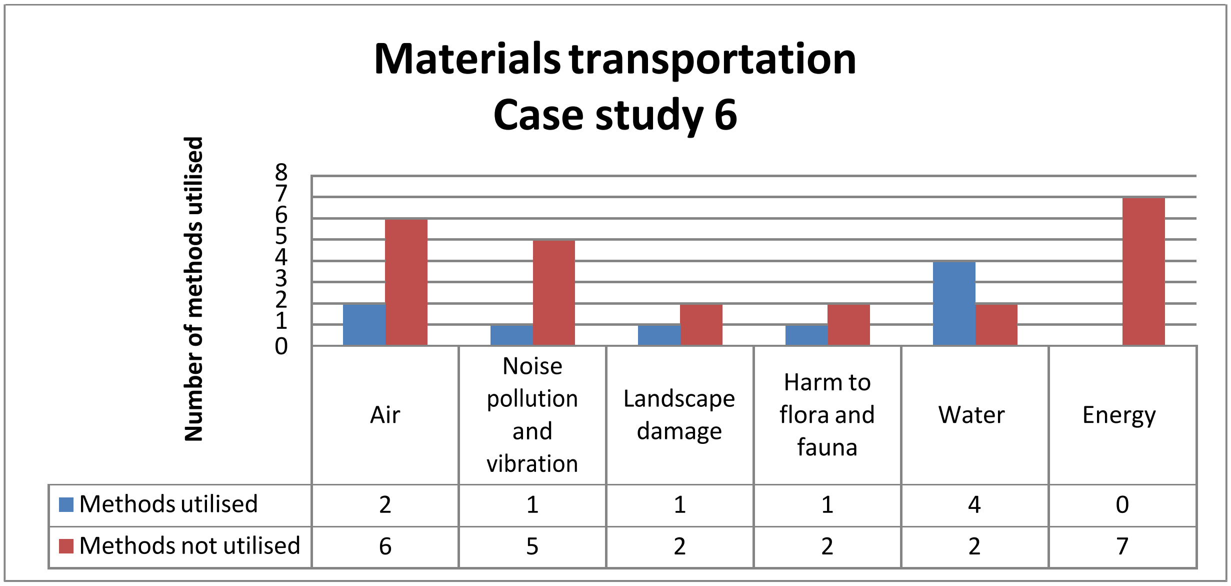


Figure 6.70: Methods utilised to mitigate the impact of material transportation in Case study 6

Figure 6.70 shows that the company in case study 6 utilised few methods to mitigate the impact of material transportation regarding air (transport pooling/ limiting hauling and maintenance of plant and equipment) and noise pollution and vibration (maintenance of plant and equipment). One method was utilised regarding landscape damage (use of alternative routes) and harm to flora and fauna (wetting of soil). Four methods were utilised to mitigate the impact of material transportation regarding water (reducing fuel spills, selection of suitable routes, proper training of drivers and continuous motoring of ground water). None of the proposed methods (educating employees regarding plant and equipment, optimising pit and mine design, use of modern plant and equipment for loading and transportation, regular energy audits and maintenance, transport pooling/

limiting hauling, reducing fuel spills and use of renewable energy sources for operation) were utilised to mitigate the impact of material transportation regarding energy.

6.7.4 Material production for Case study 6

Case study 6 utilizes 160m^3 granite blocks during the production phases, which entail cutting, trimming, calibrating, polishing, cross-cutting, chaffering and packaging of sourced rock blocks. They are then cut into desired sizes using the diamond cutter. The organisation uses a wet processing technique for granite production process. 50mgw of electricity is consumed daily; and it produces 125m^3 of granite tiles monthly on the average.

Granite-cutting process

Granite-polishing process

Figure 6.71: Material-production process for Case study 6

6.7.4.1 Impact of material production on the environment for Case study 6

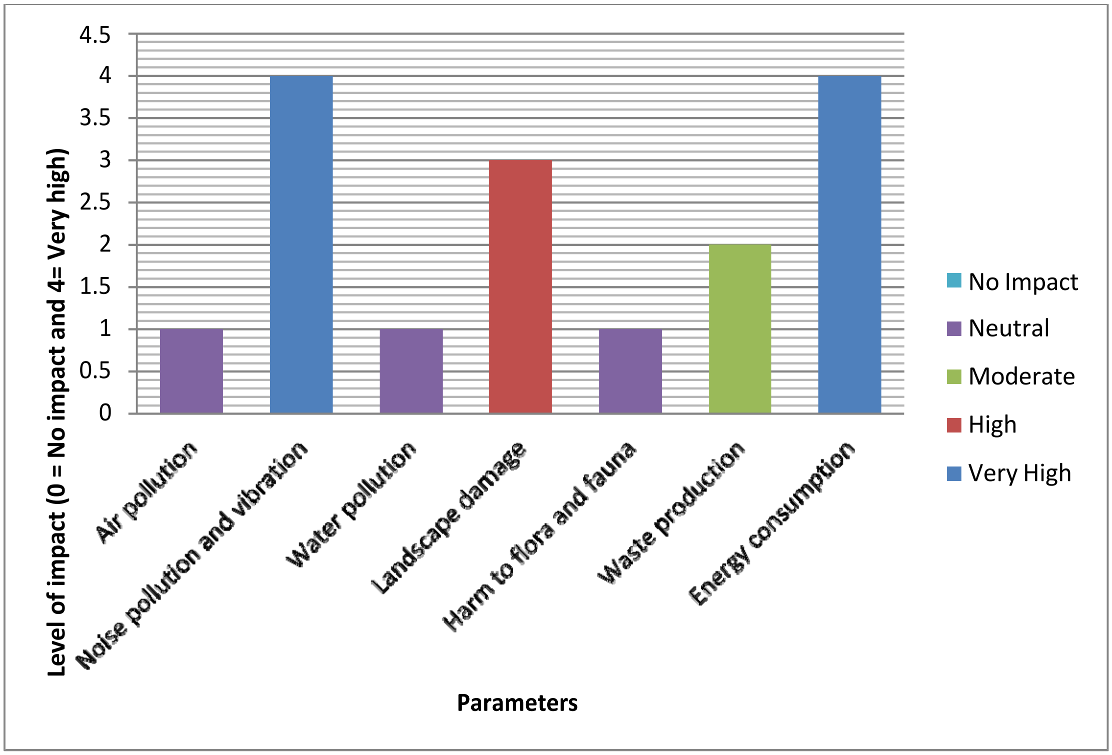
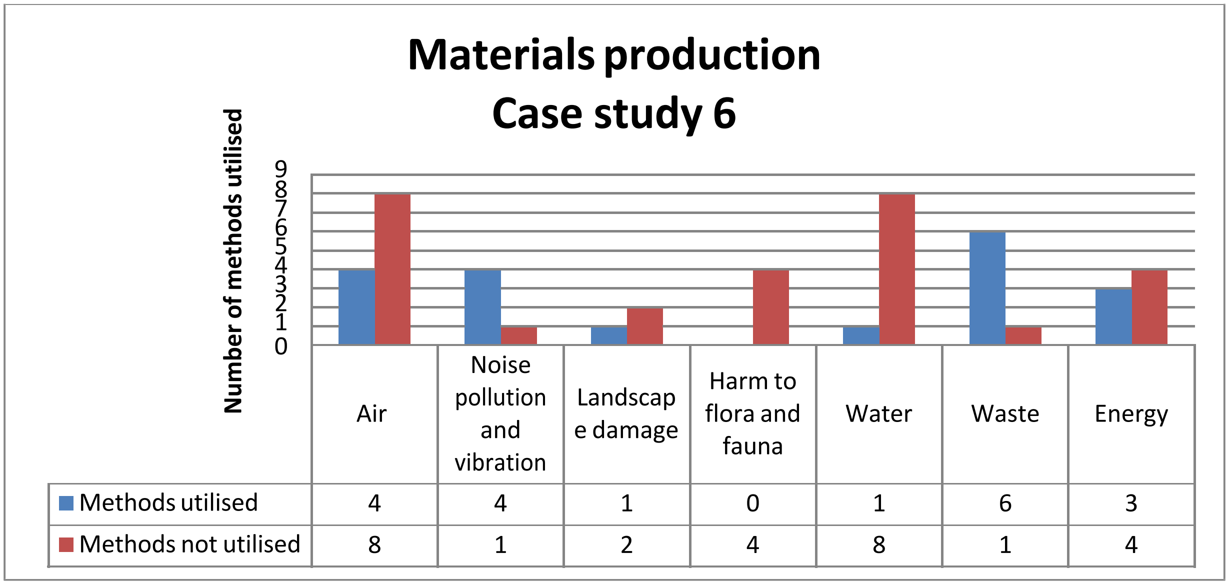


Figure 6.72: Impact of materials production on the environment (Case study 6)

Figure 6.72 shows that air pollution, water pollution and harm to flora and fauna have neutral (1) impact ratings on the environment during the material-production process. Next to these are noise pollution and vibration and energy consumption with very high (4) impact ratings. Landscape damage follows closely with a high impact (3) rating; and waste production come next with a moderate (2) impact rating.

6.7.4.2 Methods utilised to mitigate the impact of material production in Case study 6



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	4	4	1	0	1	6	3
Methods not utilised	8	1	2	4	8	1	4

Figure 6.73: Methods utilised to mitigate the impact of material production in Case study 6

Figure 6.73 shows that the company in case study 6 utilised many methods to mitigate the impact of material production regarding noise pollution and vibration and waste. Few methods were utilised regarding air (using water-cooled tools, initial and periodic compliance testing of pollutants emitted from production process, procurement of plant and equipment with less emission and maintenance of plant and equipment), landscape damage (enclosure of fuel and chemical), water (protection plan) and energy (educating employees regarding plant and equipment idling and turning off lights). None of the proposed methods (top soil substitution, continuous monitoring to maintain pH levels, addition of buffering agents to mitigate acidic seeps from mining and application of fertilizer, lime, tillage and re-vegetation) were utilised to mitigate the impact of material production on harm to flora and fauna.

6.7.5 Sustainability report for Case study 6

Sustainability reporting discloses the environmental, social and economic impact of an organisation's obligation to sustainability. The study made enquiries on the sustainability report in case study 6 and a copy of the report was made available to the researcher which was prepared once a year by a consultant on their behalf.

6.8 Case study 7- Timber processing

The company was established in the late nineties and located in the South-West geopolitical region of Nigeria. Case study 7 is involved in the cutting, felling and processing of timber. They are used for the construction of concrete form work, furniture and other building finishes.

Figure 6.74: Factory view in Case study 7

6.8.1 Material sourcing in Case study 7

Timber of various types is sourced from the forest reserve around the city. A chain saw is used to fell the timber all day round. Timber sourcing processes are illustrated in the Figures 6.75 below.

Timber sawing and felling process

Figure 6.75: Material sourcing process in Case study 7

6.8.1.1 Impact of material sourcing on the environment in Case study 7

The study observed the impact of the material sourcing process in case study 7 for timber, as follows.

(a) Destruction of fauna (b) Landscape destruction

Figure 6.76: Impact of material sourcing on landscape, flora and fauna

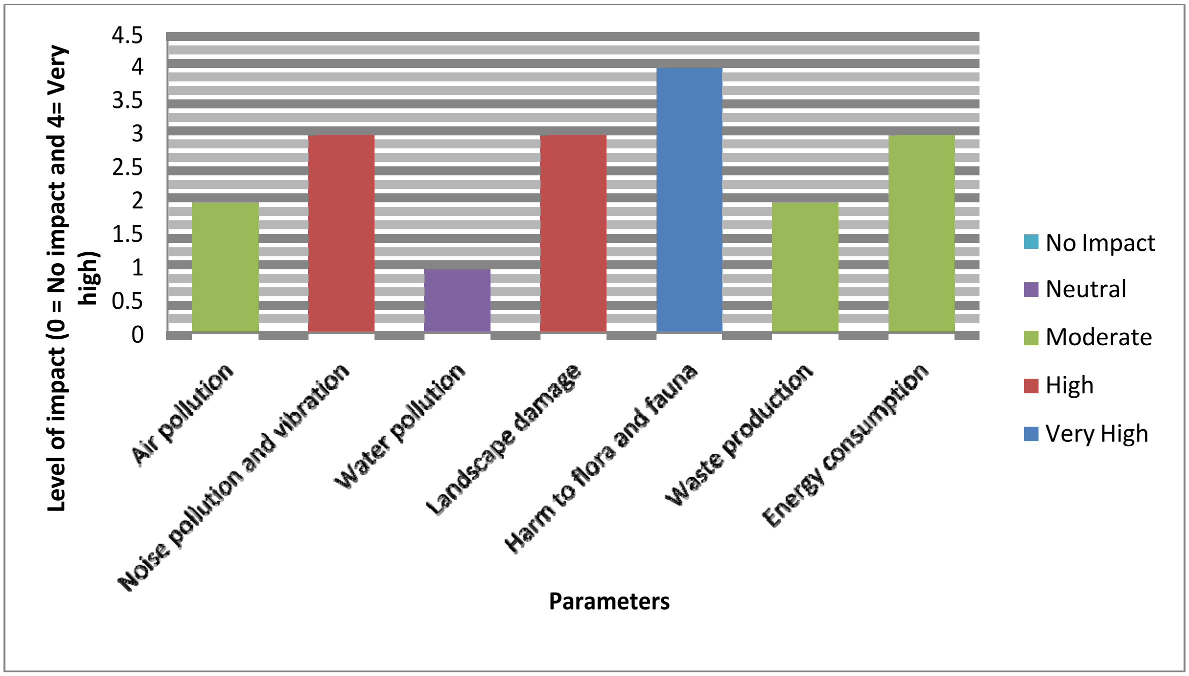
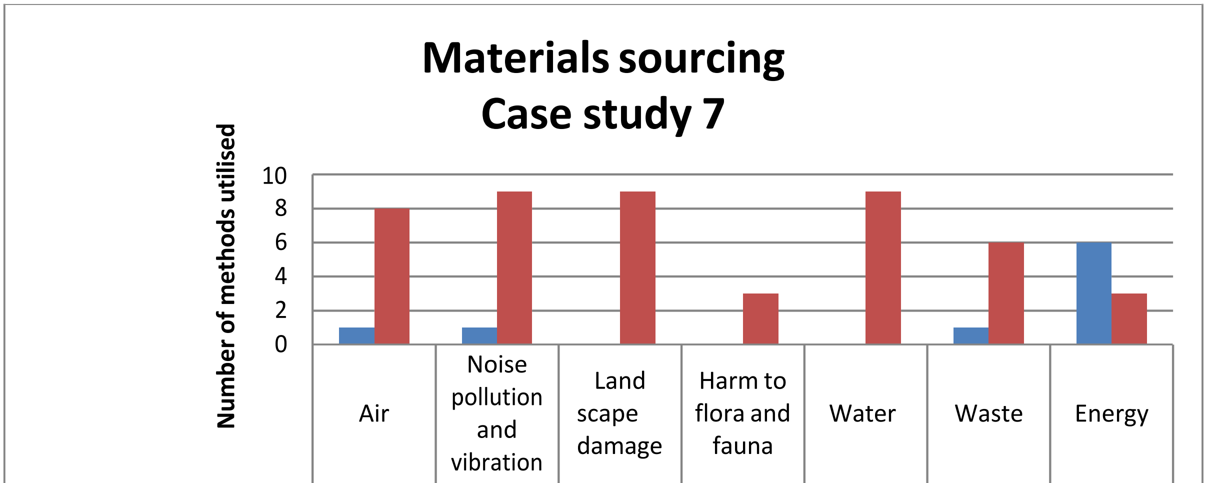


Figure 6.77: Impact of material sourcing on the environment (Case study 7)

From Figure 6.77, air pollution, waste production and energy consumption have moderate (2) impact ratings on the environment during the sourcing of materials. Next to these are noise pollution and vibration and landscape damage, with high (3) impact. Water pollution follows with neutral (1) impact rating and harm to flora and fauna comes next with a very high (4) impact.

6.8.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 7



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	1	1	0	0	0	1	6
Methods not utilised	8	9	9	3	9	6	3

Figure 6.78: Methods utilised to mitigate the impact of material sourcing in Case study 7

Figure 6.78 shows that few methods were utilised to mitigate the impact of material sourcing on air (minimise operations during windy periods), noise pollution and vibration (limiting working time to day light hours) and waste (training of employees). None of the proposed methods were utilised regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill), harm to flora and fauna (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels) and water (recycling of water, collection and treatment of waste water, protection plan, management of surface water, design of mining approaches that exclude water, use of leak detection systems, monitoring of ground water, contingency planning and buffer strips). Six methods (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills and implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts) were utilised to mitigate the impact of materials sourcing regarding energy.

6.8.2 Material transportation for Case study 7

Sourced timber logs are transported by road with Lorries to the saw mill where debarking and sawing are carried out.

(a) Material loading process (b) Material transportation process

Material-offloading process

Figure 6.79: Material transportation and offloading process in Case study 7

6.8.2.1 Impact of material transportation on the environment in Case study 7

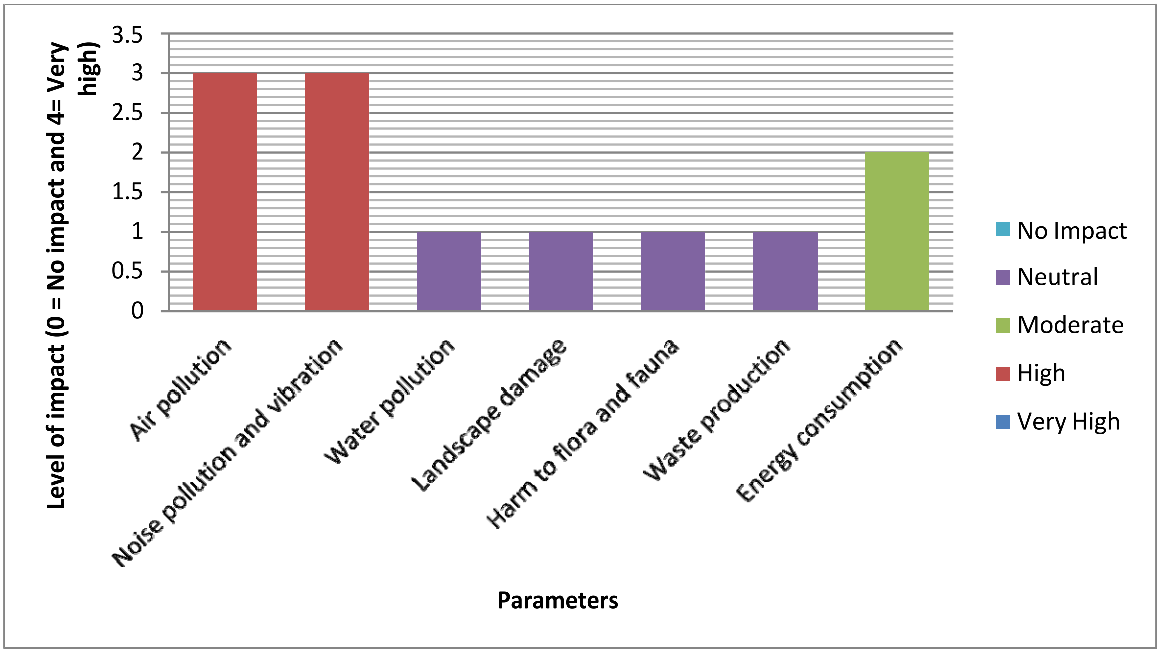


Figure 6.80: Impact of material transportation on the environment (Case study 7)

From Figure 6.80, air pollution and noise pollution and vibration have high (3) impact ratings on the environment during the transportation of materials. Next to these are water pollution, landscape damage, harm to flora and fauna and waste production, with neutral impact (1). Energy consumption comes with a moderate (2) impact.

6.8.2.2 Methods utilised to mitigate the impact of material transportation in Case study 7

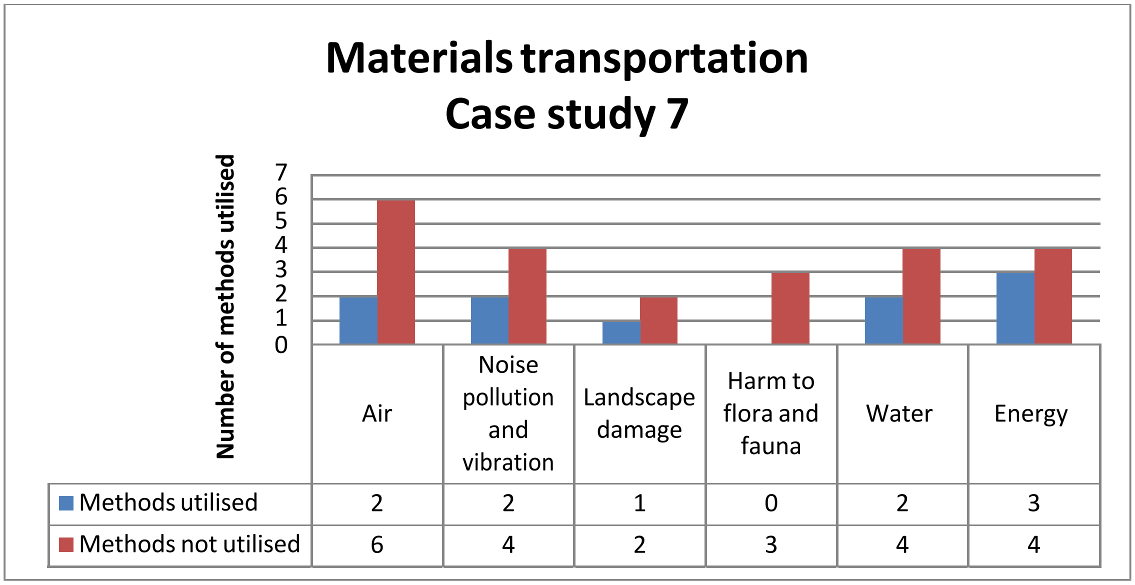


Figure 6.81: Methods utilised to mitigate the impact of material transportation in Case study 7

Figure 6.81 illustrates that few methods were utilised by the company in case study 7 to mitigate the impact of material transportation regarding air (transport pooling/ limiting hauling and selection of suitable routes), noise pollution and vibration (transport pooling/ limiting hauling and selection of suitable routes), landscape damage (use of alternative routes), water (selection of suitable routes and proper training of drivers) and energy. None of the proposed methods (buffer strips, covering of transported materials and wetting of soil) were utilised to mitigate the impact of material transportation regarding harm to flora and fauna.

6.8.3 Materials production in Case study 7

Timber transported to the saw mill is seasoned using the air method of seasoning, where they are gathered together in an open space. At the production stage, timber logs are debarked before sawing commences.

(a) Debarking process (b) Sawing process

Figure 5.82: Material production process in Case study 7

6.8.3.1 Impact of materials production on the environment in Case study 7

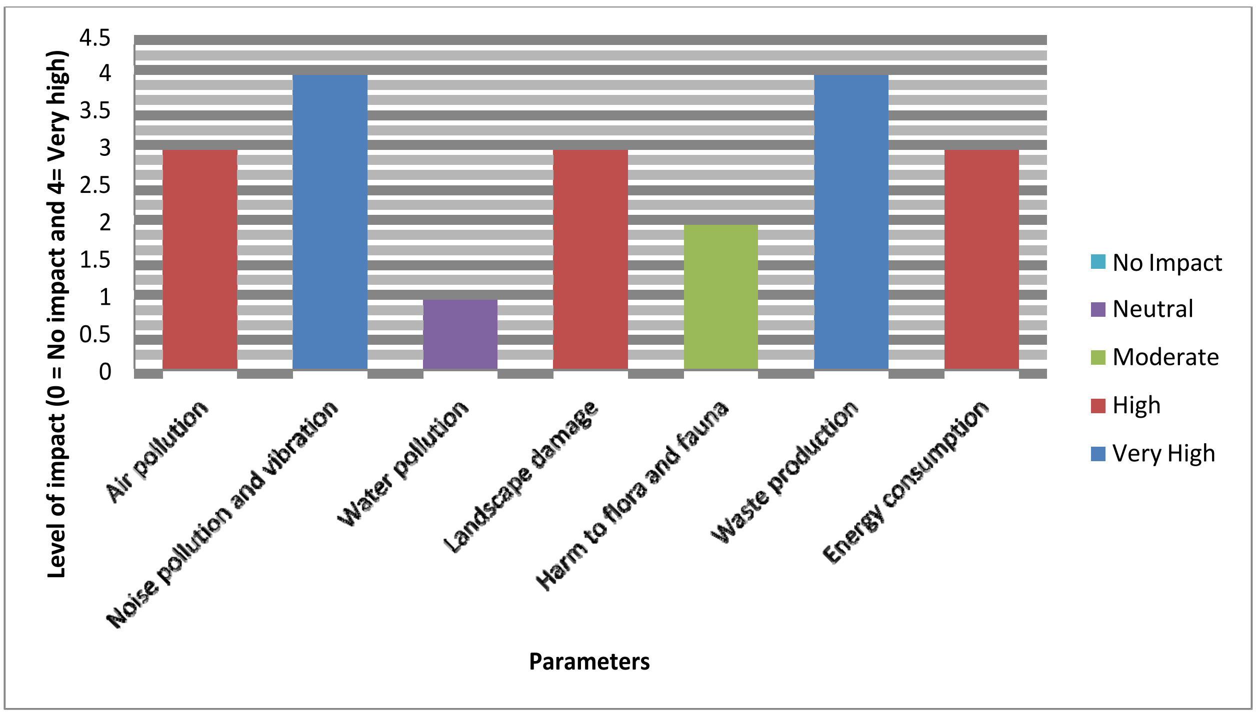
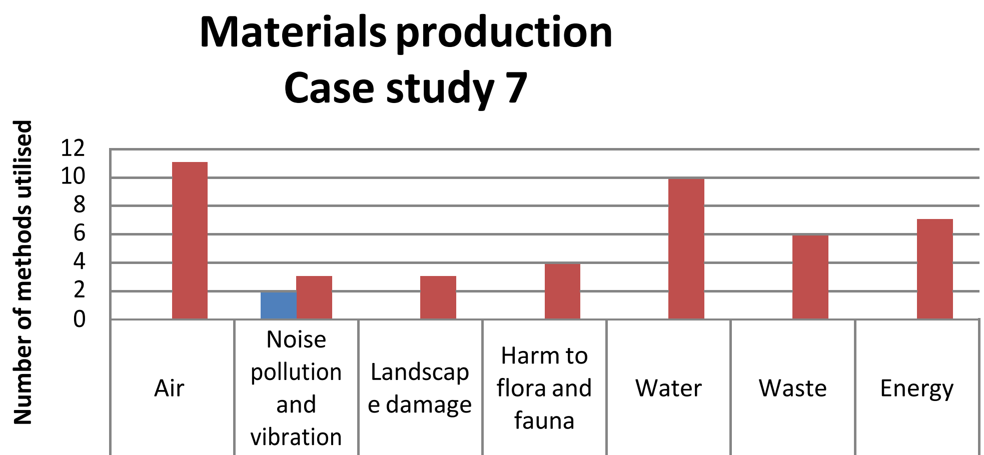


Figure 6.83: Impact of material production on the environment (Case study 7)

From Figure 6.71, air pollution, landscape damage and energy consumption have high (3) impact ratings on the environment during the production of materials. Next to these are noise pollution and vibration and waste production with very high (4) impacts. Water pollution follows with neutral (1) impact rating; and harm to flora and fauna comes next with moderate (2) impact ratings.

6.8.3.2 Methods utilised to mitigate the impact of material production in Case study 7



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	1	2	0	0	0	1	1
Methods not utilised	11	3	3	4	10	6	7

Figure 6.84: Methods utilised to mitigate the impact of material production in Case study 7

Figure 6.84 illustrates that, few methods were utilised by the company in case study 7 to mitigate the impact of material production regarding air (maintenance of plant and equipment), noise pollution and vibration (maintenance of plant and equipment and limiting working time to normal working hours), waste (re-use of fine grained solid rejects for further production) and energy (educating employees regarding plant and equipment idling and turning off lights). None of the proposed methods were utilised to mitigate the impact of material production regarding harm to flora and fauna (application of fertilizer, lime, tillage and re-vegetation, addition of buffering agents to mitigate acidic seeps from mining, addition of buffering agents to mitigate acidic seeps from mining, top soil substitution and continuous monitoring to maintain pH levels), landscape damage (enclosure of fuel and chemical, better design and planning and re-contouring of slopes) and water (use of reclaimed effluent and other recycled water for cooling, collection in sumps, better design, use of leak detection systems, control of site drainage, management of surface water, protection plan, collection and treatment of waste water, buffer strips and recycling of water).

6.8.4 Sustainability report for Case study 7

The organisation in case study 7 does not produce sustainability reports that would disclose the environmental, social and economic impact of their organisation's operation.

6. 9 Case study 8 - Timber processing

The company is located in the South-West geopolitical zone of Nigeria. The organisation is involved in felling and sawing of timber that are used for furniture production, construction and other building finishes.

Figure 6.85: Factory view in Case study 8

6.9.1 Material sourcing in Case study 8

The sourcing of timber for various purposes is sourced from the forest reserve located in the State. For sourcing, a chain saw is predominantly used to fell the timber. The sourcing processes are illustrated in the Figures 6.86 below

Timber sawing and felling process

Figure 6.86 Material sourcing process in Case study 8

6.9.1.1 Impact of material sourcing on the environment in Case study 8

The study observed the impact of the material-sourcing process in case study 8 for timber; this now follows.

Timber-sawing process

Figure 6.87: Air pollution and landscape destruction environment impact in Case study 8

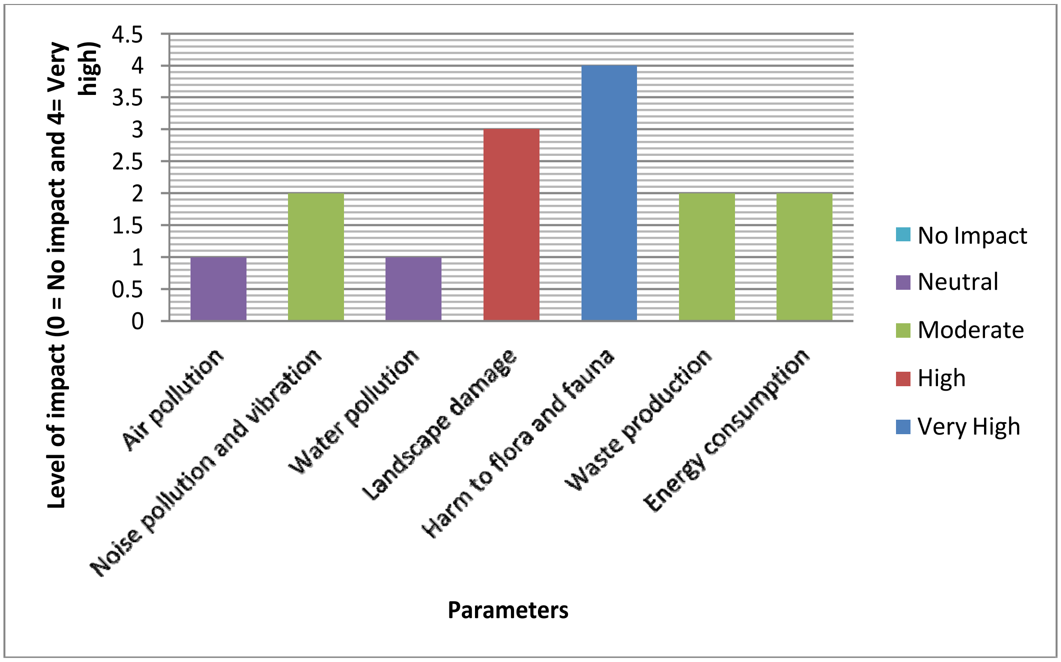


Figure 6.88: Impact of materials sourcing on the environment (Case study 8)

From Figure 5.88, air pollution and water pollution have neutral impact ratings (1) on the environment during the sourcing of materials. Next to these are noise pollution and vibration, waste production and energy consumption with moderate (1) impact rating. Landscape damage follows with high (3) impact; and harm to flora and fauna comes next with a very high (4) impact rating.

6.9.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 8

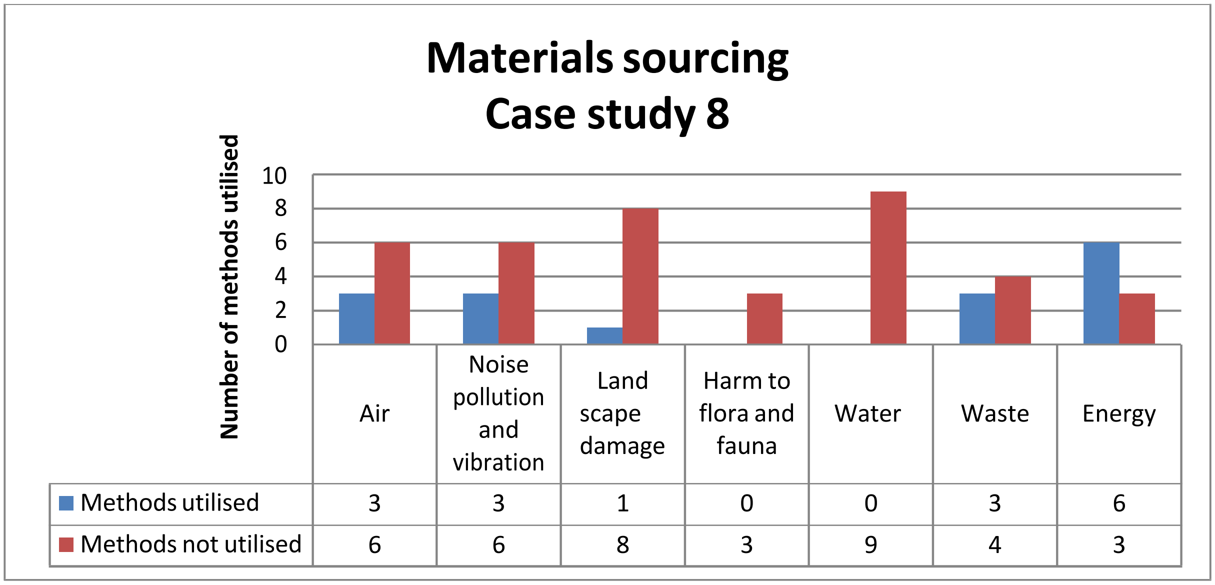


Figure 6.89: Methods utilised to mitigate the impact of material sourcing in Case study 8

Figure 6.89 shows that the company in case study 8 utilised a few methods to mitigate the impact of material sourcing regarding air (minimise operations during windy periods, increasing distance from nearest building and maintenance of plant and equipment), noise pollution and vibration (limiting working time to day light hours, early public notification of extremely noisy operation and maintenance of plant and equipment), landscape damage (reduced-impact logging) and waste (training of employees, recycling of waste, reduced-impact logging). None of the proposed methods were utilised regarding harm to flora and fauna (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels), and water (recycling of water, collection and treatment of waste water, protection plan, management of surface water, design of mining approaches that exclude water, use of leak detection systems, monitoring of ground water, contingency planning and buffer strips). Six methods (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts and transport pooling/ limiting hauling) were utilised to mitigate the impact of material sourcing regarding energy.

6.9.2 Material transportation for Case study 8

After the timber logs are sourced, they are transposed by Lorries to the saw mill where further actions, such as debarking and sawing take place.

Material-transportation means

Material-offloading process

Figure 6.90: Material transportation and offloading process in Case study 8

6.9.2.1 Impact of material transportation on the environment for Case study 8

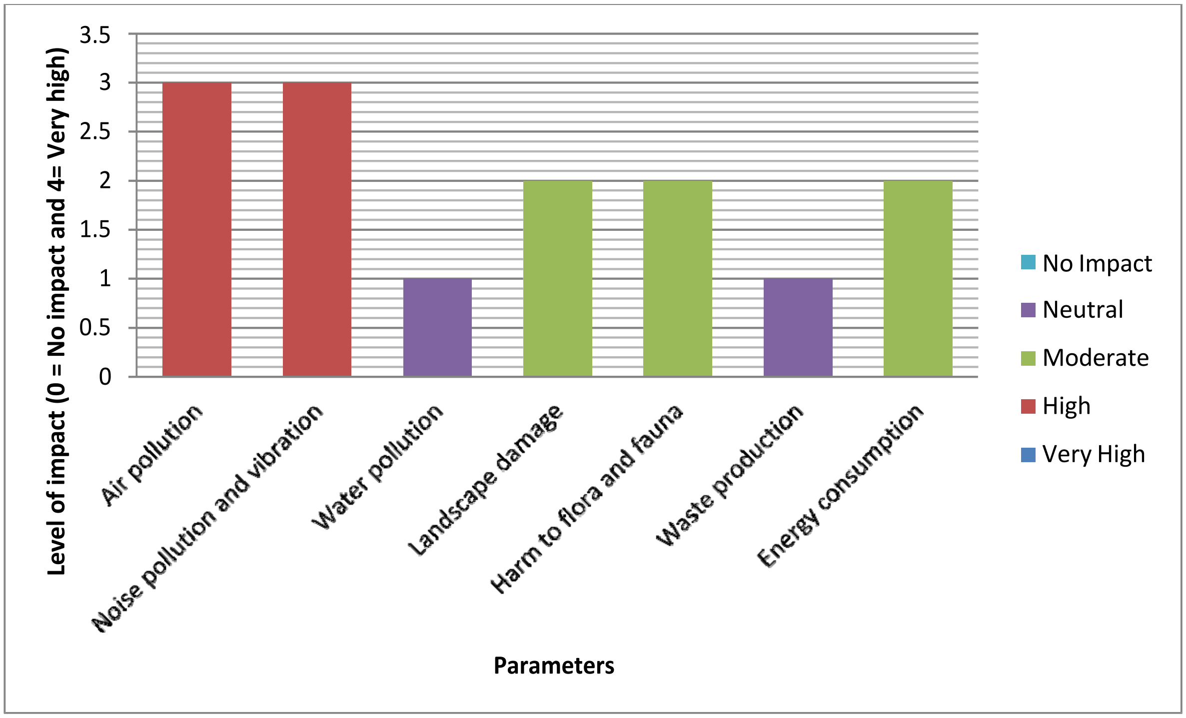


Figure 6.91 Impact of materials transportation on the environment (Case study 8)

From Figure 6.91, air pollution and noise pollution and vibration have high (3) impact rating on the environment during the transportation of materials. Thereafter, there follow water pollution and waste with neutral (1) impact, landscape damage; harm to flora and fauna; and energy consumption follows with moderate (2) impact rating.

6.9.2.2 Methods utilised to mitigate the impact of material transportation in Case study 8

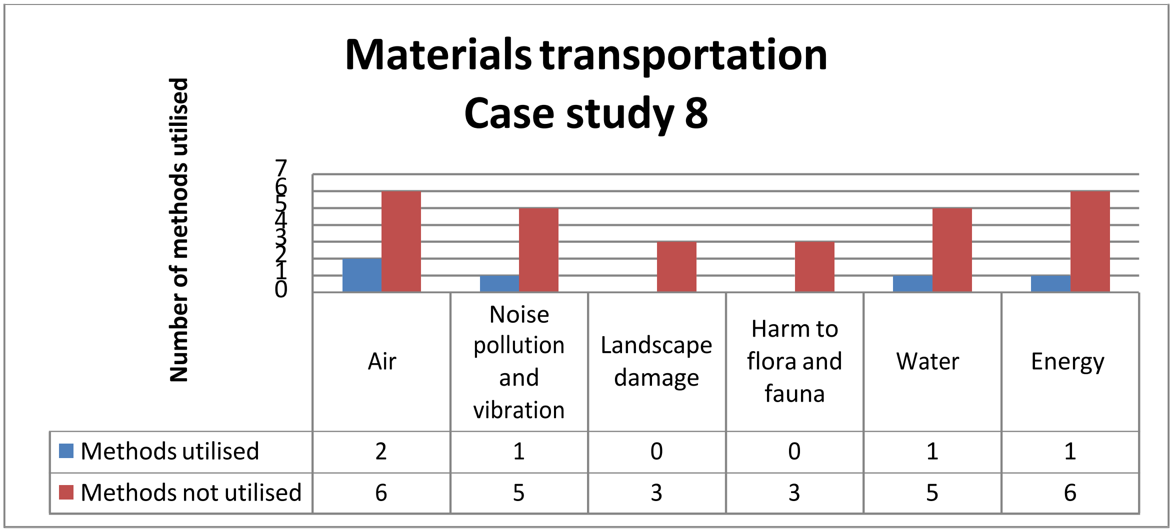


Figure 6.92: Methods utilised to mitigate the impact of material transportation in Case study 8

Figure 6.92 illustrates that the company utilises few methods to mitigate the impact of materials transportation regarding air (selection of suitable routes and transport pooling/ limiting hauling), noise pollution and vibration (transport pooling/ limiting hauling), water (proper training of drivers) and energy (educating employees regarding plant and equipment idling). None of the proposed methods were utilised to mitigate the impact of material transportation regarding landscape damage (educating employees regarding plant and equipment idling, use of alternative routes and educating employees regarding plant and equipment idling) and harm to flora and fauna (wetting of soil, covering of transported materials and buffer strips) in case study 8.

6.9.3 Material production for Case study 8

After the timber logs transported arrive the saw mill, they are stalked in the air to season. At the production stage of timber logs, debarking and sawing are carried out.

(a) Debarking process (b) Sawing process

Figure 6.93: Material production process for Case study 8

6.9.3.1 The impact of material production on the environment in Case study 8

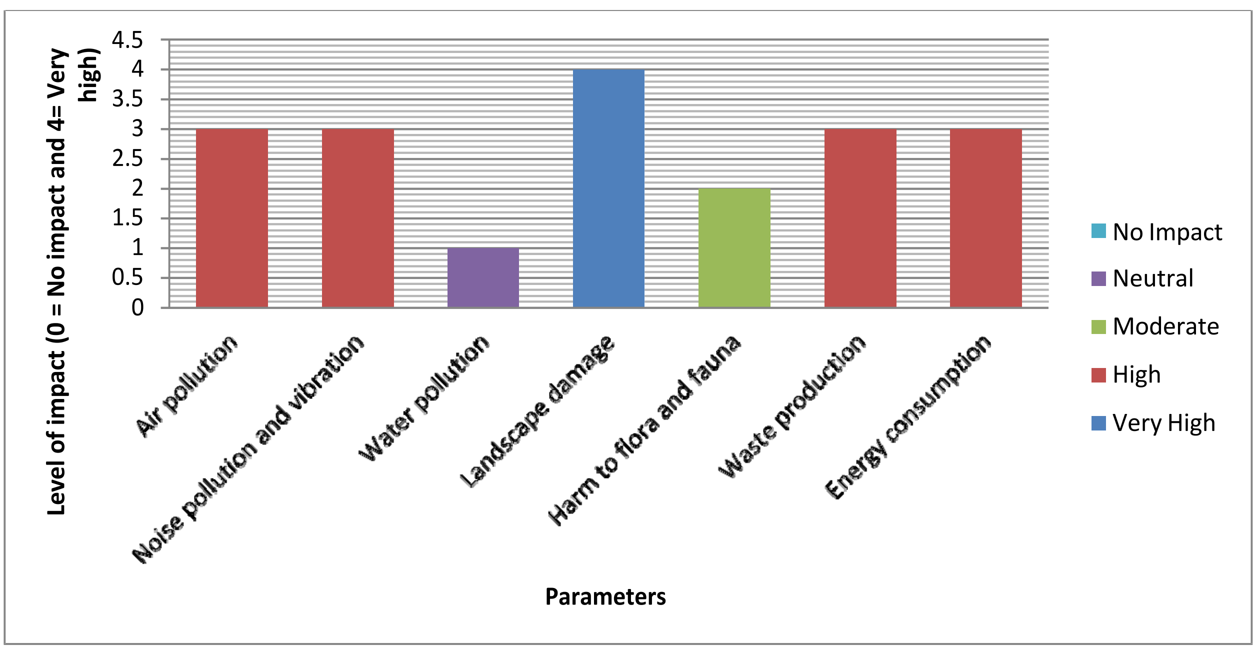
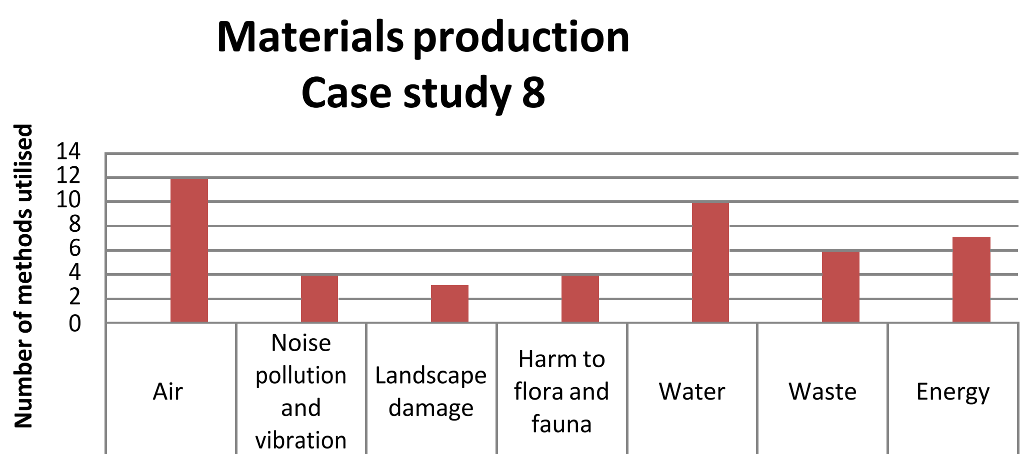


Figure 6.94: The impact of material production on the environment (Case study 8)

From Figure 6.94, air pollution, noise pollution and vibration, waste production and energy consumption have high (3) impact ratings on the environment during the production of materials. Then follows water pollution with a neutral (1) impact. Landscape damage follows with a very high (4) impact. Harm to flora and fauna comes next with a moderate (2) impact rating.

6.9.3.2 Methods utilised to mitigate the impact of material production in Case study 8



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	0	1	0	0	0	1	1
Methods not utilised	12	4	3	4	10	6	7

Figure 6.95: Methods utilised to mitigate the impact of material production in Case study 8

Figure 6.95 shows that the company in case study 8 utilises a few methods to mitigate the impact of material production regarding noise pollution and vibration (maintenance of plant and equipment), waste (re-use of fine grained solid rejects for further production) and energy (educating employees regarding plant and equipment idling and turning off lights). None of the proposed methods were utilised regarding air (using water-cooled tools, continuous sampling to eliminate equipment leaks, initial and periodic compliance testing of pollutants emitted from production process, continuous monitoring and recording of emissions, procurement of plant and equipment with less emission, use of surfactants, mechanical ventilation, use of dust suppressants, maintenance of plant and equipment, use of high temperature filters within gasification process, increasing distance from nearest building and use of bag houses), landscape damage (enclosure of fuel and chemical, better design and planning and re-contouring of slopes), harm to flora and fauna (application of fertilizer, lime, tillage and re-vegetation, addition of buffering agents to mitigate acidic seeps from mining, top soil substitution and continuous monitoring to maintain pH levels), and water (recycling of water, buffer strips, collection and treatment of waste water, protection plan, management of surface water, control of site drainage, use of leak detection systems, better design, collection in sumps and use of reclaimed effluent and other recycled water for cooling).

6.9.4 Sustainability report for Case study 8

Case study 8 does not have any sustainability reports that state their commitment to sustainability as a result of their operation.

6.10 Case study 9 - Brick factory

The company is situated in the North-central geopolitical zone of Nigeria. It produces burnt red bricks and clay pots, with a plan of going into the production of clay roofing sheets. The company remains among the few currently producing clay products in Nigeria, with products such as sun breakers, facing slips and decking pots.

Figure 6.96: Factory view in Case study 9

6.10.1 Material sourcing for Case study 9

The raw material is clay; and it is mostly located around the company. Material sourcing is usually carried out during the dry season with an excavator and bulldozer. Materials are sourced between 8 am to 5pm.

6.10.1.1 Impact of material sourcing on the environment in Case study 9

The study observed the impact of the material-sourcing process in case study 9 for clay as follows.

Landscape damage

Figure 6.97: The impact of material sourcing on the environment in Case study 9

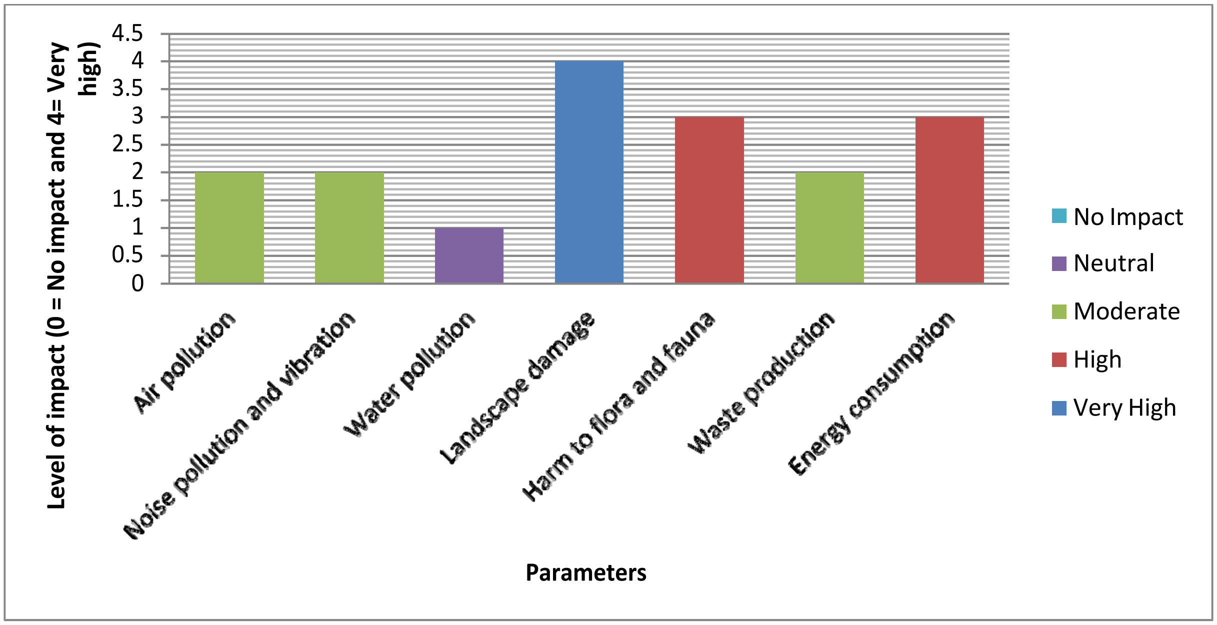
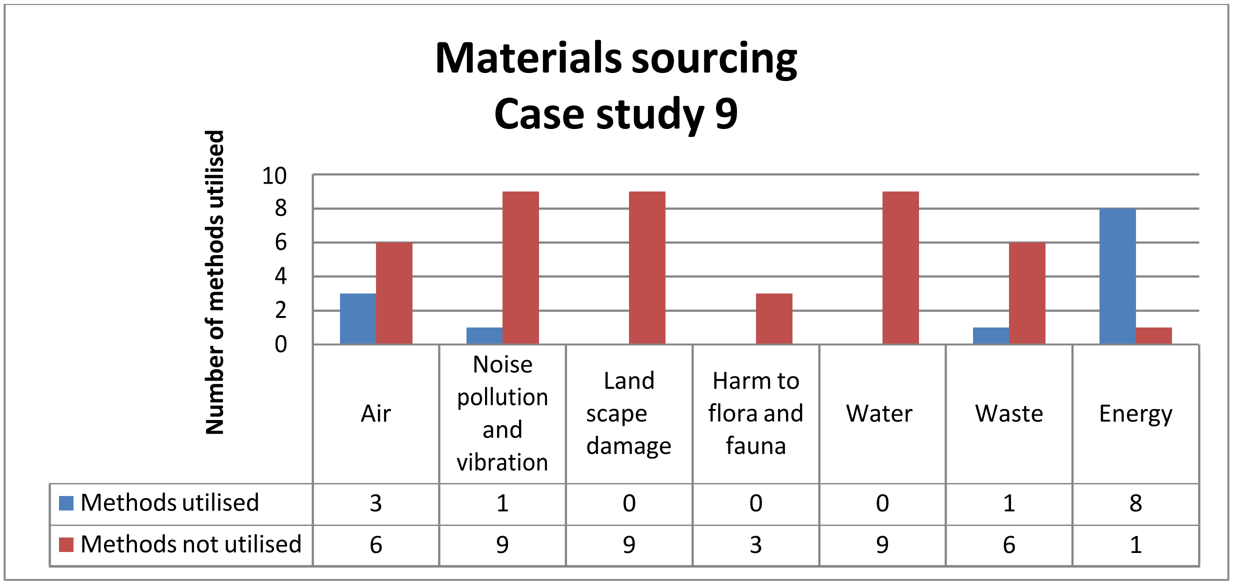


Figure 6.98: Impact of material sourcing on the environment (Case study 9)

From Figure 6.98, it can be seen that air pollution, noise pollution and vibration have a moderate impact on the environment during the sourcing of materials. Next to this is water pollution with a neutral impact. Landscape damage follows with a very high (4) impact rating. Harm to flora and fauna and energy consumption come next with a high (3) impact.

6.10.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 9



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	3	1	0	0	0	1	8
Methods not utilised	6	9	9	3	9	6	1

Figure 6.99: Methods utilised to mitigate the impact of material sourcing in Case study 9

Figure 6.99 shows that the company in case study 9 utilised only a few methods in mitigating the impact of materials sourcing regarding air (minimise operations during windy periods, increasing distance from nearest building and maintenance of plant and equipment), noise pollution and vibration (maintenance of plant and equipment) and waste (recycling of waste). None of the proposed methods were utilised regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill), harm to flora and fauna (continuous monitoring to maintain pH levels, replacement with saplings and addition of buffering agents to mitigate acidic seepage from mining), and water (recycling of water, collection and treatment of waste water, protection plan, management of surface water, design of mining approaches that exclude water, use of leak detection systems, monitoring of ground water, contingency planning and buffer strips). Eight methods (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, regular energy audits and maintenance, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts and transport pooling/ limiting hauling) were utilised to mitigate the impact of material sourcing regarding energy.

6.10.2 Raw material transportation for Case study 9

The extracted clay was transported with tippers to the production plant

Figure 6.100: Material transportation and off-loading process for Case study 9

6.10.2.1 Impact of material transportation on the environment for Case study 9

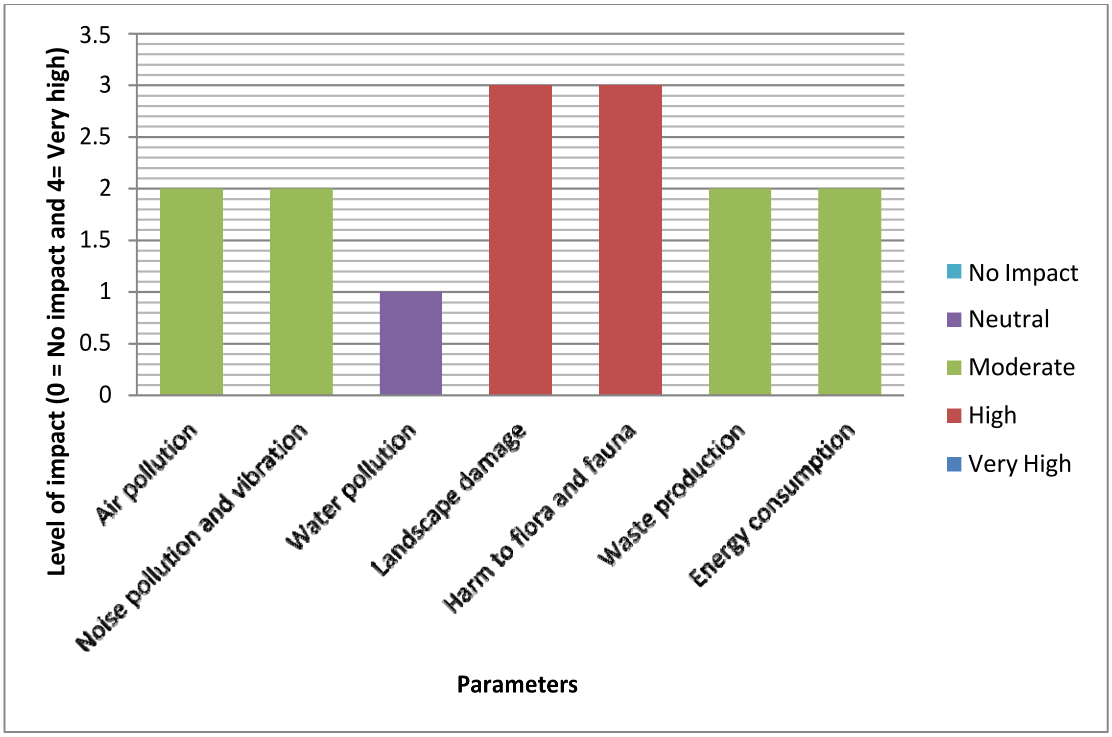


Figure 6.101: Impact of material transportation on the environment (Case study 9)

From Figure 6.101, air pollution, noise pollution and vibration, waste production and energy consumption have moderate (2) impact ratings during the transportation of materials. Then follows water pollution with a neutral (1) impact. Landscape damage, and harm to the flora and fauna follow, with high (3) impact ratings.

6.10.2.2 Methods utilised to mitigate the impact of material transportation in Case study 9

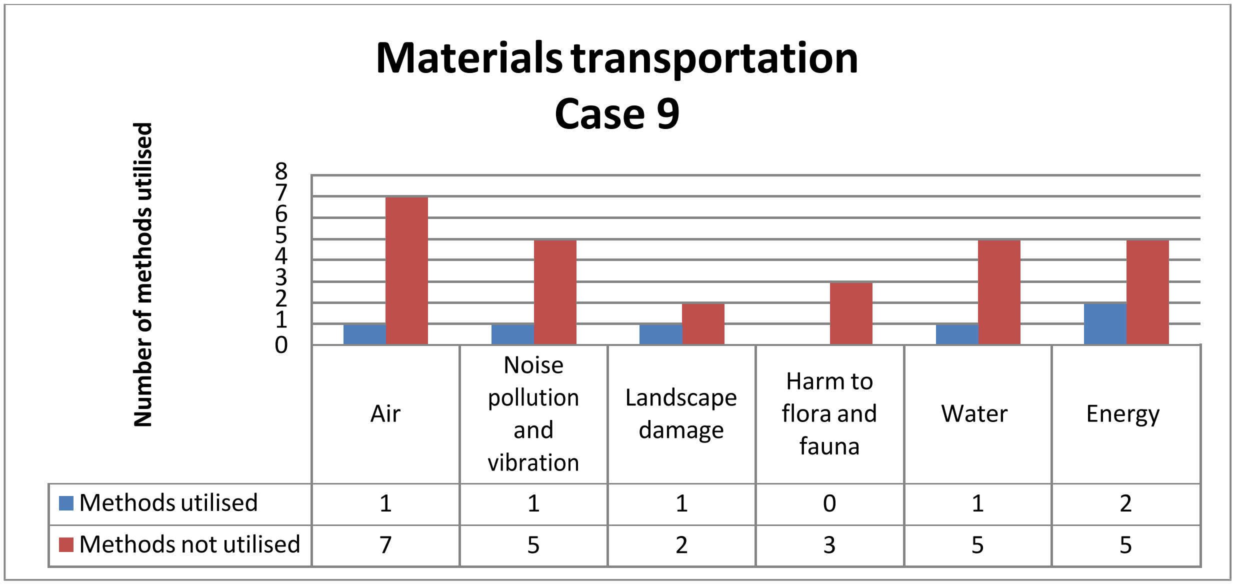


Figure 6.102: Methods utilised to mitigate the impact of material transportation in Case study 9

Figure 6.102 shows that the organization utilised only a few methods to mitigate the impact of material transportation on air (selection of suitable routes), noise pollution and vibration (selection of suitable routes), landscape damage (use of alternative routes), water (proper training of drivers) and energy (optimising pit and mine design and reducing fuel spills). None of the proposed methods was utilised regarding mitigating harm to flora and fauna (covering of transported materials, buffer strips and wetting of soil).

6.10.3 Material production for Case study 9

Raw material-mixing process

Drying process before firing

Figure 6.103: Materials production process for Case study 9

6.10.3.1 The impact of raw material transportation on the environment in Case study 9

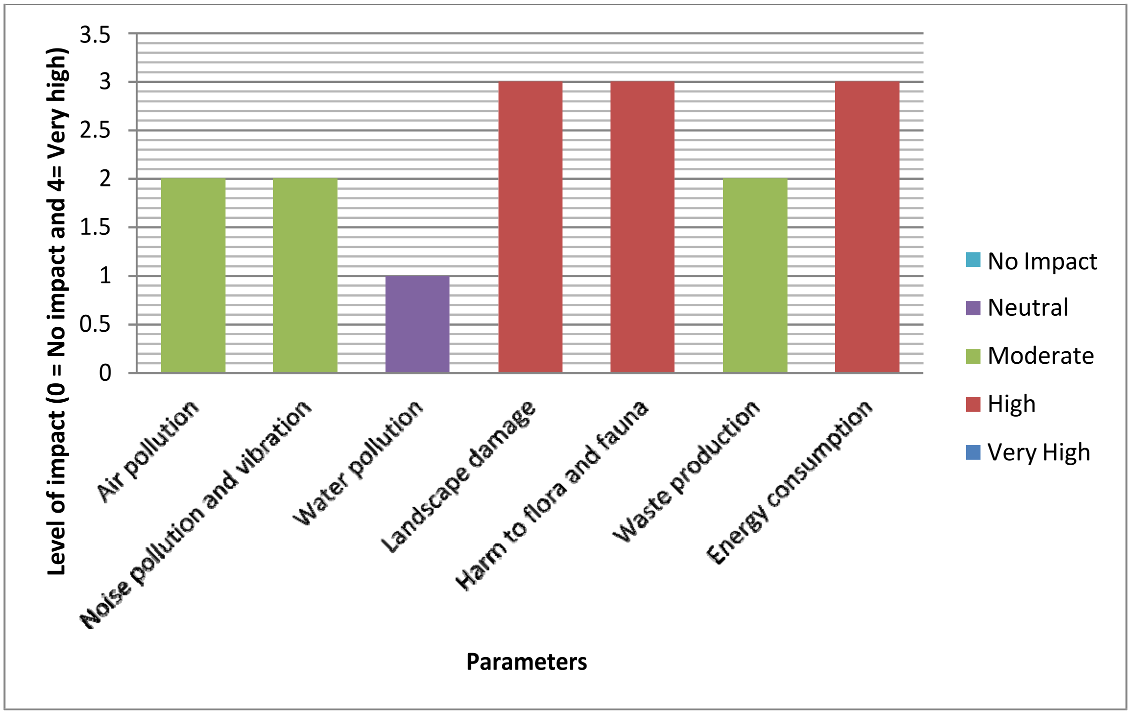
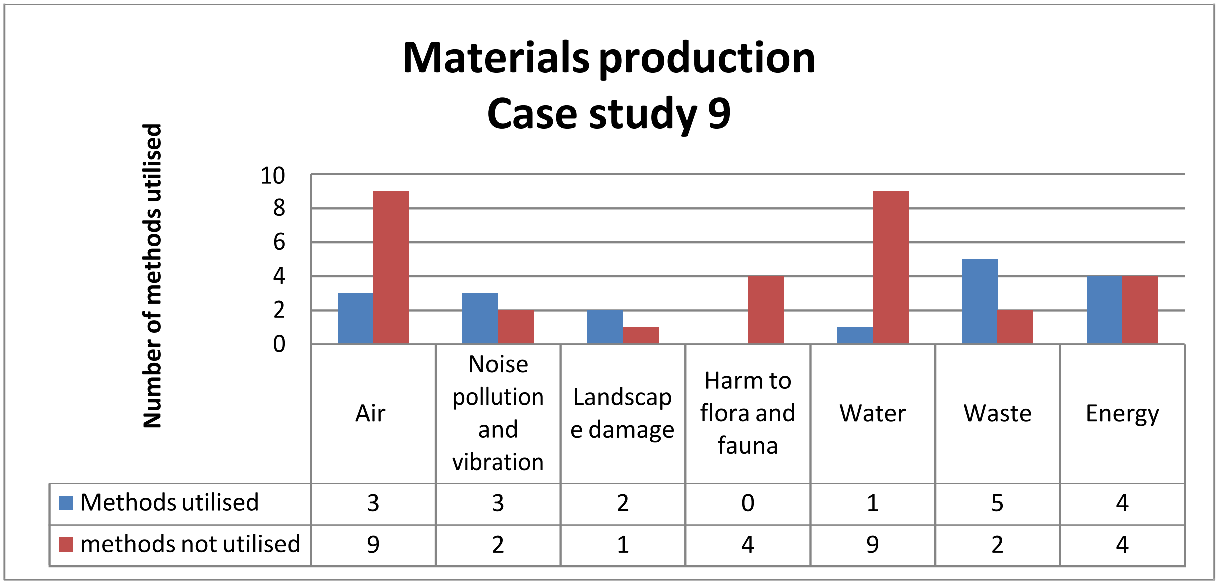


Figure 6.104: Impact of material production on the environment (Case study 9)

From Figure 6.104, it can be observed that air pollution, noise pollution and vibration and waste production have a moderate (2) impact rating during the production of materials. Next to these is water pollution with a neutral impact. Landscape damage, harm to flora and fauna and energy consumption follow with high (3) impact ratings.

6.10.3.2 Methods utilised to mitigate the impact of material production in Case study 9



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	3	3	2	0	1	5	4
methods not utilised	9	2	1	4	9	2	4

Figure 5.105: Methods utilised to mitigate the impact of material production in Case study 9

Figure 6.105, shows that the company in case study 9 utilised only a few methods to mitigate the impact of materials production regarding air (increasing distance from nearest building, maintenance of plant and equipment and mechanical ventilation) and water (control of site drainage). Three methods were utilised regarding noise pollution and vibration (limiting working time to normal working hours, construction of barrier walls and maintenance of plant and equipment) ; and two methods were utilised regarding landscape damage (addition of buffering agents to mitigate acidic seeps from mining and top soil substitution); four methods were utilised regarding energy (implementation of energy saving/ conservation measures for plant and equipment e.g catalysts, regular energy audits and maintenance, reducing fuel spills and educating employees regarding plant and equipment idling and turning off lights); and five methods (re-crushing to form aggregate, segregation of fine grained solid rejects, re-use of fine grained solid rejects for further production, treatment of solid reject and use of innovative cutting tools) were utilised regarding waste. None of the proposed methods (continuous monitoring to maintain pH levels, top soil substitution and addition of buffering agents to mitigate acidic seeps from mining and application of fertilizer, lime, tillage and re-vegetation) were utilised regarding harm to flora and fauna.

6.10.4 Sustainability report for Case study 9

It was observed that the organisation in case study 9 does not have sustainability reports to account for its stewardship on the various impact its operation has on the environment.

6.11 Case study 10 - Brick factory

Case study 10 is located in the South-West geopolitical zone in Nigeria. The company started operation in 1980; and it is now owned by two shareholders. Case study 10 currently produces about 20 million units per annum of fired clay brick of load bearing, sun breakers, decking pots and facing slips.

Figure 6.106: Factory view of Case study 10

6.11.1 Material sourcing for Case study 10

Clay materials are readily available around the company in case study 10. Excavators and bulldozers are used to source the raw materials for clay products during the dry season. Material sourcing is done from 8.am - 4pm. The sourcing processes are illustrated in Figure 6.107.

Extraction processes

Figure 6.107: Material sourcing

5.11.1.1 The impact of material-sourcing on the environment for Case study 10

(a) Harm to flora and fauna (b) Landscape destruction

Figure 6.108: The Impact of material sourcing on the environment

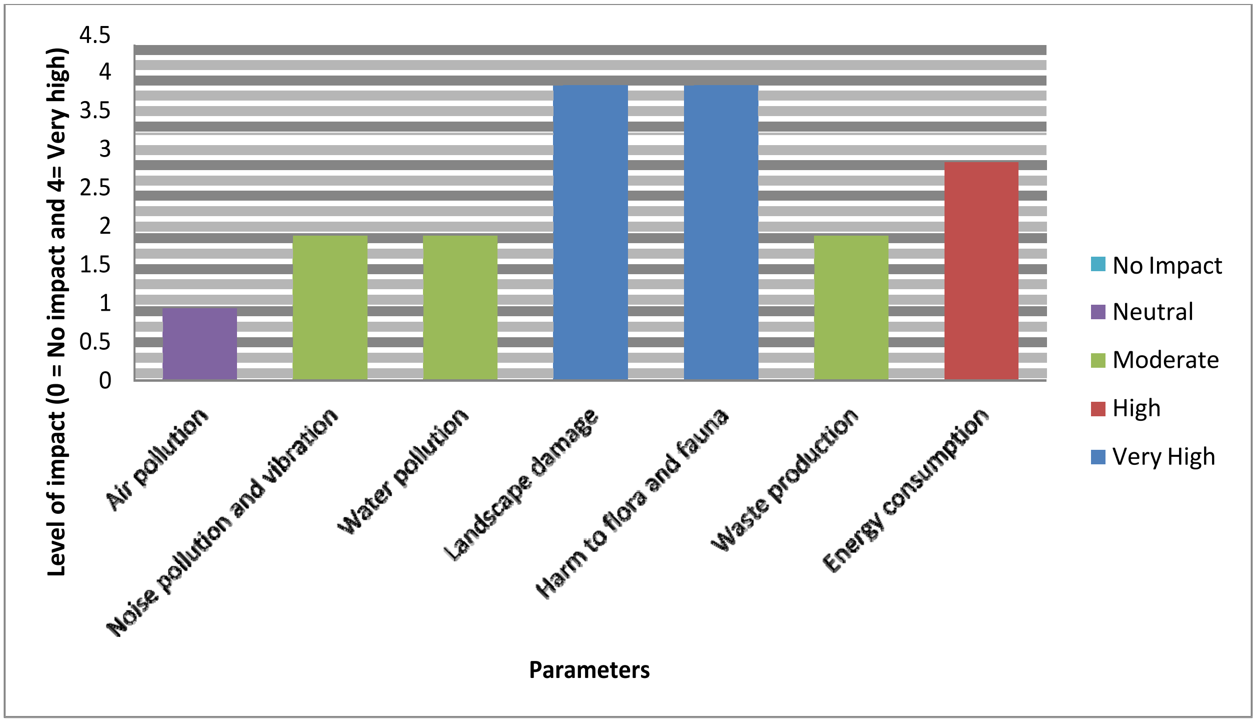
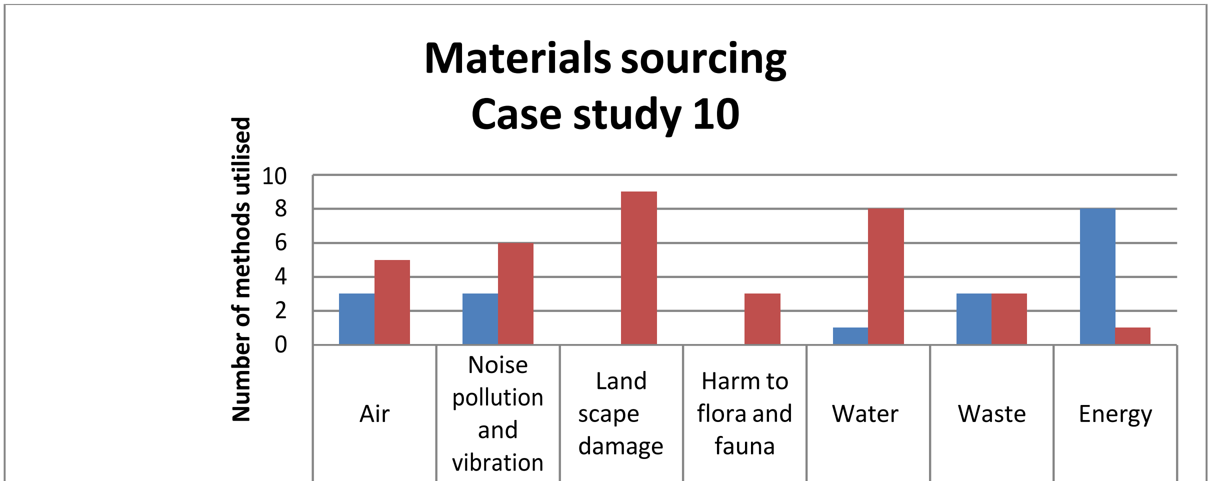


Figure 6.109: Impact of material sourcing on the environment (Case study 10)

From Figure 6.109, air pollution, it can be observed that have neutral (1) impact rating on the environment during sourcing of materials. Next to these are noise pollution and vibration, water pollution and waste production with moderate impact. Landscape damage; and harm to flora and fauna follow with very high (4) impact rating. Energy consumption comes next with high (3) impact.

6.11.1.2 Methods utilised to mitigate material sourcing impact in Case study 10



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	3	3	0	0	1	3	8
Methods not utilised	5	6	9	3	8	3	1

Figure 6.110: Methods utilised to mitigate material sourcing impact in Case study 10

Figure 6.110 shows that the company in case study 10 utilised a few methods regarding air (minimise operations during windy periods, increasing distance from nearest building and maintenance of plant and equipment) and water (design of mining approaches that exclude water). Three methods each were utilised, regarding noise pollution and vibration (maintenance of plant and equipment, limiting working time to day light hours, and use of modern equipment) and waste (use of modern plant and equipment for sourcing/ extraction, training of employees and recycling of waste). None of the proposed methods were utilised regarding harm to flora and fauna (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels) and landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill). Eight methods (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, regular energy audits and maintenance, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts and transport pooling/ limiting hauling) were utilised to mitigate the impact of materials regarding energy.

6.11.2.1 Material transportation in Case study 10

(a) Trucks loading materials (b) Bulldozer moving materials

Figure 6.111: Material-transportation process in Case study 10

6.11.2.2 Impact of material transportation on the environment for Case study 10

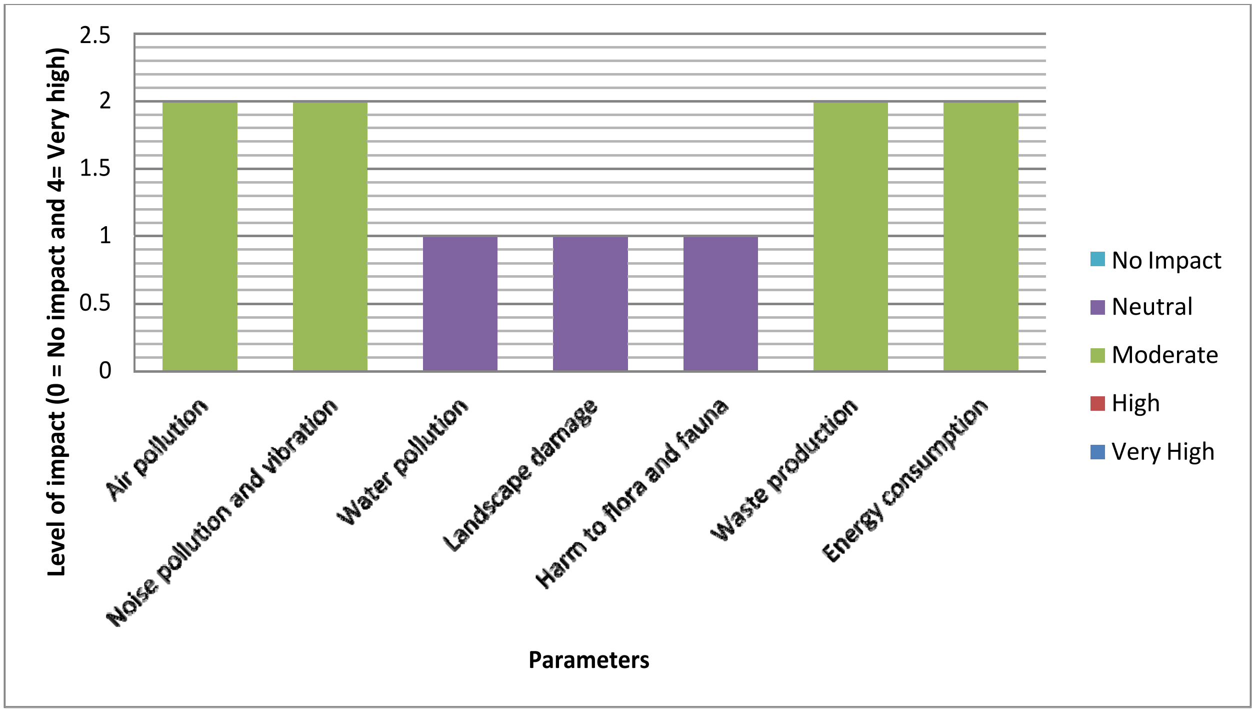
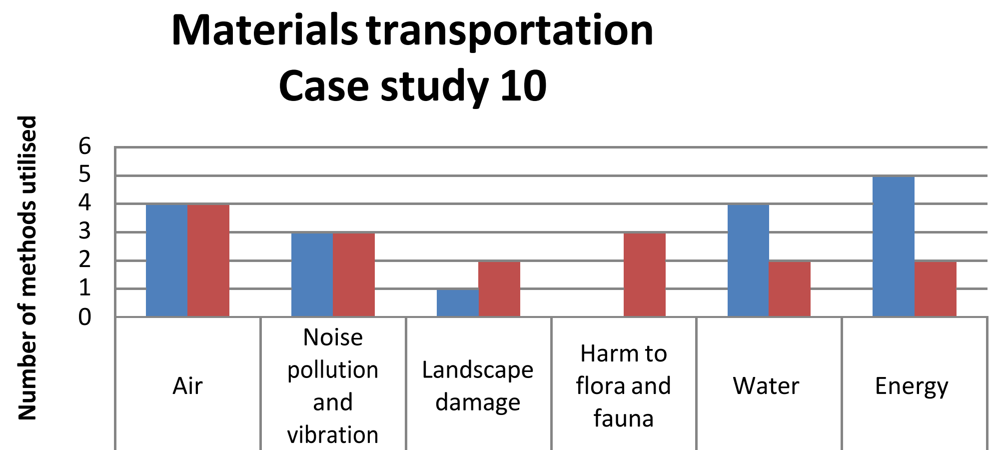


Figure 6.112: Impact of material transportation on the environment (Case study 10)

From Figure 6.112, it can be observed that air pollution, noise pollution and vibration, waste production; and energy consumption have moderate (2) impact ratings on the environment during the transportation of materials. Water pollution, landscape damage; and harm to flora and fauna follow closely with a neutral (1) impact.

6.11.2.2 Methods utilised to mitigate the impact of material transportation in Case study 10



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Energy
Methods utilised	4	3	1	0	4	5
Methods not utilised	4	3	2	3	2	2

Figure 6.113: Methods utilised to mitigate the impact of material transportation in Case study 10

Figure 6.113 illustrates that the company in case study 10 utilised many methods to mitigate the impact of materials transportation on air (transport pooling/ limiting hauling ,procurement of plant and equipment with less emission, maintenance of plant and equipment and selection of suitable routes) noise pollution and vibration (transport pooling/ limiting hauling, selection of suitable routes and maintenance of plant and equipment), water (selection of suitable routes, proper training of drivers, procurement of plant and equipment with less emission and reducing fuel spills) and energy (educating employees regarding plant and equipment idling, use of modern plant and equipment for loading and transportation, optimising pit and mine design, regular energy audits and maintenance and transport pooling/ limiting hauling). One method each was utilised to mitigate the impact of materials transportation in case study 10 regarding landscape damage (use of alternative routes). Four methods (transport pooling/ limiting hauling, selection of suitable routes, maintenance of plant and equipment and procurement of plant and equipment with less emission) were utilised regarding air.

None of the proposed methods (wetting of soil, covering of transported materials and buffer strips) were utilised regarding harm to flora and fauna.

6.11.3 Material production for Case study 10

Raw materials mixing

(a) Brick-cutting process (b) Drying process before firing

Figure 6.114: Material-production process for Case study 10

6.11.3.1 Impact of material production on the environment for Case study 10

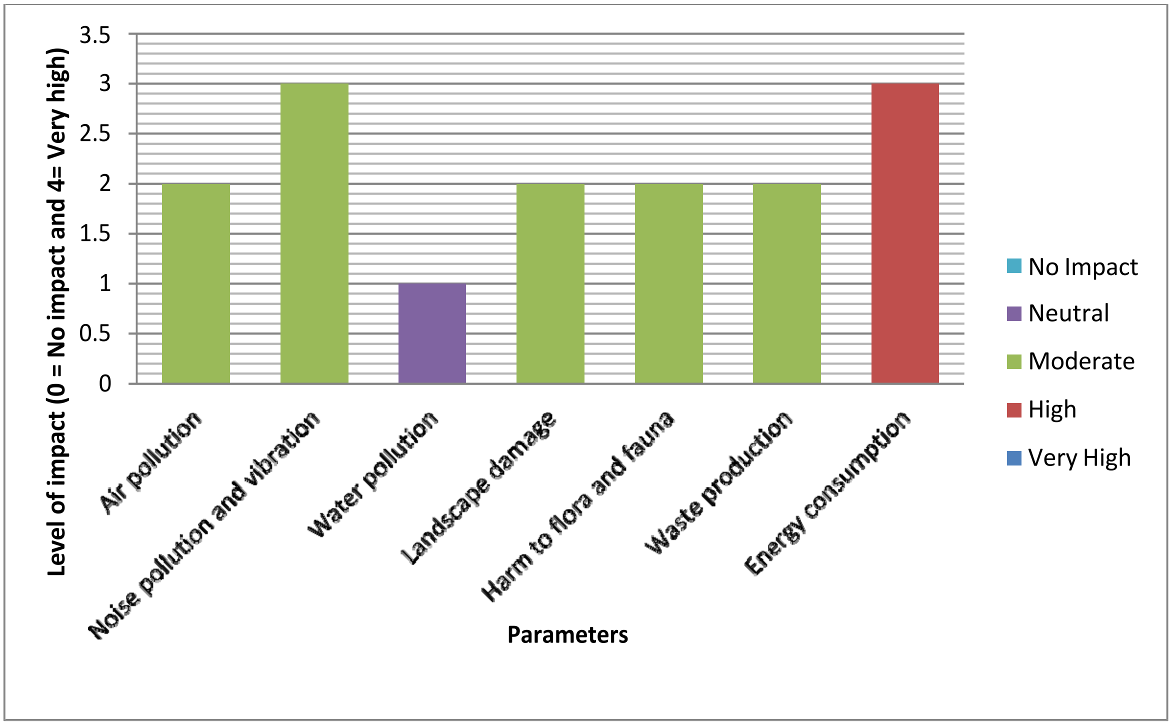
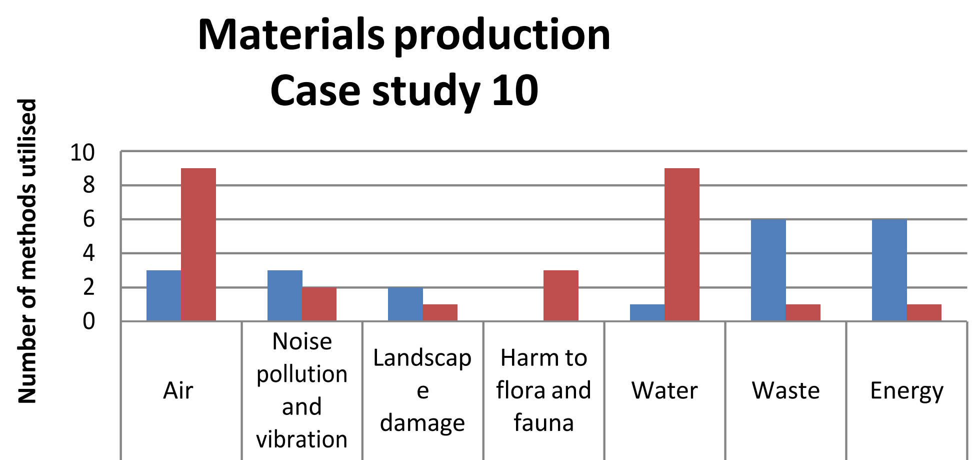


Figure 6.115: The impact of material production on the environment (Case study 10)

From Figure 5.115, it can be seen that air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna, water pollution and waste production have moderate (2) impact ratings on the environment during the production of materials. Next to this is water pollution with a neutral (1) impact and energy consumption with a high (3) impact rating.

6.11.3.2 Efforts adopted to mitigate the impact of material production in Case study 10



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	3	3	2	0	1	6	6
Methods not utilised	9	2	1	3	9	1	1

Figure 6.116: Methods utilised to mitigate the impact of material production in Case study 10

Figure 6.116 shows that the company in case study 10 utilised a few methods to mitigate the impact of material production regarding air (increasing distance from nearest building, maintenance of plant and equipment and procurement of plant and equipment with less emission) and water (recycling of water). Three methods were utilised regarding noise pollution and vibration (limiting working time to normal working hours, use of modern equipment and maintenance of plant and equipment), one method was utilised regarding the landscape (enclosure of fuel and chemical), six methods were utilised regarding waste (re-crushing to form aggregate, segregation of fine grained solid rejects, re-use of fine grained solid rejects for further production, treatment of solid reject, use of modern plant and equipment and use of innovative cutting tools); and six methods (implementation of energy saving/ conservation measures for plant and equipment e.g catalysts, regular energy audits and maintenance, reducing fuel spills, minimisation of non- utilised power, educating employees regarding plant and equipment idling and turning off lights and installation of more efficient lighting) were utilised regarding energy. None of the proposed methods (continuous monitoring to maintain pH levels, top soil substitution, addition of buffering agents to mitigate acidic seeps from mining and application of fertilizer, lime, tillage and re-vegetation) were utilised to mitigate the impact of material production regarding harm to flora and fauna.

6.11.4 Sustainability report for Case study 10

Case study 10 does not have any sustainability reports on the various impacts their activities have on the environment.

6.12 Case study 11 - Aggregates production

Case study 11 is located in the federal capital territory authority in Nigeria. The company produces coarse aggregate of different sizes for various construction projects.

Figure 6.117 Site view of Case study 11

6.12.1 Material sourcing for Case study 11

Large rock formations are readily available around case study 11 for the production of coarse aggregate. A drilling machine, excavator and bulldozer are used in the sourcing process. Material sourcing is done from 8.am to 4pm.

6.12.1.1 Impact of material sourcing on the environment for Case study 11

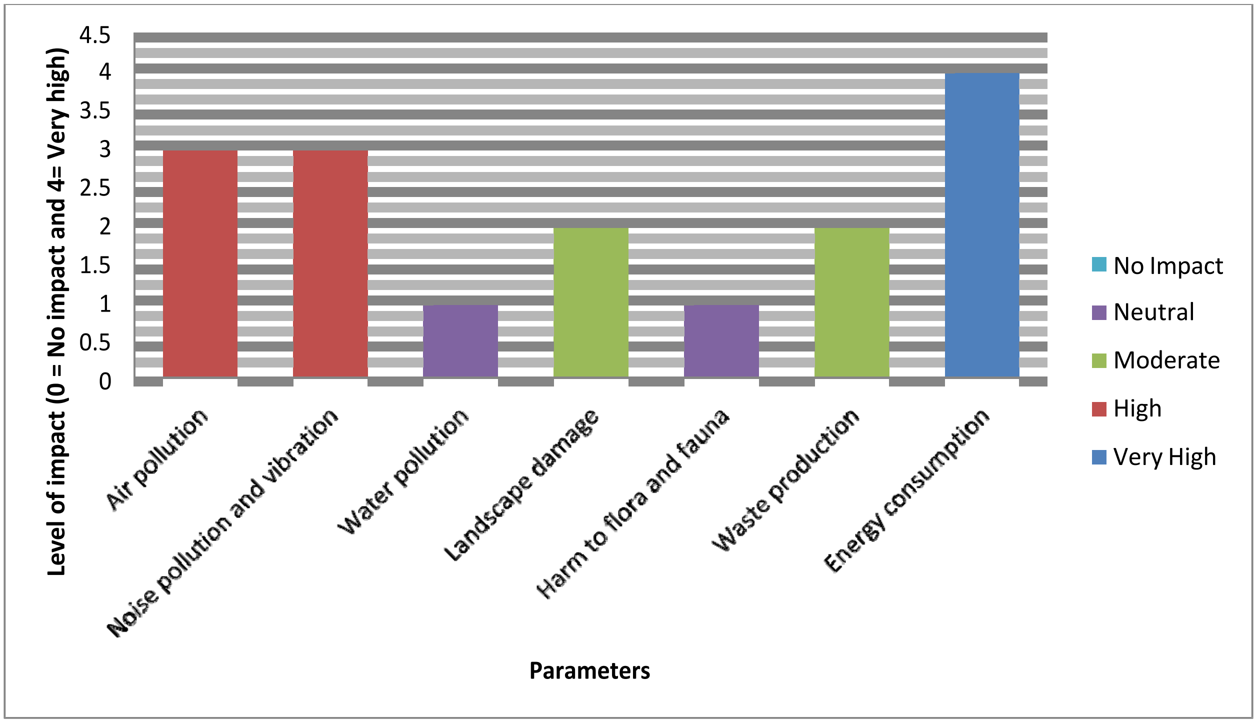


Figure 6.118: The impact of material sourcing on the environment (Case study 11)

From Figure 6.118, it can be seen that air pollution and noise pollution and vibration have high (3) impact ratings on the environment during the sourcing of materials. Next to these are water pollution and harm to flora and fauna with neutral (1) impacts. Landscape damage and waste production follow with moderate (2) impact ratings; and energy consumption comes with a very high impact.

6.12.1.2Methods utilised to mitigate the impact of material sourcing in Case study 11

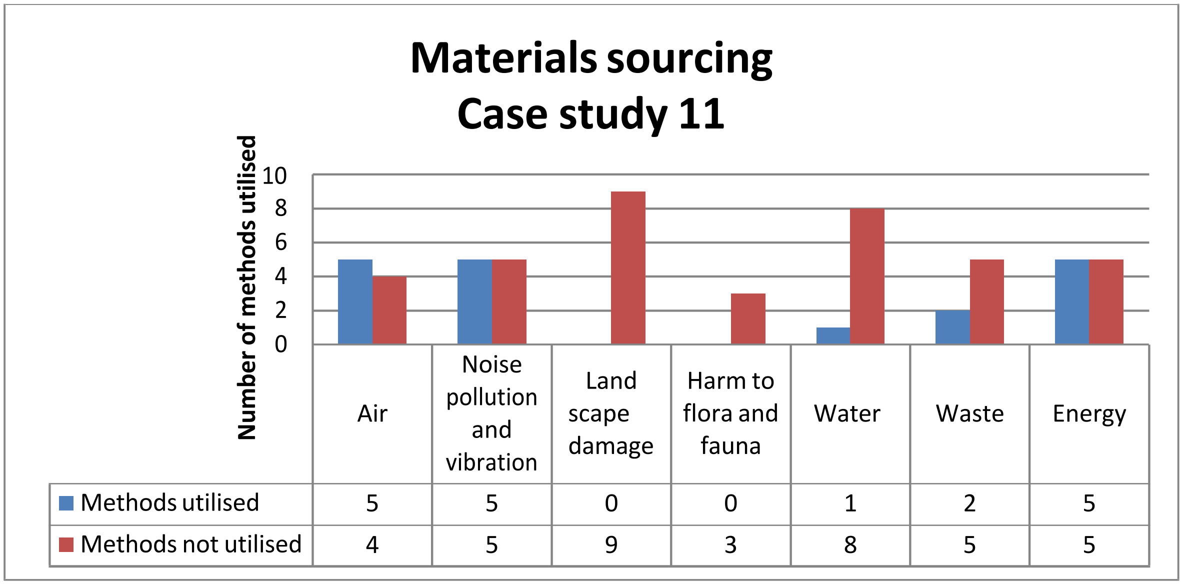


Figure 6.119: Methods utilised to mitigate the impact of material sourcing in Case study 11

Figure 6.119 shows that the company in case study 11 utilised five methods each to mitigate the impact of material sourcing regarding air (minimise operations during windy periods, increasing distance from nearest building, maintenance of plant and equipment, wet of suppression and tapping of drilled holes before blasting), noise pollution and vibration (maintenance of plant and equipment, early public notification of extremely noisy operation, limiting working time to day light hours, use of modern equipment and use of bed of debris to absorb most of the impact energy) and energy (altering processing parameter e.g. belt speed, transport pooling/ limiting hauling, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts, reducing fuel spills and minimisation of non- utilized power and educating employees regarding plant and equipment idling). A few methods were utilised regarding water (management of surface water) and waste (installation of a mobile crushing/ grinder- pulverisation unit at quarry site and training of employees). None of the proposed methods were utilised regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill) and harm to flora and fauna (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels).

6.12.2 Raw material transportation for Case study 11

Trucks transporting materials

Figure 6.120: Materials transportation process in Case study 11

6.12.2.1 Impact of material transportation on the environment in Case study 11

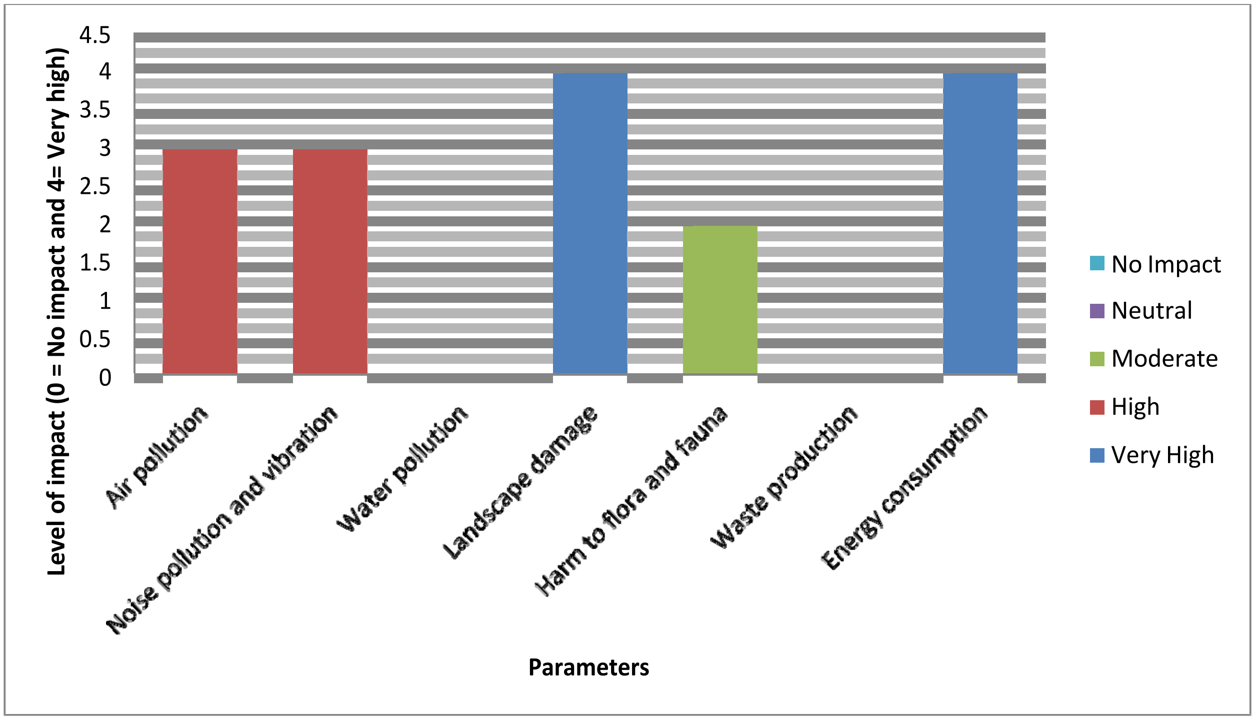


Figure 6.121: The impact of material transportation on the environment (Case study 11)

From Figure 6.121, it may be observed that air pollution, waste pollution and noise pollution and vibration have high (3) impact ratings on the environment during material transportation. Next to these are water pollution and waste production, with no impact (0). Landscape damage and energy consumption follow with very high impact ratings.

6.12.2.2 Methods utilised to mitigate the impact of material transportation in Case study 11

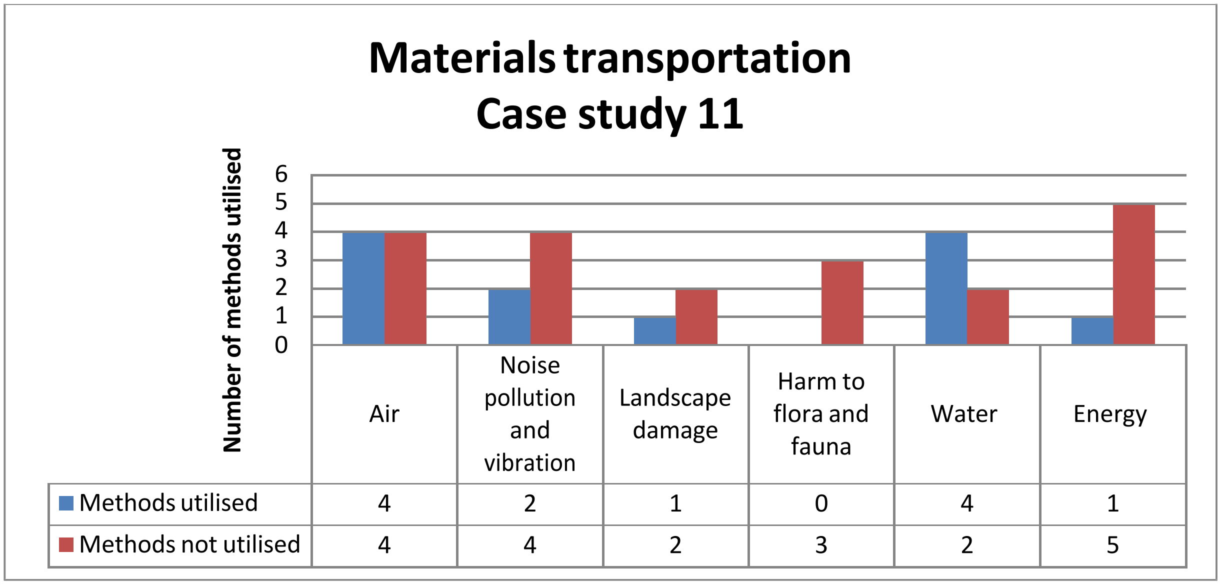


Figure 6.122: Methods utilised to mitigate the impact of material transportation in Case study 11

Figure 6.122 shows that the company utilised five methods regarding air (transport pooling/ limiting hauling, selection of suitable routes, maintenance of plant and equipment and procurement of plant and equipment with less emission); four methods (selection of suitable routes, proper training of drivers, procurement of plant and equipment with less emission and reducing fuel spills) regarding water, to mitigate the impact of material production. Few methods were utilised regarding noise pollution and vibration (transport pooling/ limiting hauling and maintenance of plant and equipment), landscape damage (use of alternative routes); and energy. None of the proposed methods were utilised regarding harm to flora and fauna (buffer strips, covering of transported materials and wetting of soil).

6.12.4 Material production for Case study 11

Stone-crushing process

Figure 6.123 Material production process for Case study 11

6.12.3.1 Impact of material production on the environment in Case study 11

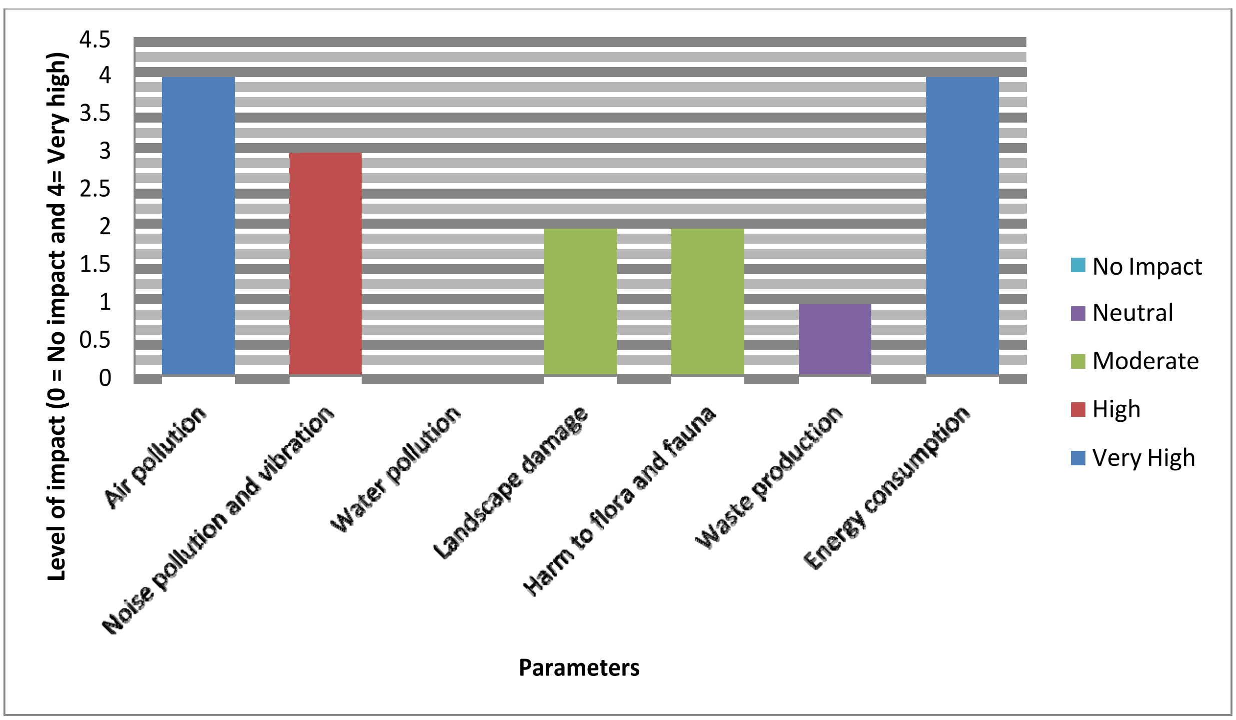


Figure 6.124: Impact of material production on the environment (Case study 11)

From Figure 6.124, air pollution and energy consumption have very high (4) impact ratings on the environment during the production of materials. Next to these is noise pollution and vibration, both with a high (3) impact. Water pollution follows with no impact (0). Landscape damage and harm to flora and fauna follow, with moderate (2) impact ratings; and waste production comes next with a neutral (1) impact rating.

6.12.3.2 Methods utilised to mitigate the impact of material production in Case study 11

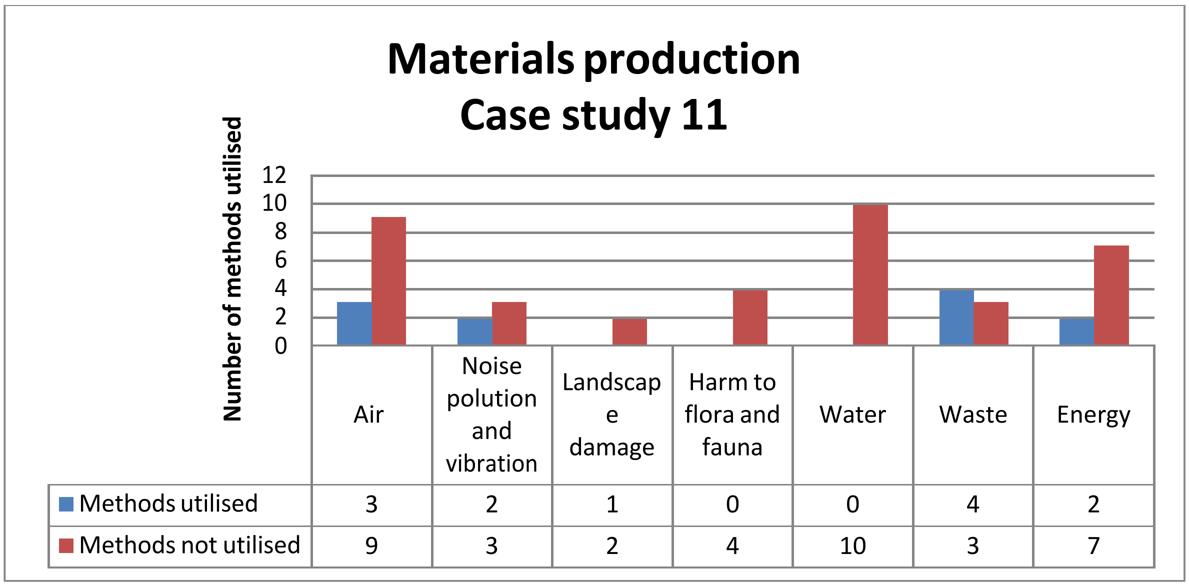


Figure 6.125: Methods utilised to mitigate the impact of material production in Case study 11

Figure 6.125 shows that the company in case study 11 utilised a few methods to mitigate the impact of material production regarding air (increasing distance from nearest building, maintenance of plant and equipment and procurement of plant and equipment with less emission), noise pollution and vibration (maintenance of plant and equipment and limiting working time to normal working hours), landscape damage (enclosure of fuel and chemical) and energy (minimisation of non- utilised power and reducing fuel spills). None of the proposed methods were utilised to mitigate the impacts arising from materials production the on harm to flora and fauna (application of fertilizer, lime, tillage and re-vegetation, addition of buffering agents to mitigate acidic seeps from mining, top soil substitution and continuous monitoring to maintain pH levels) and water (recycling of water, buffer strips, collection and treatment of waste water, protection plan, management of surface water, control of site drainage, use of leak detection systems, better design, collection in sumps and use of reclaimed effluent and other recycled water for cooling). Four methods (re-crushing to form aggregate, re-use of fine grained solid rejects for further production, use of modern plant and equipment and use of innovative cutting tools) were utilised regarding waste.

6.12.4 Sustainability report for Case study 11

No sustainability report is prepared and available for case study 11 to show their commitment to the environment.

6.13 Case study 12 - Aggregate production

Case study 12 is located in the North-West geopolitical zone in Nigeria. Case study 12 turns out coarse aggregate used during construction. The case 12 study employs around 310 workers.

Figure 6.126: Quarry view of Case study 12

5.13.1 Material sourcing for Case study 12

There exist abundant rock formations around case study 12 for crushing into various sizes where the use of a drilling machine, excavator and compressor are used in the sourcing process. Blasting is also carried out, in order to break the large rock mass into smaller sizes before crushing commences. The material-sourcing process is done from 8.am - 4pm. Aggregate sourcing processes are illustrated in figures 6.127.

Drilling and excavation process

Figure 6.127: Material sourcing

6.13.1.1 Impact of material sourcing on the environment in Case study 12

In the study, direct observation of the impact of materials sourcing process in case study 12 on coarse aggregate was carried out.

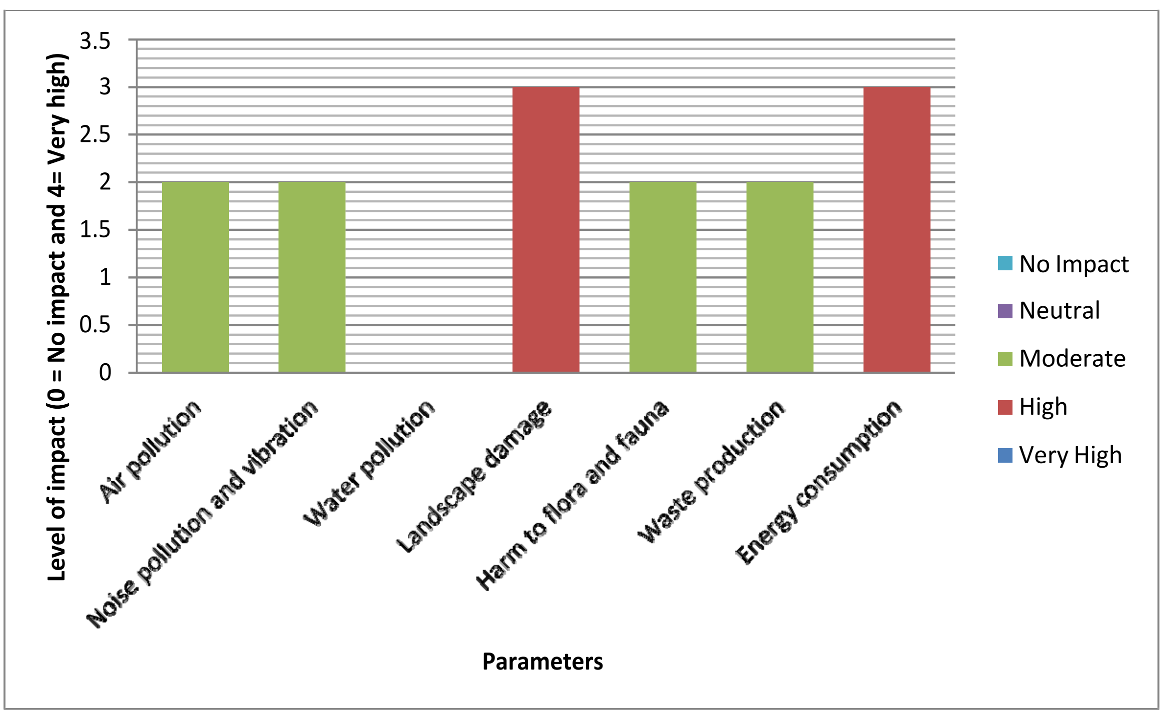


Figure 6.128: Impact of material sourcing on the environment (Case study 12)

From Figure 6.128, air pollution, noise pollution and vibration, harm to flora and fauna and waste production have a moderate (2) impact rating on the environment during the sourcing of the materials. Water pollution follows with no impact (0); and landscape damage and energy consumption come next with high (3) impact ratings.

6.13.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 12

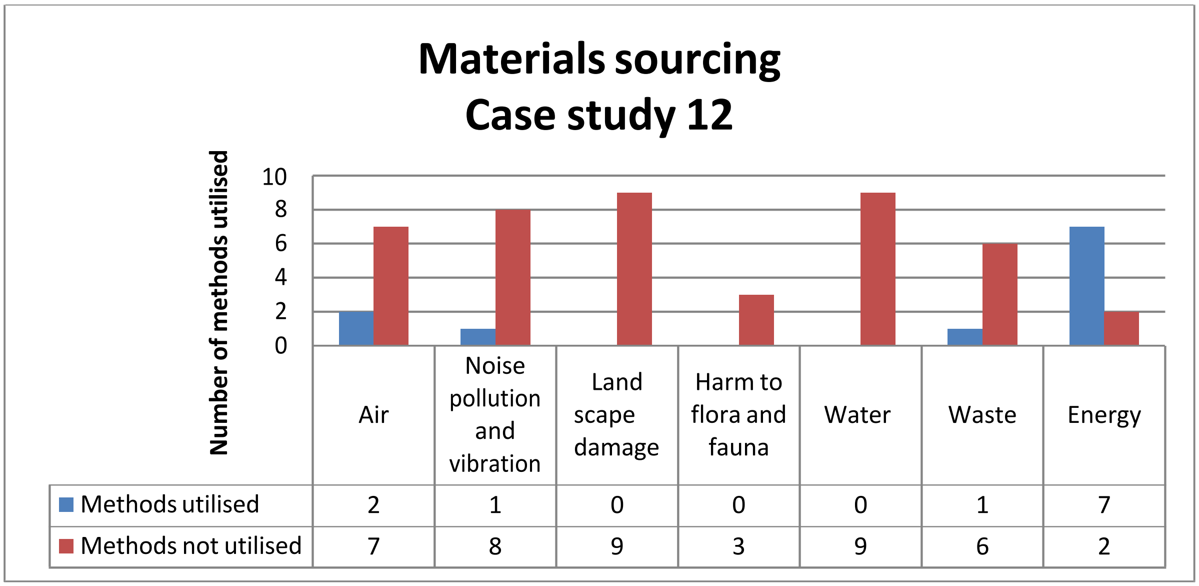


Figure 6.129: Methods utilised to mitigate the impact of material sourcing in Case study 12

Figure 6.129 shows that the company in case study 12 utilised a few methods to mitigate the impact of material sourcing regarding air (minimise operations during windy periods and tapping of drilled holes before blasting), noise pollution and vibration (limiting working time to day light hours); and waste (installation of a mobile crushing/ grinder- pulverisation unit at quarry site). None of the proposed methods was utilised to mitigate the impact of material sourcing regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill) and harm to flora (addition of buffering agents to mitigate acidic seepage from mining, replacement with saplings and continuous monitoring to maintain pH levels); and water (recycling of water, collection and treatment of waste water, protection plan, management of surface water, design of mining approaches that exclude water, use of leak detection systems, monitoring of ground water, contingency planning and buffer strips). Nine methods (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts and transport pooling/ limiting hauling) were utilised regarding energy.

6.13.2 Raw material transportation for Case study 12

Coarse aggregate materials are transported in tippers as shown in Figure 6.130.

Trucks transporting materials

Figure 6.130: Materials transportation process in Case study 12

6.13.2.1 The impact of raw material transportation on the environment for Case study 12

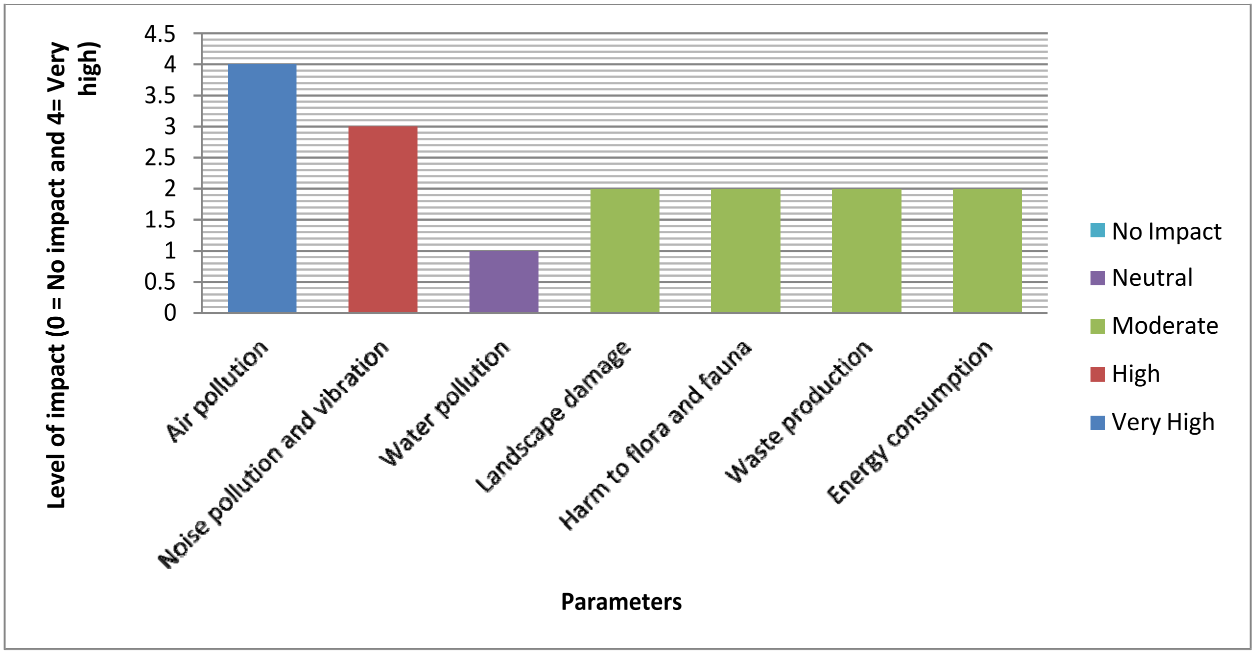
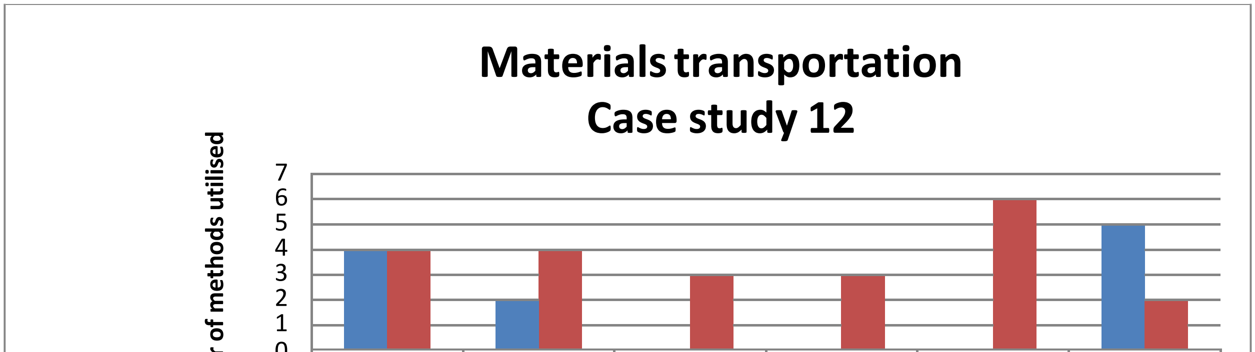


Figure 6.131: The impact of material transportation on the environment (Case study 12)

From Figure 6.131, it can be observed that air pollution has a very high (4) impact rating on the environment during the transportation of materials. Next to this is noise pollution and vibration, both with high (3) impacts. Water pollution comes thereafter with neutral (1) impact. Next to this are landscape damage, harm to flora and fauna, waste production and energy consumption with moderate (2) impact ratings.

6.13.2.2 Methods utilised to mitigate the impact of material transportation in Case study 12



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Energy
Methods utilised	4	2	0	0	0	5
Methods not utilised	4	4	3	3	6	2

Figure 6.132: Methods utilised to mitigate the impact of material transportation in Case study 12

As can be seen in Figure 6.132, the company utilised four methods regarding air (transport pooling/ limiting hauling, selection of suitable routes, maintenance of plant and equipment and procurement of plant and equipment with less emission), two methods regarding noise pollution and vibration (transport pooling/ limiting hauling and maintenance of plant and equipment); and five methods (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, optimising pit and mine design, regular energy audits and maintenance and transport pooling/ limiting hauling) were implemented regarding energy to mitigate the impact of material production. None of the proposed methods was utilised to mitigate the impact of material transportation regarding landscape damage (re-contouring of slopes, use of alternative routes and educating employees regarding plant and equipment idling), harm to flora and fauna (wetting of soil, covering of transported materials and buffer strips) and water (continuous motoring of ground water, reducing fuel spills, procurement of plant and equipment with less emission, covering of transported materials, proper training of drivers and selection of suitable routes).

6.13.3 Material production for Case study 12

The raw material from the blasting site is transported to the quarry plant; where it is crushed into various sizes and specifications.

Stone-crushing process

Figure 6.133: The material-production process for Case study 12

6.13.3.1 Impact of raw material production on the environment in Case study 11

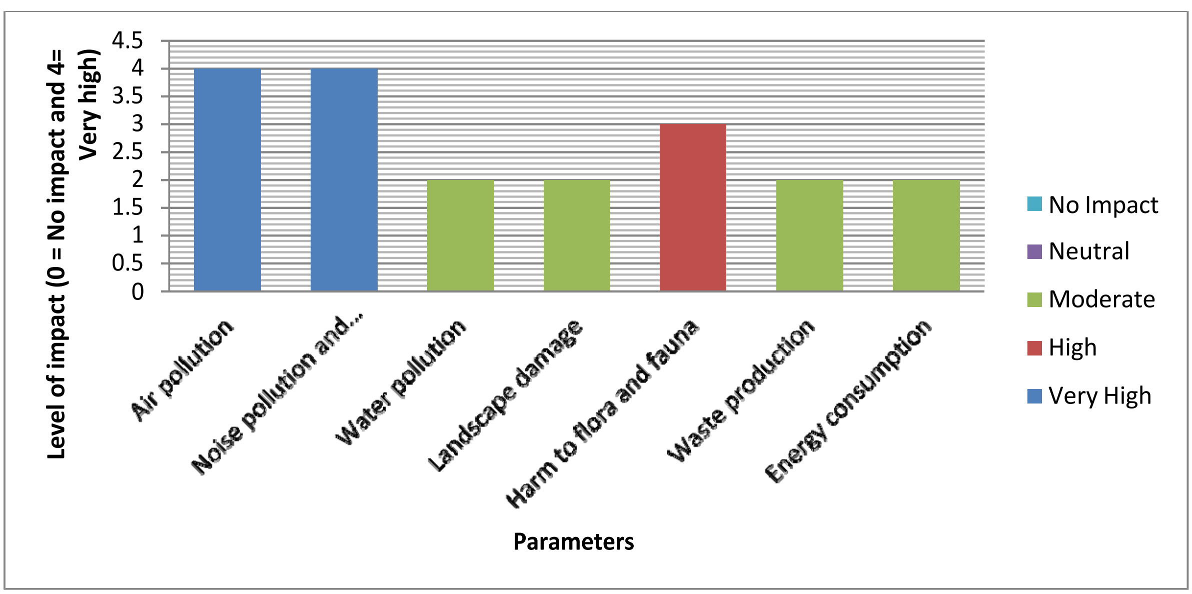


Figure 6.134 Impact of material production on the environment (Case study 12)

From Figure 6.134, it can be seen that air pollution, noise pollution and vibration and energy consumption have very high impact (4) on the environment during the production of materials. Next to this are water pollution, landscape damage, waste production; and energy consumption with moderate (2) impacts. Harm to flora and fauna follows with a high (3) impact rating.

6.13.3.2 Methods utilised to mitigate the impact of material production in Case study 12

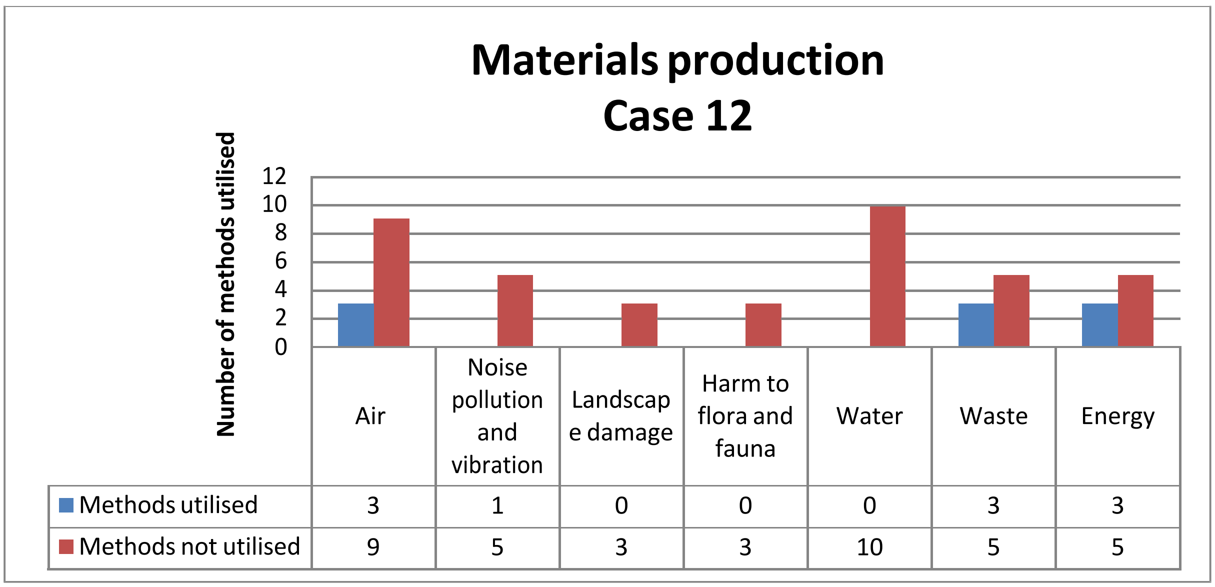


Figure 6.135: Methods utilised to mitigate the impact of material production in Case study 12

From Figure 6.135, it is obvious that the company in case 12 utilised a few methods to mitigate the impact of material production on air (maintenance of plant and equipment, procurement of plant and equipment with less emission and increasing distance from nearest building), noise pollution and vibration (maintenance of plant and equipment), waste (re-crushing to form aggregate, segregation of fine grained solid rejects and re-use of fine grained solid rejects for further production); and energy (educating employees regarding plant and equipment idling and turning off lights, implementation of energy saving/ conservation measures for plant and equipment e.g catalysts and minimisation of non- utilised power). None of the proposed methods were utilised to mitigate the impacts of material production on landscape damage (re-contouring of slopes, better design and planning and enclosure of fuel and chemical), harm to flora and fauna (continuous monitoring to maintain pH levels, top soil substitution, addition of buffering agents to mitigate acidic seeps from mining and application of fertilizer, lime, tillage and re-vegetation) and water (recycling of water, buffer strips, collection and treatment of waste water, protection plan, management of surface water, control of site drainage, use of leak detection systems, better design, collection in sumps and use of reclaimed effluent and other recycled water for cooling).

6.13.4 Sustainability report for Case study 12

From the fieldwork carried, it was noted that Case study 12 do not have a sustainability report.

6.14 Case study 13 - Sand extraction

Case study 13 operates in the North-West geopolitical zone in Nigeria. The organisation is involved in the extraction and supply of sand of various types, such as: fine sand with a clear sieve opening of 1.587mm, coarse sand with a clear sieve opening of 3.175mm, and gravel sand with a clear sieve opening of 7.62mm with various applications including brick works, plastering works and concreting works.

6.14.1 Material sourcing for Case study 13

Case study 13 sources sands from the river using manual labour with the use of head pans, shovels and buckets during the material-sourcing process. The material sourcing process is done from 7.am - 6pm. Sand-sourcing processes are illustrated in Figure 6. 136.

Figure 6.136 Material sourcing

6.14.1.1 Impact of material sourcing on the environment for Case study 13

Figure 6.137: Showing destruction of the landscape and harm to flora and fauna in Case study 13

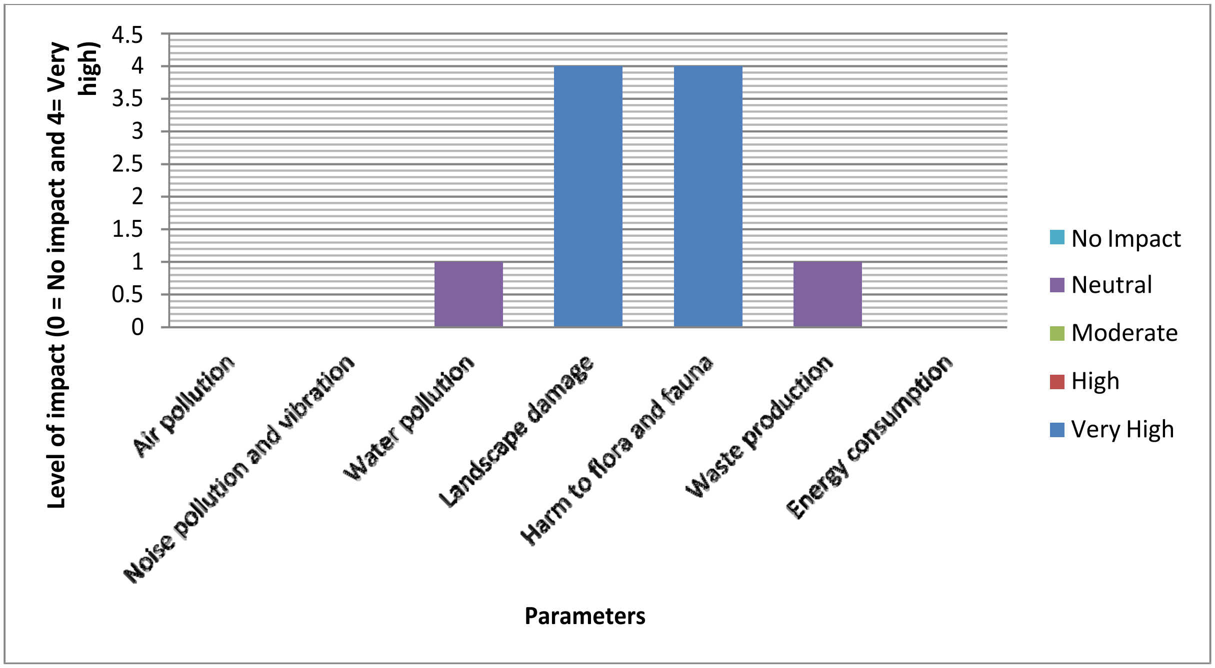
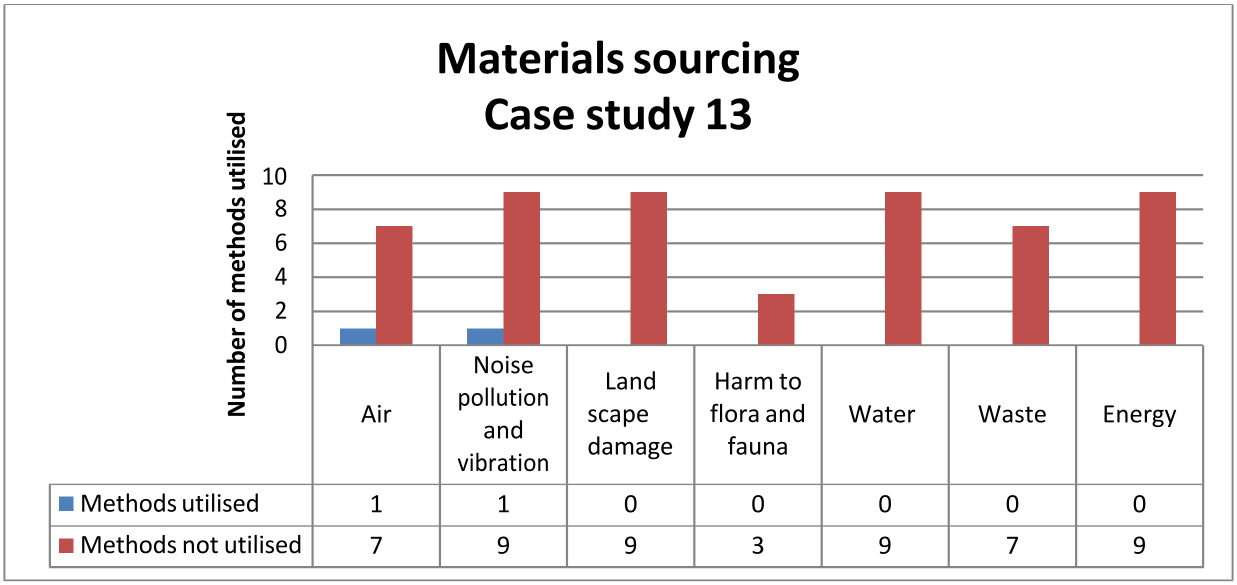


Figure 6.138: Impact of material sourcing on the environment (Case study 13)

From Figure 6.138, it can be seen that air pollution, noise pollution and vibration and energy consumption have no impact (0) on the environment during the sourcing of materials. Next to these are water pollution and waste production with neutral (1) impact ratings. Landscape damage and harm to flora and fauna follow with very high (4) impact ratings.

6.14.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 13



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	1	1	0	0	0	0	0
Methods not utilised	7	9	9	3	9	7	9

Figure 6.139: Methods utilised to mitigate the impact of material sourcing in Case study 13

Figure 6.139 shows that the company in case study 13 utilised few methods to mitigate the impact of materials sourcing on air (increasing distance from nearest building) and noise pollution and vibration (limiting working time to day light hours). None of the proposed methods were utilised regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill), harm to flora and fauna (continuous monitoring to maintain pH levels, replacement with saplings and addition of buffering agents to mitigate acidic seepage from mining), water (recycling of water, collection and treatment of waste water, protection plan, management of surface water, design of mining approaches that exclude water, use of leak detection systems, monitoring of ground water, contingency planning and buffer strips), waste (use of modern plant and equipment for sourcing/ extraction, proper planning and efficient management, training of employees, use of

Ground Penetrating Radars (GPR), installation of a mobile crushing/ grinder-pulverisation unit at quarry site, recycling of waste and reduced-impact logging) ; and energy (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non-utilized power, reducing fuel spills, regular energy audits and maintenance, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts, use of renewable energy sources for operation and transport pooling/ limiting hauling) to mitigate impact of materials sourcing.

Material-loading process

Figure 6.140: Material-transportation in Case study 13

6.14.3.1 Impact of raw material transportation on the environment for Case study 13

Landscape damages

Figure 6.141: Impact of material-transportation process in Case study 13

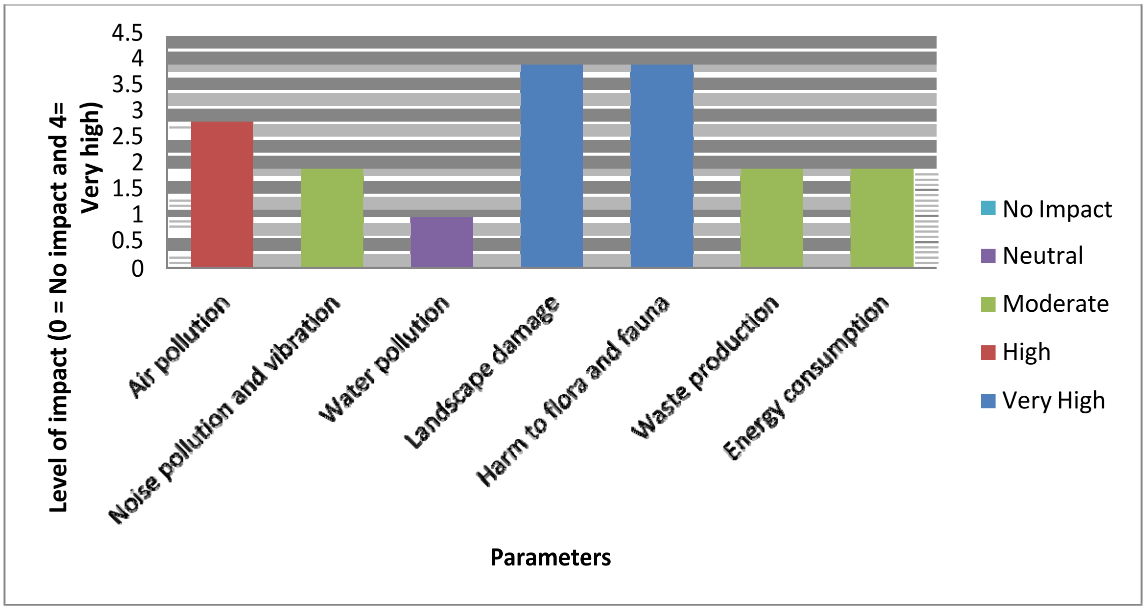
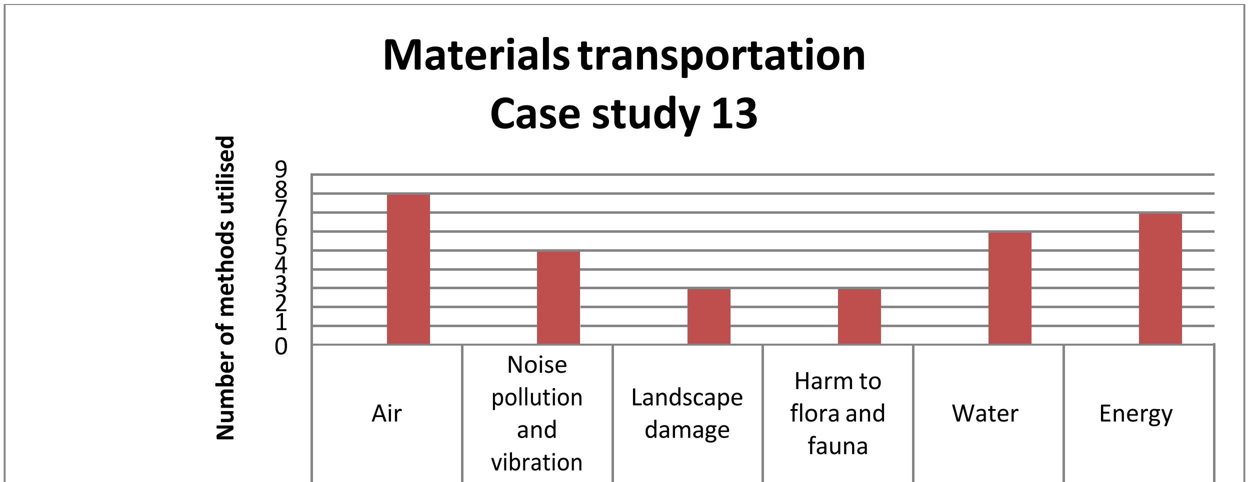


Figure 6.142: Impact of material transportation on the environment (Case study 13)

From Figure 6.142, it can be seen that air pollution, has a high (3) impact rating on the environment during the transportation of materials. Noise pollution, waste production; and energy consumption followed closely with moderate (2) impacts. Next to these is water pollution with a neutral (1) impact rating. Landscape damage and harm to flora and fauna come next with very high impact ratings.

6.14.3.2 Methods utilised to mitigate the impact of material transportation in Case study 13



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Energy
Methods utilised	0	0	0	0	0	0
Methods not utilised	8	5	3	3	6	7

Figure 6.143: Methods utilised to mitigate the impact of material transportation in Case study 13

From Figure 6.143, it is obvious that none of the proposed methods was utilised to mitigate the impact of material transportation on air (transport pooling/ limiting hauling, selection of suitable routes, wet suppression, maintenance of plant and equipment, partial enclosure of transferring and conveying equipments and process, partial enclosure of unloading area, covering of transported materials and procurement of plant and equipment with less emission), noise pollution and vibration (transport pooling/ limiting hauling, selection of suitable routes, maintenance of plant and equipment, traffic diversion, working with relevant authority to prevent unnecessary traffic congestion and use of plant and equipment with less emission), landscape damage (re-contouring of slopes, use of alternative routes and educating employees regarding plant and equipment idling), harm to flora and fauna (wetting of soil, covering of transported materials and buffer strips), water (selection of suitable routes, proper training of drivers, covering of transported materials, procurement of plant and equipment with less emission, reducing fuel spills and continuous motoring of ground water) and energy (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, optimising pit and mine design, regular energy audits and maintenance, transport pooling/ limiting hauling, reducing fuel spills and use of renewable energy sources for operation).

6.14.4 Sustainability report for Case study 13

The organisation in Case study 13 does not have a sustainability report.

6.15 Case study 14 - Sand extraction

The organisation in Case study 14 is situated in the North-West geopolitical zone of Nigeria. Case study 14 extracts, and transports sand; since the organisation is involved in the extraction and delivers fine sand with aggregate size of 1.587mm, coarse sand with aggregate size of 3.175mm and gravel sand with aggregate size of 7.62mm that can be used for different construction processes.

6.15.1 Material sourcing for Case study 14

Sand is sourced from a river flowing under a bridge, by using manual labour. The workers sourcing sand make use of shovels during the material-sourcing process. Sand sourcing is carried out between 8.am - 5pm. The various sand-sourcing processes are illustrated in the Figure 6.144.

Extraction and loading of materials

Figure 6.144: Material sourcing in Case study 14

6.15.1.1 Impact of material sourcing on the environment for Case study 14

Landscape damage and harm to flora and fauna

Figure 6.145: Environmental impact due to material sourcing in Case study 14

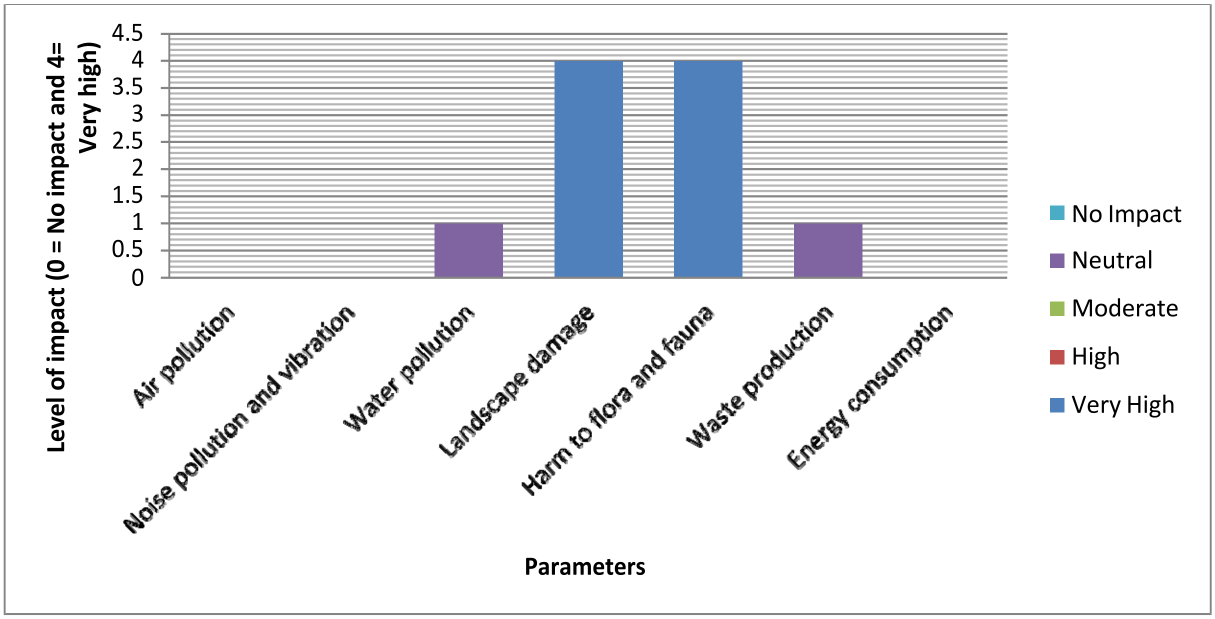
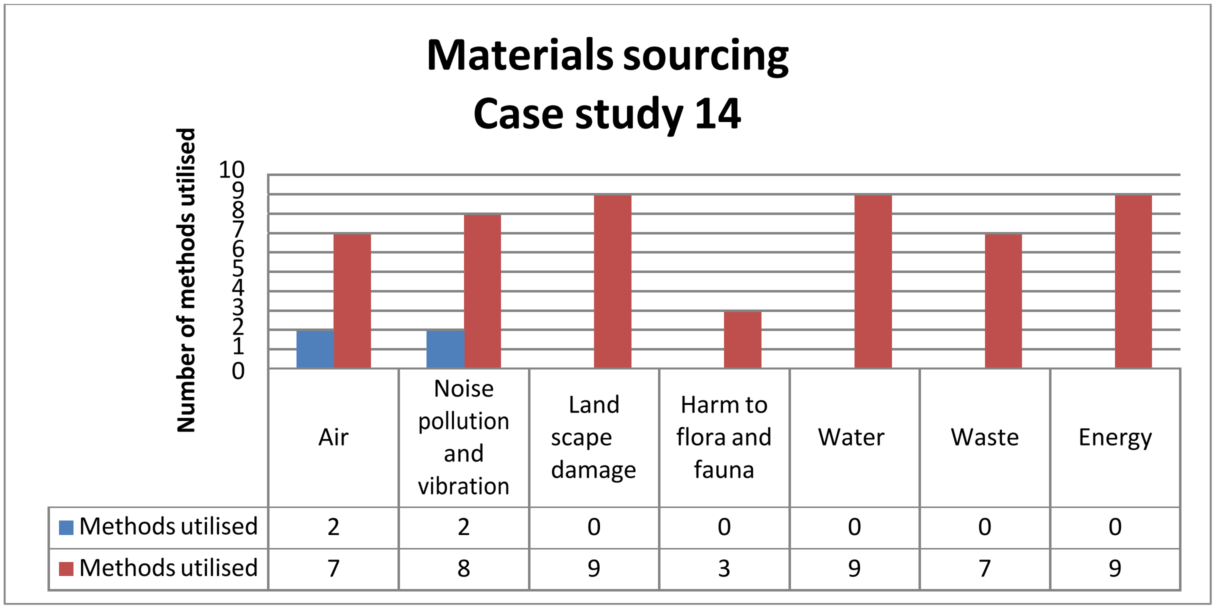


Figure 6.146: Impact of material sourcing on the environment (Case study 14)

From Figure 6.146, it can be observed that air pollution, noise pollution and vibration; and energy consumption have no impact on the environment during the sourcing of materials. Next to these are water pollution and waste production with a neutral (1) impact rating. Landscape damage and harm to flora and fauna follow with very high (4) impacts.

6.15.1.2 Methods utilised to mitigate materials sourcing impact in Case study 14



	Air	Noise pollution and vibration	Land scape damage	Harm to flora and fauna	Water	Waste	Energy
Methods utilised	2	2	0	0	0	0	0
Methods utilised	7	8	9	3	9	7	9

Figure 6.147: Methods utilised to mitigate materials sourcing impact in Case study 14

Figure 6.147 shows that the company in case study 14 utilised a few methods regarding air (increasing distance from nearest building and minimise operations during windy periods) and noise pollution and vibration (early public notification of extremely noisy operation, limiting working time to day light hours) to mitigate the impact of material sourcing. None of the proposed methods were utilised to mitigate the impact of material sourcing regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill) and harm to flora and fauna (continuous monitoring to maintain pH levels, replacement with saplings and addition of buffering agents to mitigate acidic seepage from mining), water (buffer strips, contingency planning, monitoring of ground water, use of leak detection systems, design of mining approaches that exclude water, management of surface water, protection plan, collection and treatment of waste water and recycling of water), waste (use of modern plant and equipment for sourcing/ extraction, proper planning and efficient management, training of employees, use of Ground Penetrating Radars (GPR), installation of a mobile crushing/ grinder- pulverisation unit at quarry site and recycling of waste) and energy (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, regular energy audits and maintenance, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts, use of renewable energy sources for operation and transport pooling/ limiting hauling).

6.15.2 Material transportation for Case study 14

Case study 14 utilises tippers of various sizes, such as 10 tyres, 14tyres and 18 tyres to transport sand sourced to various areas where it is needed.

6.15.2.1 Impact of material transportation on the environment for Case study 14

(a) Air pollution

(b) Landscape damages

Figure 6.148: Environmental impact of material transportation on the environment in Case study 14

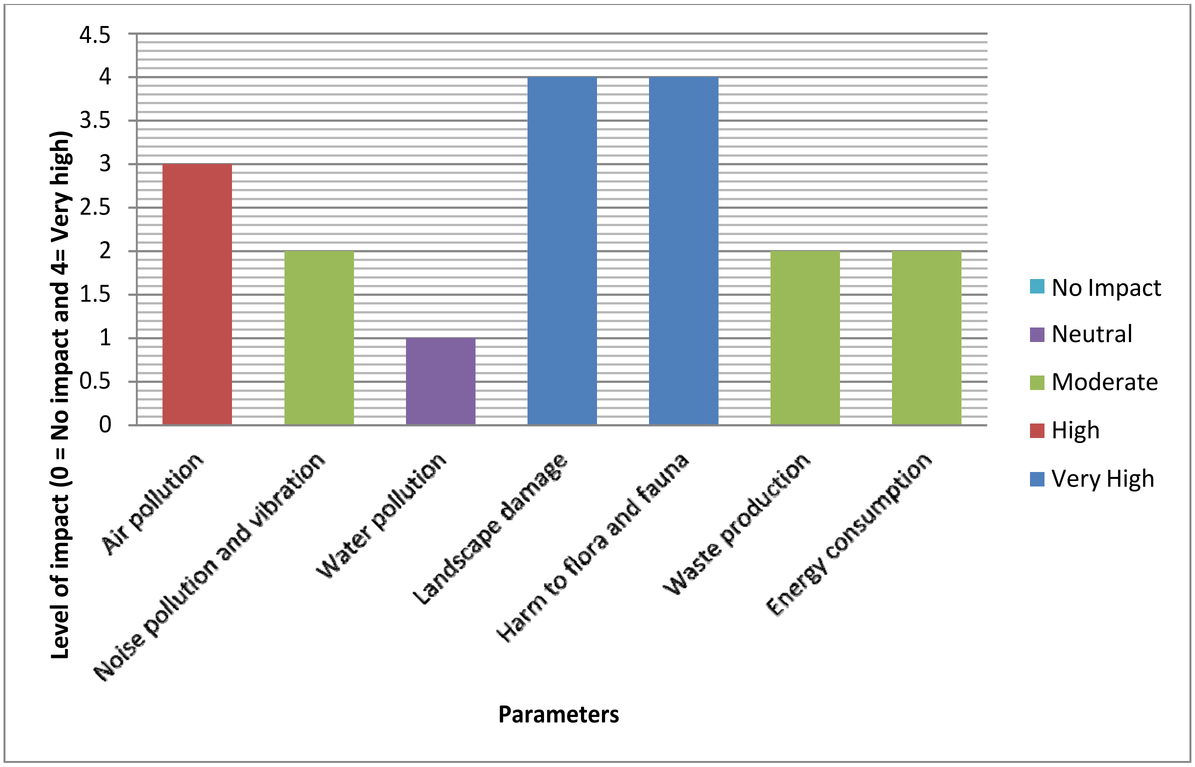


Figure 6.149: Impact of material transportation on the environment (Case study 14)

From Figure 6.149, it can be seen that air pollution has a high (3) impact rating on the environment during the transportation of materials. Next to this are noise pollution and vibration, waste production; and energy consumption, which all have a moderate (2) impact. Water pollution follows closely with a neutral (1) impact rating and landscape damage and harm to flora and fauna come next with very high (4) impact ratings.

6.15.2.2 Methods utilised to mitigate the impact of material transportation in Case study 14

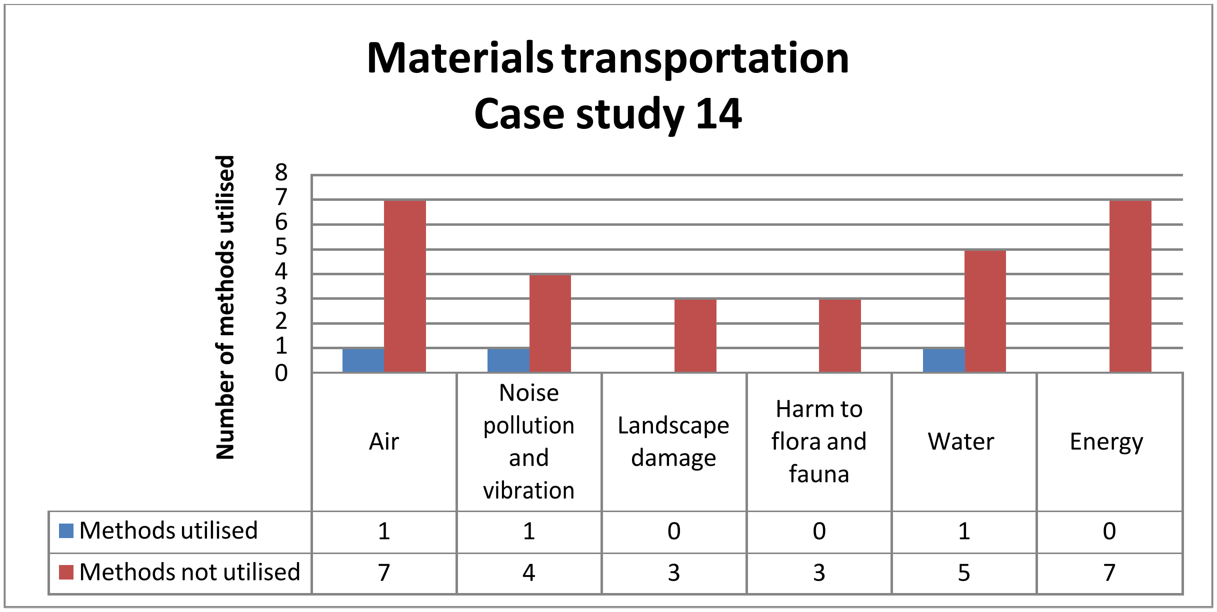


Figure 6.150: Methods utilised to mitigate the impact of material transportation in Case study 14

Figure 6.150 shows that a few methods were utilised to mitigate the impact of material transportation on air (increasing distance from nearest building), noise pollution and vibration (transport pooling/ limiting hauling) and water (reducing fuel spills). None of the proposed methods were utilised to mitigate the impact of material transportation regarding landscape damage (re-contouring of slopes, use of alternative routes and educating employees regarding plant and equipment idling), harm to flora and fauna (wetting of soil, covering of transported materials and buffer strips) and energy (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, optimising pit and mine design, regular energy audits and maintenance, transport pooling/ limiting hauling, reducing fuel spills and use of renewable energy sources for operation).

6.15.3 Sustainability report for Case study 14

Case study 14 does not have a sustainability report for the various activities in which they engage.

6. 16 Case study 15 - Laterite extraction

Case study 15 is located in the North-West geopolitical zone in Nigeria. The organisation sources and supplies laterite material for various purposes, not limited to construction and agricultural purposes.

6.16.1 Material sourcing in Case study 15

Laterite is sourced from open pits dug with the use of manual labour and tools, such as spades and shovels in case study 15. Sourcing in case study 15 is carried out between 10.am - 5pm. The Laterite-sourcing processes are illustrated in Figure 6.151.

Material-extraction process

Figure 6.151: Material-sourcing process in Case study 15

6.16.1.1 Impact of material sourcing on the environment in Case study 15

Landscape destruction

Figure 6.152: Environmental impact of material sourcing in Case study 15

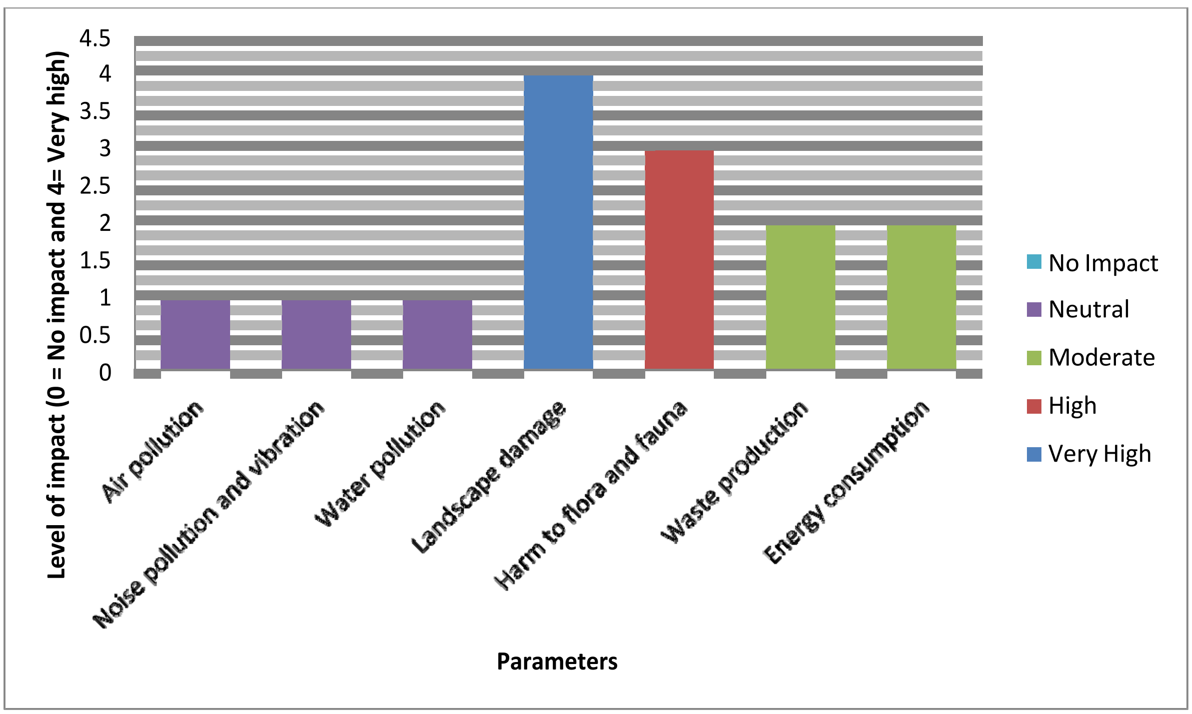


Figure 6.153: Impact of material sourcing on the environment (Case study 15)

From Figure 6.153, it can be seen that air pollution, noise pollution and vibration and water pollution have neutral (1) impact ratings on the environment during sourcing of materials. Next to this is landscape damage with a very high (4) impact. Harm to flora and fauna follows closely with a high (3) impact rating; and waste production and energy consumption come next with a moderate (2) impact.

6.16.1.2 Methods utilised to mitigate the impact of material sourcing in Case study 15

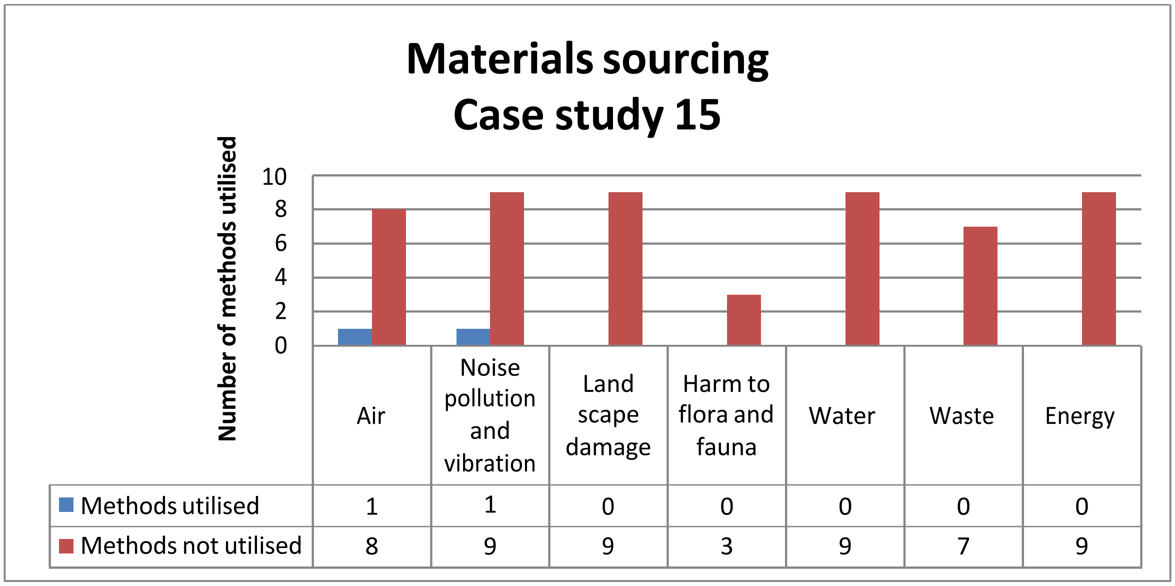


Figure 6.154: Methods utilised to mitigate the impact of material sourcing in Case study 15

Figure 6.154 shows that the company in case study 15 utilised a few methods to mitigate the impact of material sourcing regarding air (increasing distance from nearest building) and noise pollution and vibration (limiting working time to day light hours). None of the proposed methods were utilised to mitigate the impact of material sourcing regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill) and harm to flora and fauna (continuous monitoring to maintain pH levels, replacement with saplings and addition of buffering agents to mitigate acidic seepage from mining), water (buffer strips, contingency planning, monitoring of ground water, use of leak detection systems, design of mining approaches that exclude water, management of surface water, protection plan, collection and treatment of waste water and recycling of water), waste (use of modern plant and equipment for sourcing/ extraction, proper planning and efficient management, training of employees, use of Ground Penetrating Radars (GPR), installation of a mobile crushing/ grinder- pulverisation unit at quarry site and recycling of waste) and energy (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, regular energy audits and maintenance, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts, use of renewable energy sources for operation and transport pooling/ limiting hauling).

6.16.2 Material transportation for Case study 15

Case study 15 uses tippers of various sizes, such as 10 tyres, 14tyres and 18 tyres to transport the laterite to areas where it is needed.

6.16.2.1 Material transportation on the environment for Case study 15

Air pollution

Figure 6.155: Environmental impact of material transportation in Case study 15

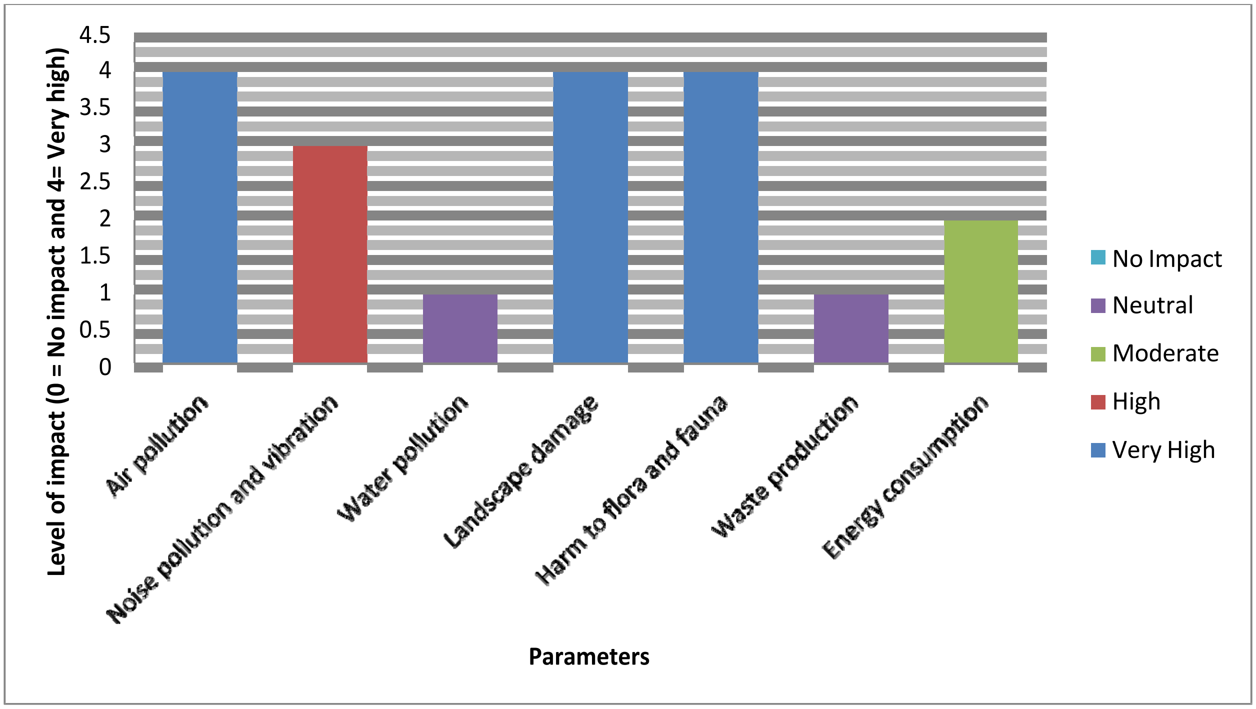
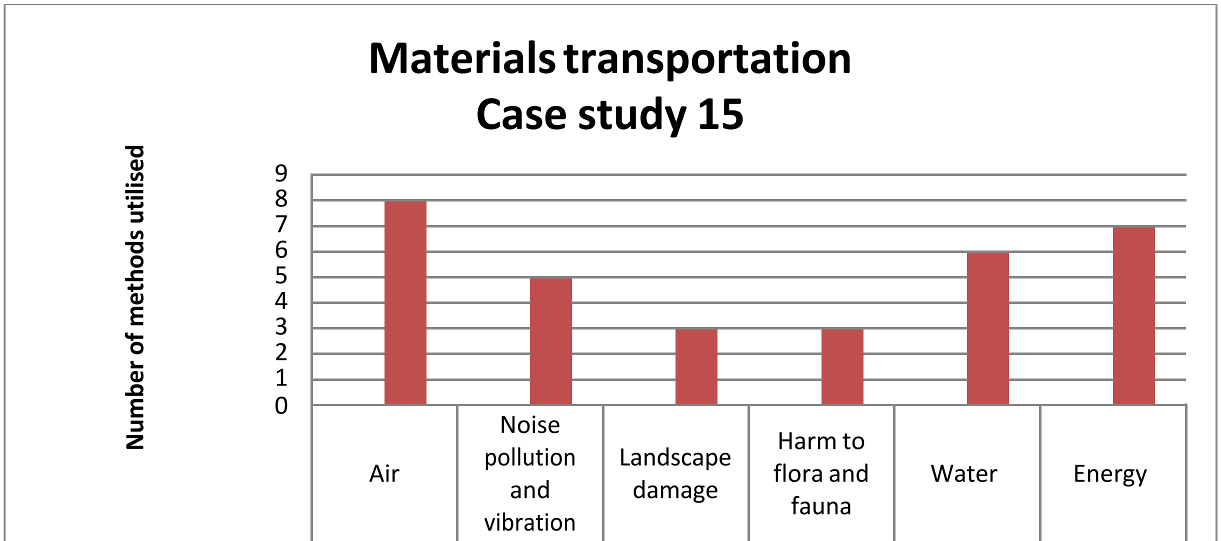


Figure 6.156: The impact of material transportation on the environment (Case study 15)

From Figure 6.156, it can be seen that air pollution, landscape damage and harm to flora and fauna have very high (4) impact ratings on the environment during the transportation of materials. Next to these are noise pollution and vibration with high (3) impact ratings. Water pollution and waste production follow with neutral impact rating; and energy consumption comes next with a moderate impact.

6.16.2.2 Methods utilised to mitigate the impact of material transportation in Case study 15



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Energy
Methods utilised	0	0	0	0	0	0
Methods not utilised	8	5	3	3	6	7

Figure 6.157: Methods utilised to mitigate the impact of materials transportation in Case study 15

Figure 5.157 shows that none of the proposed methods was utilised to mitigate the impact of material transportation on air (transport pooling/ limiting hauling, selection of suitable routes, wet suppression, maintenance of plant and equipment, partial enclosure of transferring and conveying equipments and process, partial enclosure of unloading area, covering of transported materials and procurement of plant and equipment with less emission), noise pollution and vibration (use of plant and equipment with less emission, working with relevant authority to prevent unnecessary traffic congestion, traffic diversion, maintenance of plant and equipment, selection of suitable routes and transport pooling/ limiting hauling) landscape damage (re-contouring of slopes, use of alternative routes and educating employees regarding plant and equipment idling), harm to flora and fauna (wetting of soil, covering of transported materials and buffer strips) ; water (selection of suitable routes, proper training of drivers, covering of transported materials, procurement of plant and equipment with less emission, reducing fuel spills and continuous motoring of ground water) and energy (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, optimising pit and mine design, regular energy audits and maintenance, transport pooling/ limiting hauling, reducing fuel spills and use of renewable energy sources for operation).

6.16.3 Sustainability report for Case study 15

Case study 15 does not have a sustainability report.

6.17 Case study 16 - Laterite extraction

The organisation in Case study 16 operates in the North-West geopolitical zone of Nigeria. Case study 16 extracts and supplies laterite of different grades.

6.17.1 Material sourcing for Case study 16

Case study 16 sources laterite from open pits. Diggers, shovels, excavator and bulldozer are used to extract the laterite from the earth crust. Material sourcing in case study 16 is done from 8.am - 6pm. The various procedures for laterite sourcing by the company are illustrated in Figure 6.146.

Figure 6.158: Material-sourcing process in Case study 16

6.17.1.1 Impact of material sourcing on the environment for Case study 16

Landscape destruction and harm to flora

Figure 6.159: Environmental impact of material sourcing in Case study 16

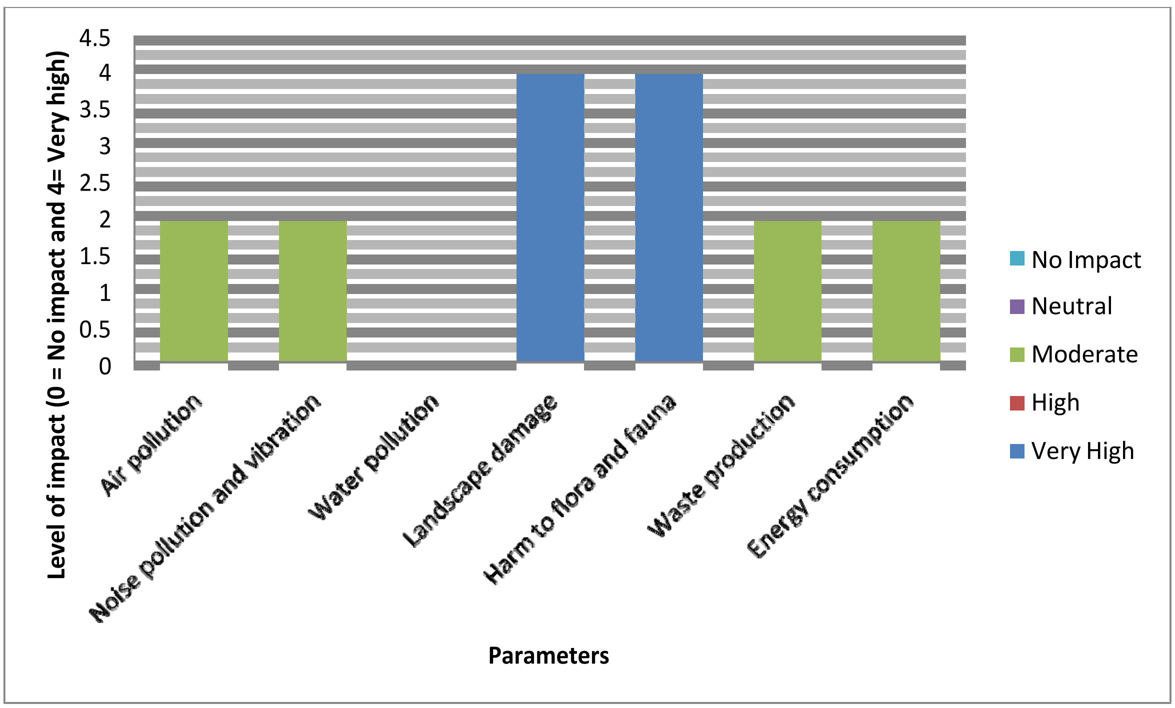


Figure 6.160: Impact of material sourcing on the environment (Case study 16)

From Figure 6.160, it can be observed that air pollution, noise pollution and vibration, waste production; and energy consumption have moderate (2) impacts on the environment during the sourcing of materials. Next to these is water pollution with no impact (0). Landscape damage and harm to flora and fauna follow, both with very high (4) impact ratings.

6.17.1.2Methods utilised to mitigate the impact of material sourcing in Case study 16

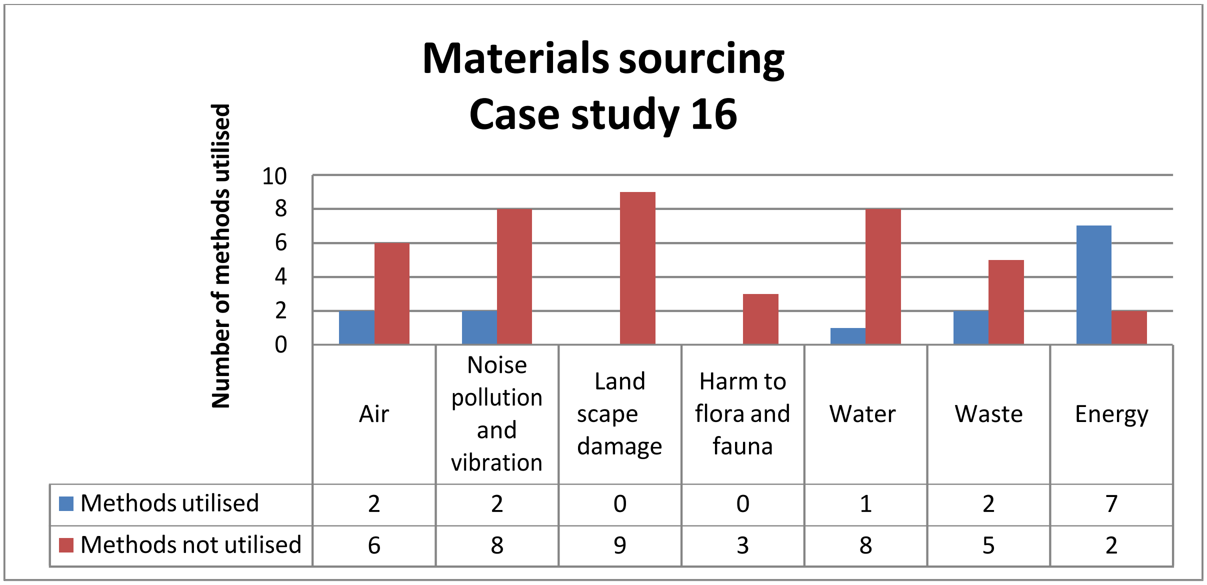


Figure 6.161: Methods utilised to mitigate the impact of material sourcing in Case study 16

Figure 6.161 illustrates that the company in case study 16 utilised a few methods to mitigate the impact of material sourcing on air (increasing distance from nearest building and minimise operations during windy periods), noise pollution and vibration (limiting working time to day light hours and early public notification of extremely noisy operation), water (design of mining approaches that exclude water); and waste (recycling of waste and use of modern plant and equipment for sourcing/ extraction). None of the proposed methods was utilised regarding landscape damage (slope stabilisation through vegetation planning, use of rip-rap, re - use of stockpiled soil removed during clearance operation, top soil substitution, application of fertilizer, lime, tillage and re-vegetation, reduced-impact logging, skid trailing, re-contouring of slopes and use of gasification ash to land fill) and harm to flora and fauna (continuous monitoring to maintain pH levels, replacement with saplings and addition of buffering agents to mitigate acidic seepage from mining). Seven methods (altering processing parameter e.g. belt speed, educating employees regarding plant and equipment idling, optimisation of plant and equipment, minimisation of non- utilized power, reducing fuel spills, implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts and transport pooling/ limiting hauling) were utilised to mitigate the impacts of the material sourcing regarding energy.

6.17.2 Material transportation in Case study 16

In case study 16, tippers are used to transport the laterite, as shown in Figure 6.162.

Air pollution and landscape damage

Figure 6.162: Environmental impact of material transportation in Case study 16

6.17.2.1 The impact of materials transportation on the environment for Case study 16

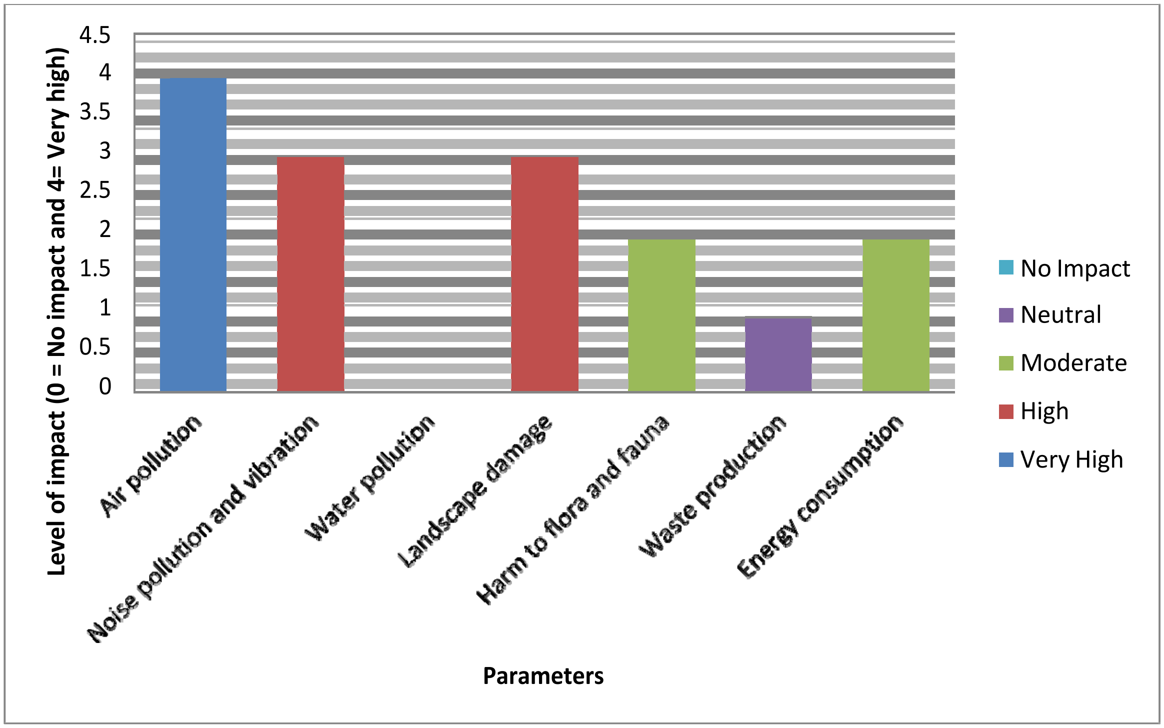
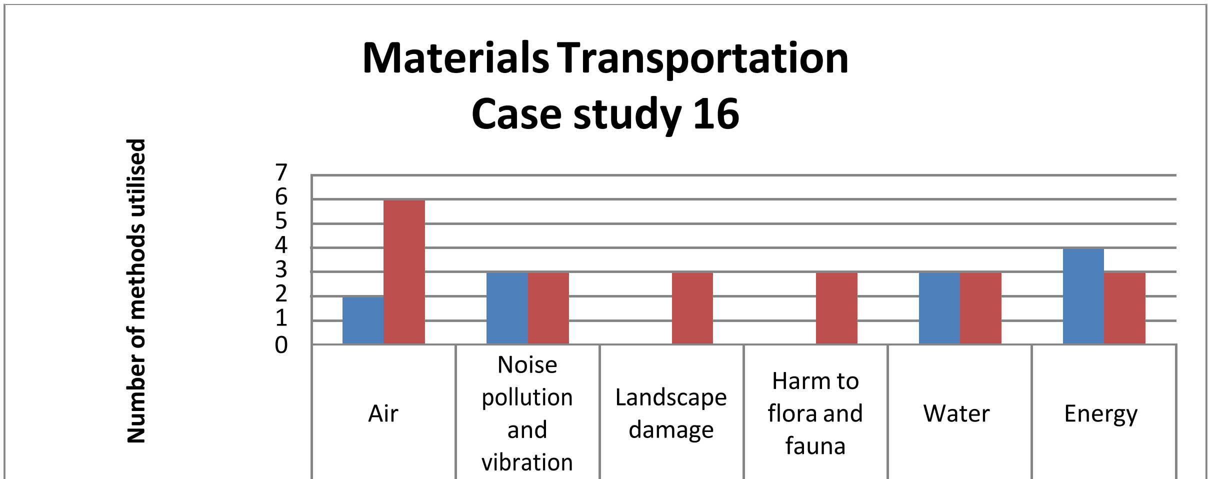


Figure 6.163 Impact of materials transportation on the environment (Case study 16)

From Figure 6.151, it can be seen that air pollution has very high (4) impact rating on the environment during the transportation of materials. Next to this are noise pollution and vibration and landscape damage, all with high (3) impact ratings. No impact (0) on water pollution during materials sourcing. Harm to flora and fauna and energy consumption follow closely with moderate (2) impact. Waste production comes next with a moderate (2) impact rating.

6.17.2.2 Methods utilised to mitigate the impact of material transportation in Case study 16



	Air	Noise pollution and vibration	Landscape damage	Harm to flora and fauna	Water	Energy
Methods utilised	2	3	0	0	3	4
Methods not utilised	6	3	3	3	3	3

Figure 6.164: Methods utilised to mitigate the impact of material transportation in Case study 16

Figure 6.152, shows that the company in case study 16 utilised two methods regarding air (transport pooling/ limiting hauling and selection of suitable routes), three methods each regarding noise pollution and vibration (transport pooling/ limiting hauling, selection of suitable routes and maintenance of plant and equipment), water (selection of suitable routes, proper training of drivers and reducing fuel spills); and four methods (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling, transport pooling/ limiting hauling and regular energy audits and maintenance) regarding energy to mitigate the impact of material transportation. None of the proposed methods was utilised regarding landscape damage (re-contouring of slopes, use of alternative routes and educating employees regarding plant and equipment idling), harm to flora and fauna (wetting of soil, covering of transported materials and buffer strips).

6.17.3 Sustainability report for Case study 16

Case study 16 admitted that they do not have sustainability reports on the activities carried out.

6.4 Conclusive remarks

This chapter has presented individual case studies of the sixteen (16) organisations used for the study. The next chapter presents the combined data for all the sixteen (16) organisations.

Chapter 7: Combined Data Presentation and Analysis

7.1 Introduction

The previous chapter presented the data collected for each of the case studies with the use of charts and a pictographic representation of the methods adopted for material sourcing, transportation and production. The chapter also presented the methods adopted in mitigating the impact of material sourcing, transportation and production on the environment. This chapter presents the results of the combination of the sixteen (16) case studies carried out.

7.2 Company sizes

Figure 7.1 shows the various sizes of the companies studied. A total of 62% of the companies were medium-sized with a staff number ranging from 61-300; as many as 38% were large, with staff numbers above 300. None of the companies studied were either micro- or small-sized.

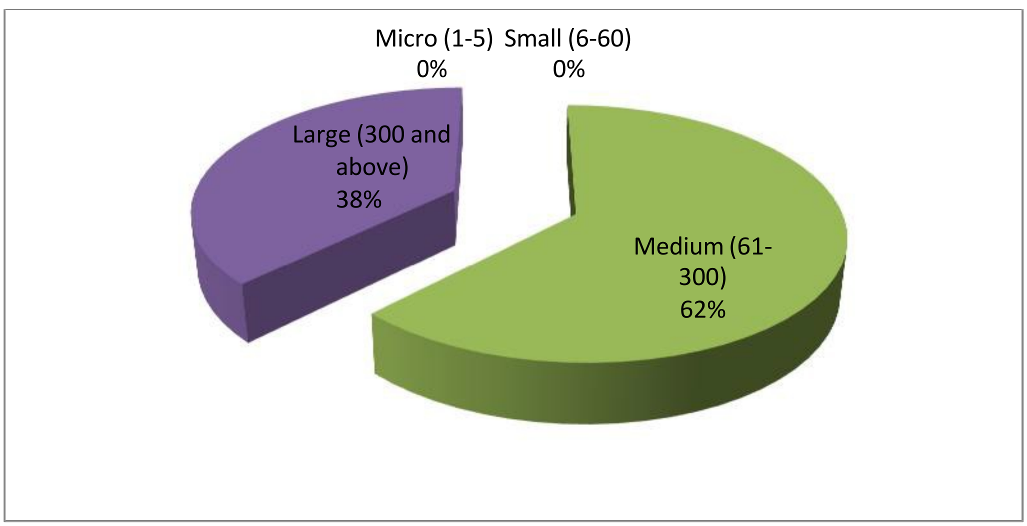


Figure 7.1 Company size

7.3 Site location

The study assessed the site location of the organisations studied. From Figure 7.2, it can be observed that 63% of the organisations are not located around ecology-sensitive areas; while 37% of the organisations are located around ecology-sensitive areas.

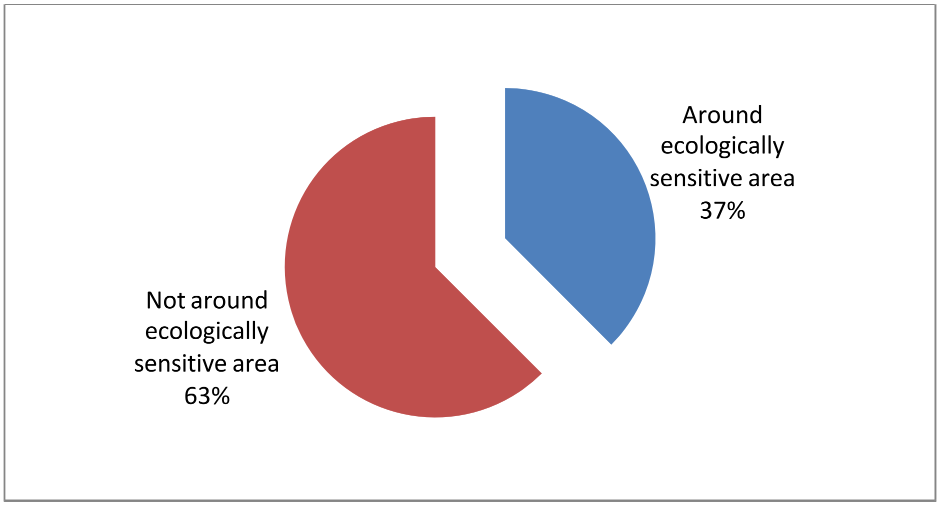


Figure 7.2 Site location

7.4 Distance of resource extraction site from built-up areas

Figure 7.3 depicts the distance of the site of the resource extraction to built-up areas. As many as 94% of the sites are situated more than 500 metres away from buildings and houses; while 6% of the resource-extraction sites are less than 500 metres away from buildings and houses.

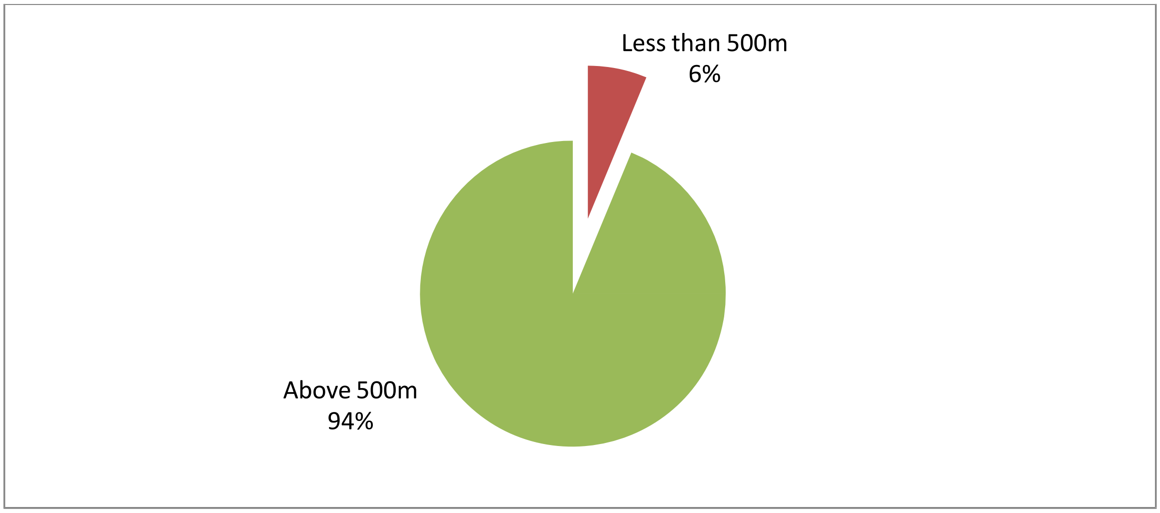


Figure 7.3: Distance of resource-extraction site from buildings and houses

7.5 Mode of sensitization adopted

Figure 7.4 presents the mode of sensitization used before extracting the raw materials. As many as 12% of the organisations use public-campaign awareness; while 6% of the organisations use other methods to sensitize the public. However, 82% of the organisations do not use public-campaign awareness, communiqués to the public, media briefing and other methods to inform the surrounding communities before extraction.

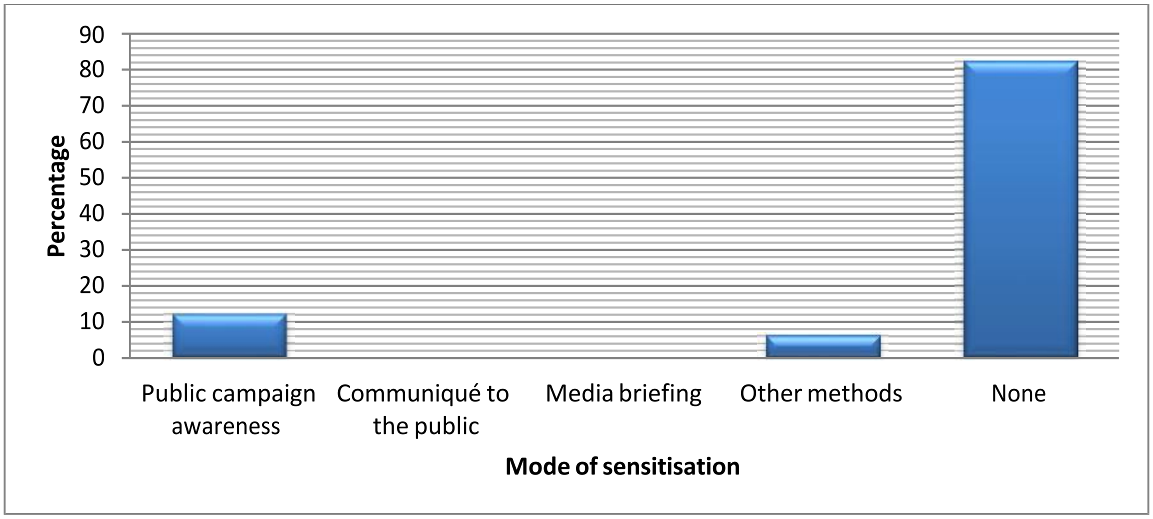


Figure 7.4: Mode of sensitization adopted

7.6 Time of operation

Figure 7.5 shows that the majority of the organisations carry out the extraction of resources between early mornings to late afternoon. Only six organisations extract resources in the evening.

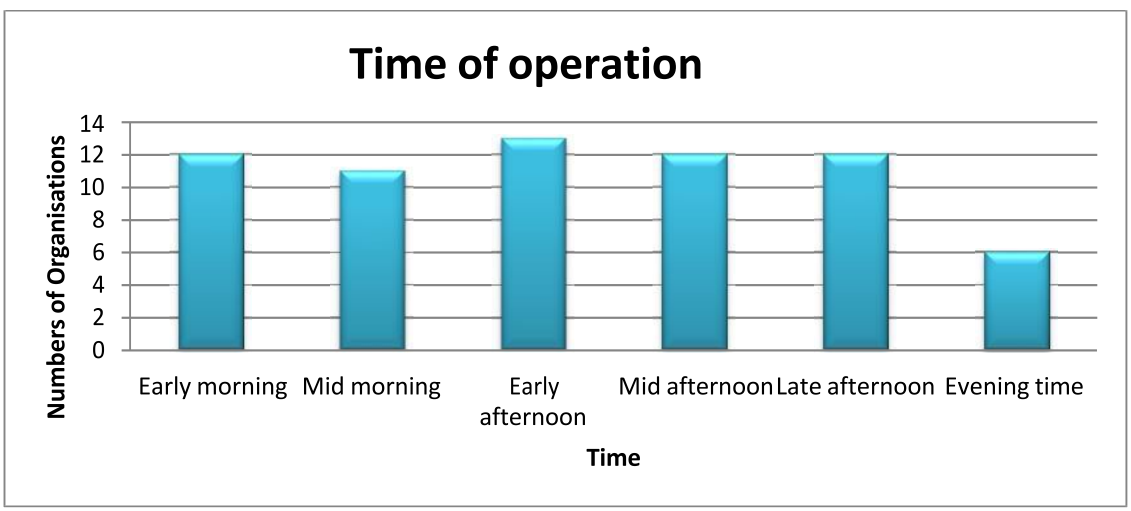


Figure 7.5: Time of operation

7.7 Method of resources extraction

Figure 7.6 shows that 88% of the organisations use the open-pit method of resources extraction for materials sourcing, while 12% use the surface method of resource extraction for material sourcing.

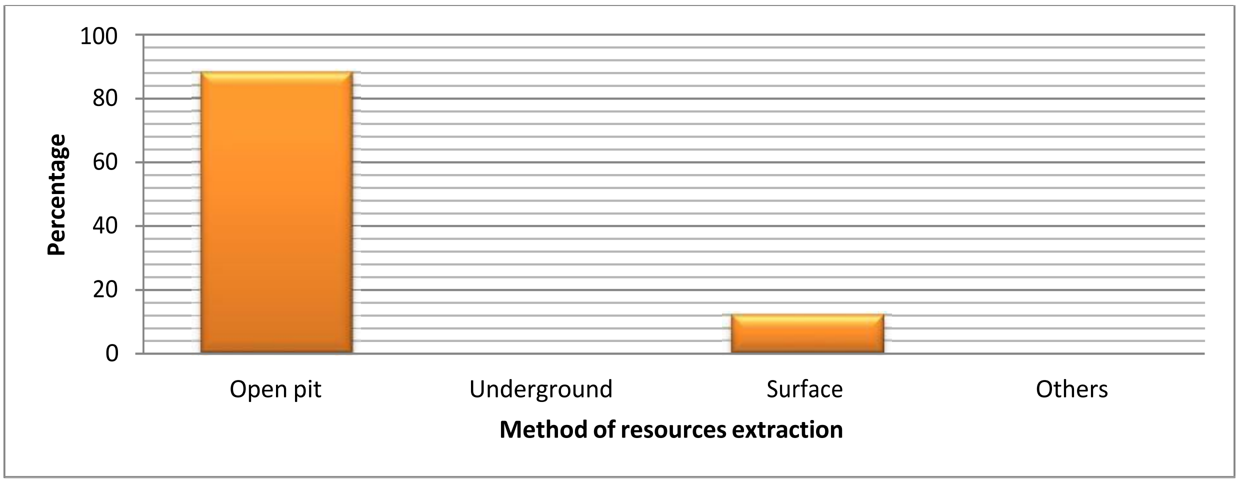


Figure 7.6: Method of resource extraction

7.8: Method of plant and equipment operation

Figure 7.7 reveals the mode of plant and equipment for material extraction; while 64% use mechanical methods of equipment for extraction; and 12% utilize a manual method for material extraction; while 25% apply both mechanical and manual methods during the extraction.

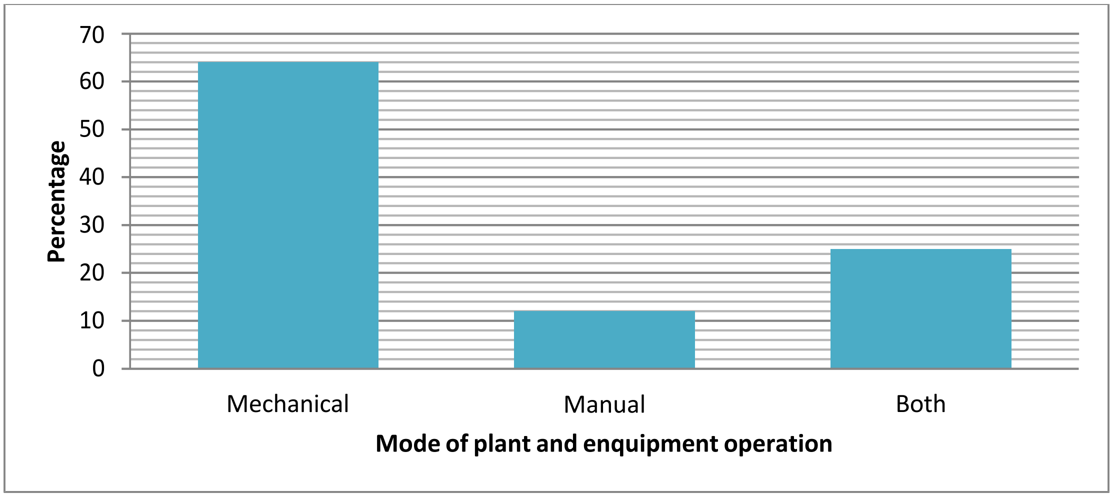


Figure 7.7: Mode of plant and equipment operation

7.9 Method of loading materials

Figure 7.8 shows that 25% of the organisations use manual methods for loading the materials; while 69% use mechanical methods for loading the materials. Only 6% of the organisations use both manual and mechanical methods for loading the materials.

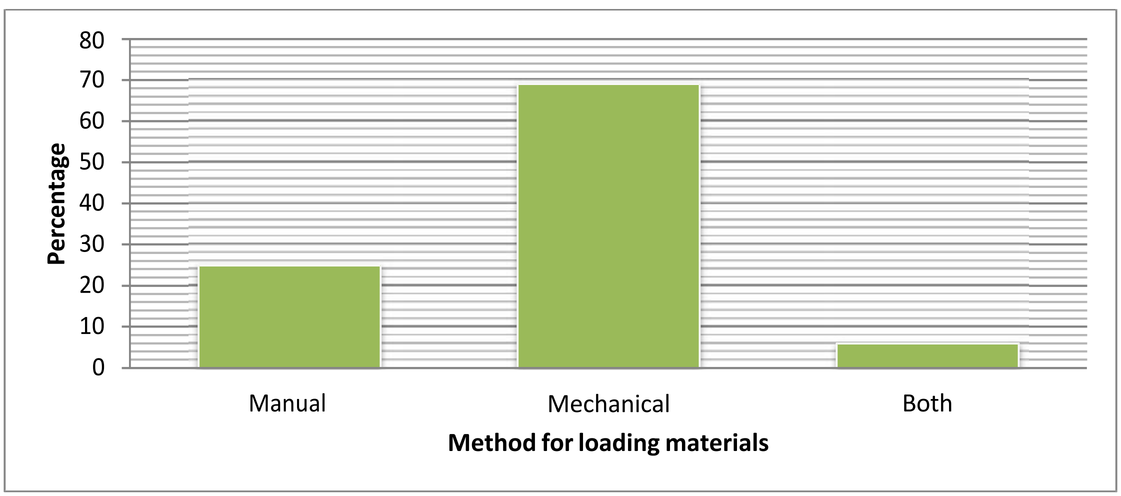


Figure 7.8: Method of loading materials

7.10 Method of transportation/haulage

Figure 7.9 reveals the method of transportation/ haulage for the materials extracted. As many as 94% of the organisations use road transportation/haulage for material extracted; while 6% use other methods of transportation/haulage for material movement.

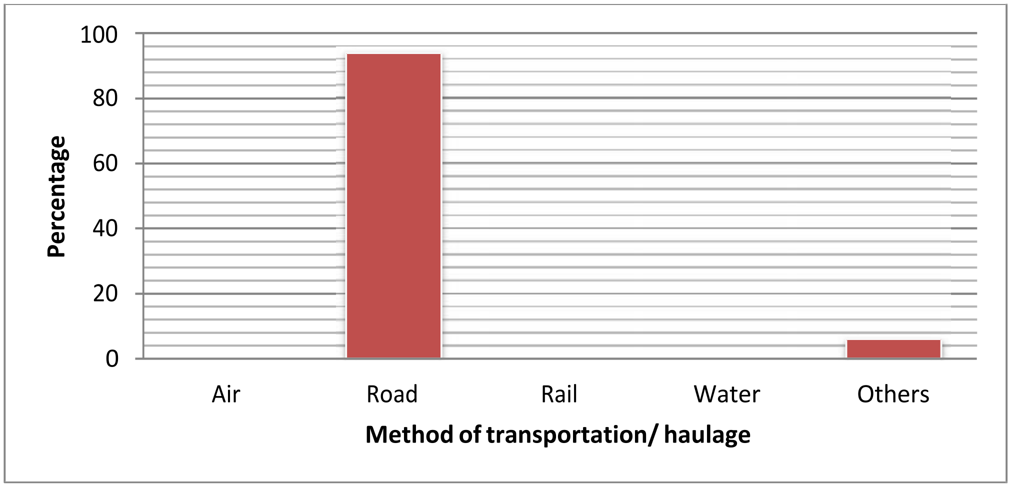


Figure 7.9: Method of transportation/ haulage

6.11 Method of material offloading

Figure 7.10 illustrates that 31% of the organisations use a manual method for offloading materials; while 63% use mechanical methods for offloading the materials. Only 6% of the organisations use both manual and mechanical methods for offloading the materials.

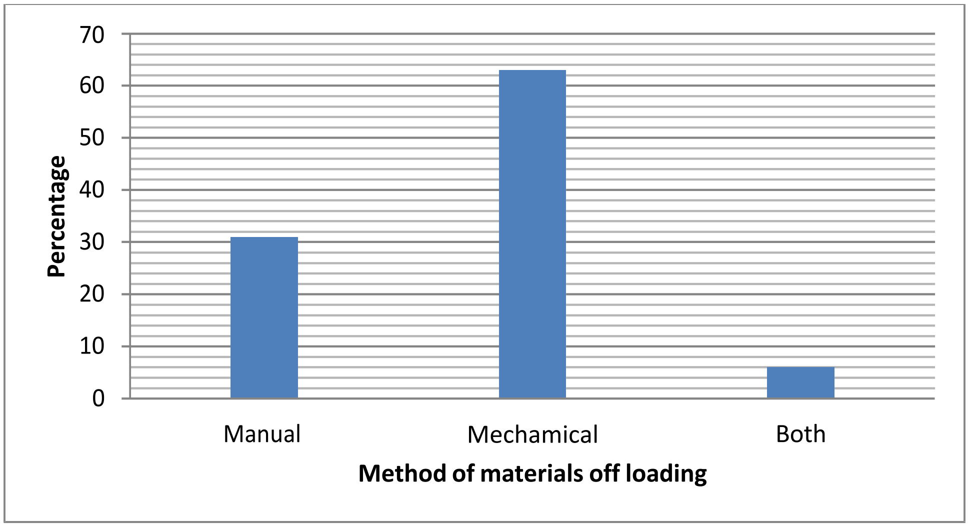


Figure 7.10: Method of material offloading

7.12 Method of material production/ processing

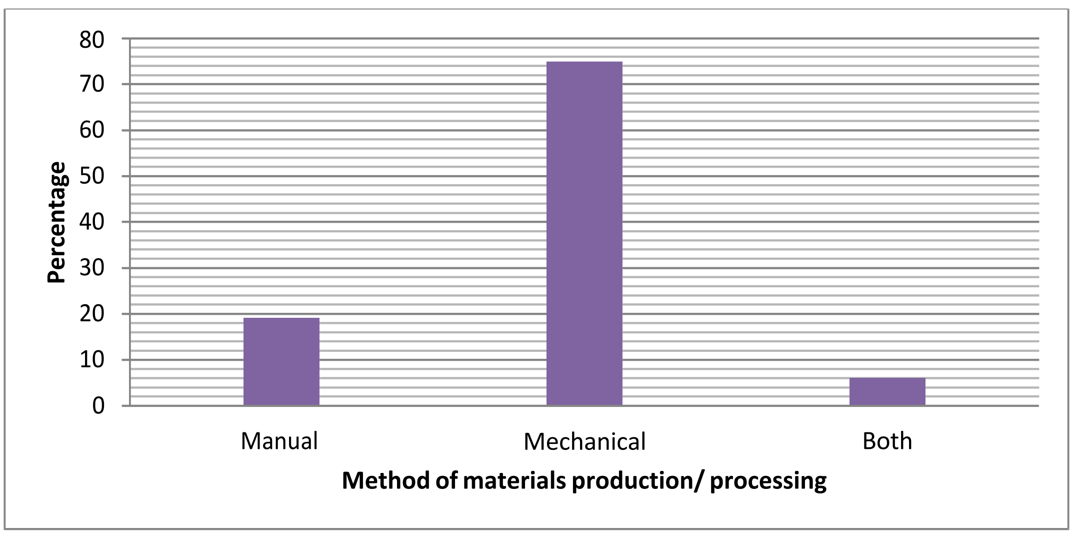


Figure 7.11: Method of material production/ processing

7.13 Combined impact of material sourcing

Figure 7.12 presents the combined impact of the material sourcing of the sixteen (16) case studies. Figure 7.12 shows that due to materials sourcing, the impact on landscape damage, energy consumption, noise pollution and vibration waste production and fauna was very high (4). The impact of material sourcing regarding water pollution for the combined case studies was high

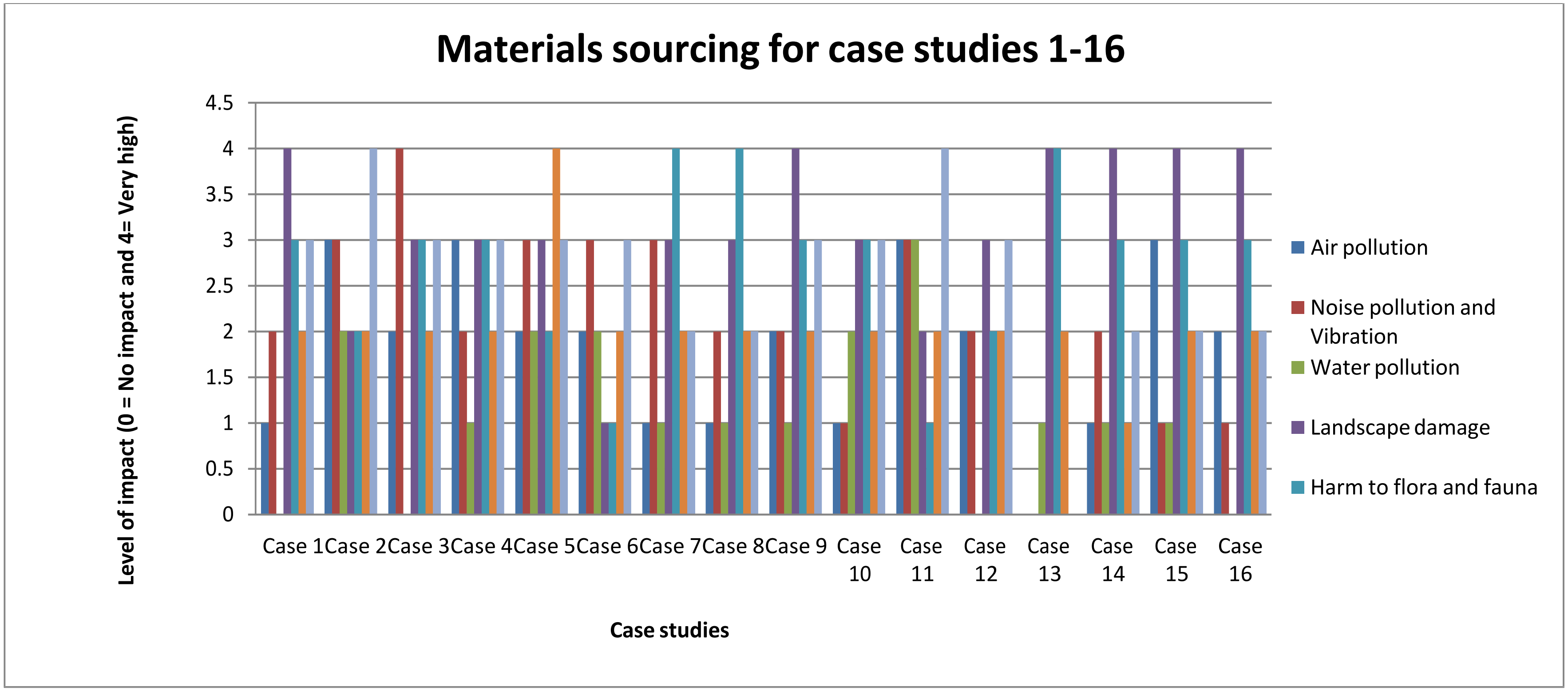
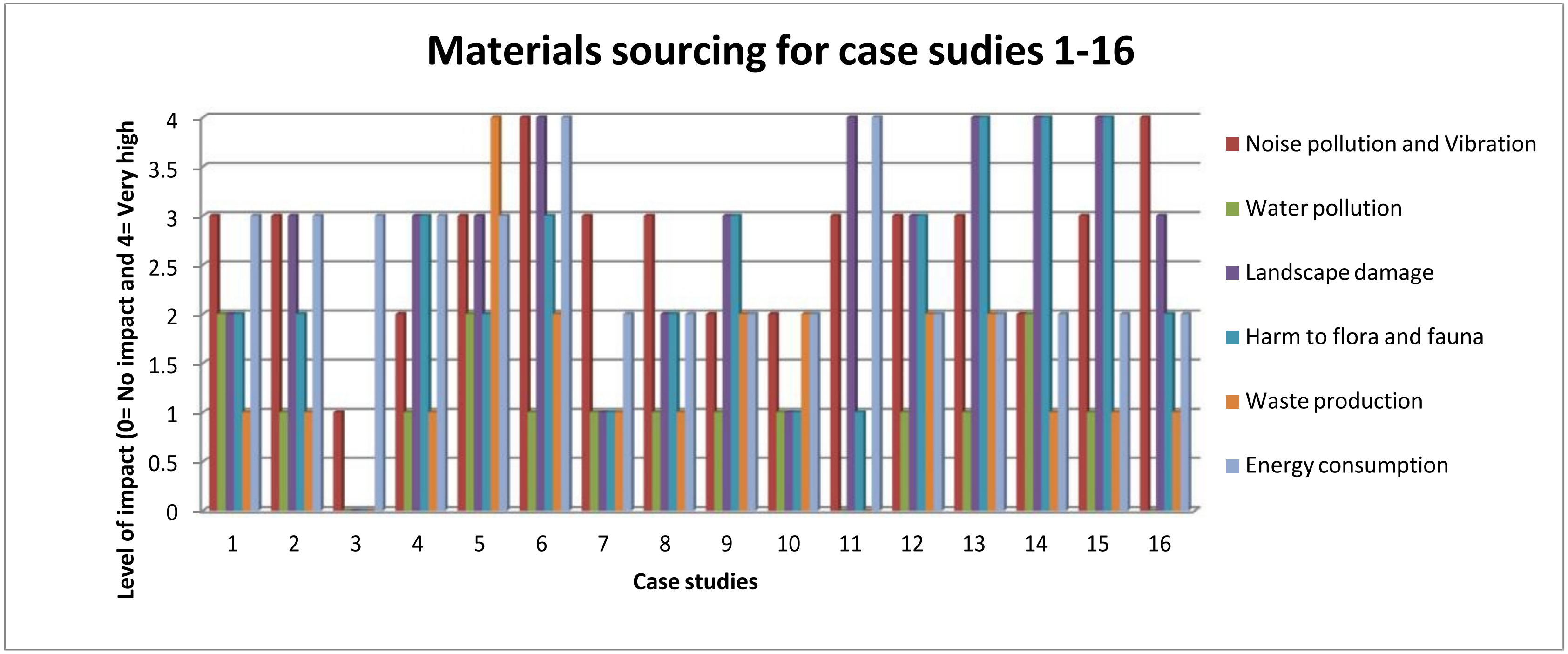


Figure 7.12 Combined impact of material sourcing

7.14 Combined impact of material transportation

Figure 7.13 shows that the combined impact of material transportation was very high regarding waste pollution, air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna and energy. The impact of material transportation regarding water pollution was moderate.

Figure 7.13 Combined impact of material transportation



7.15 Combined impact of material production

Figure 7.14 shows that the combined impact of material production regarding landscape damage, energy consumption, water pollution, waste production, noise pollution and vibration and air pollution were very high. Harm to flora and fauna was high, due to material productions.

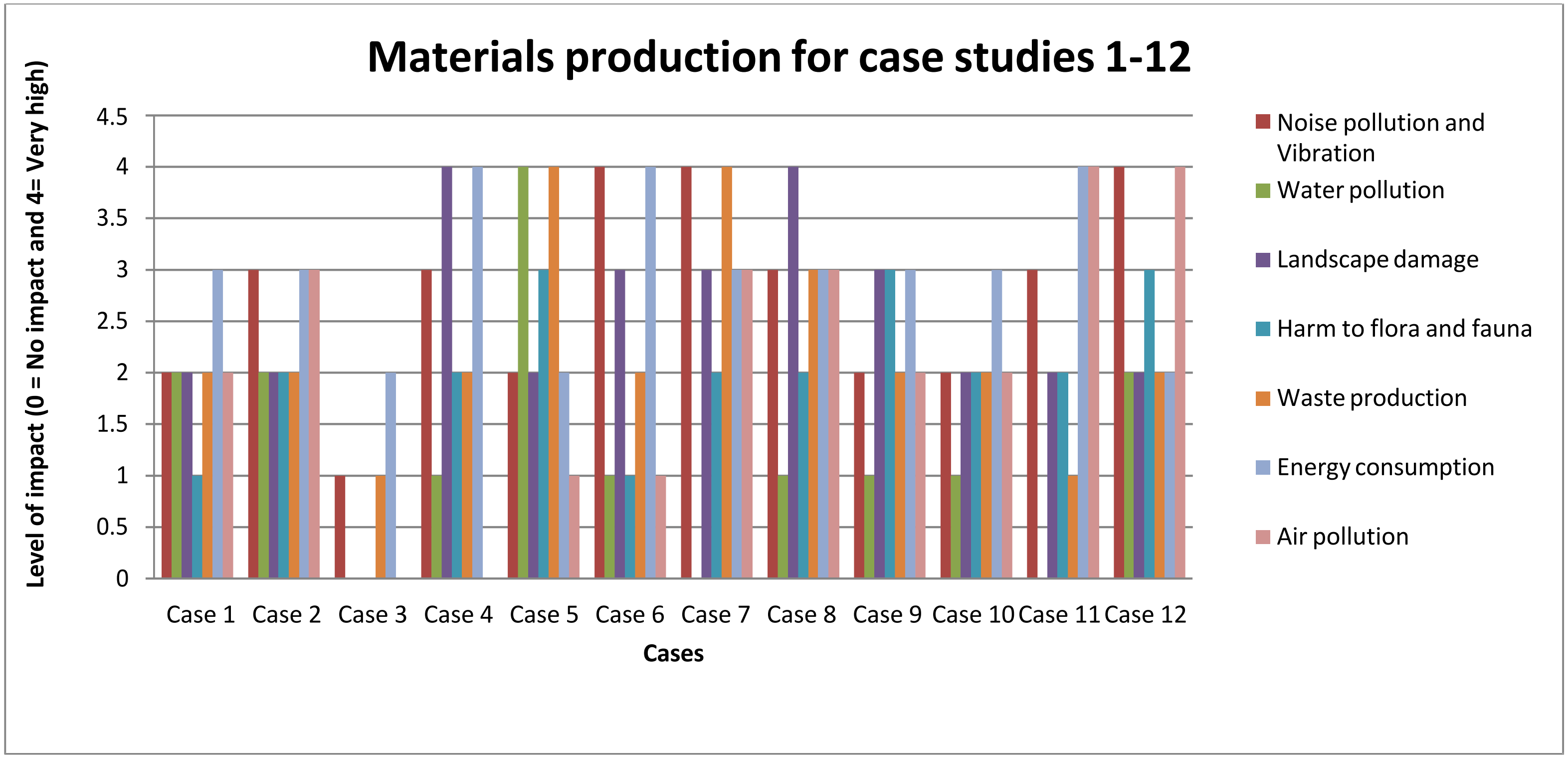


Figure 7.14 Combined impact of material production

7.16 Sustainability reporting

The field work assessed the sustainability reporting by the organisations in the case studies. This revealed that only two (12%) out of the sixteen organisations produce sustainability reports regarding the non-financial matters of their operations as shown in Figure 7.15.

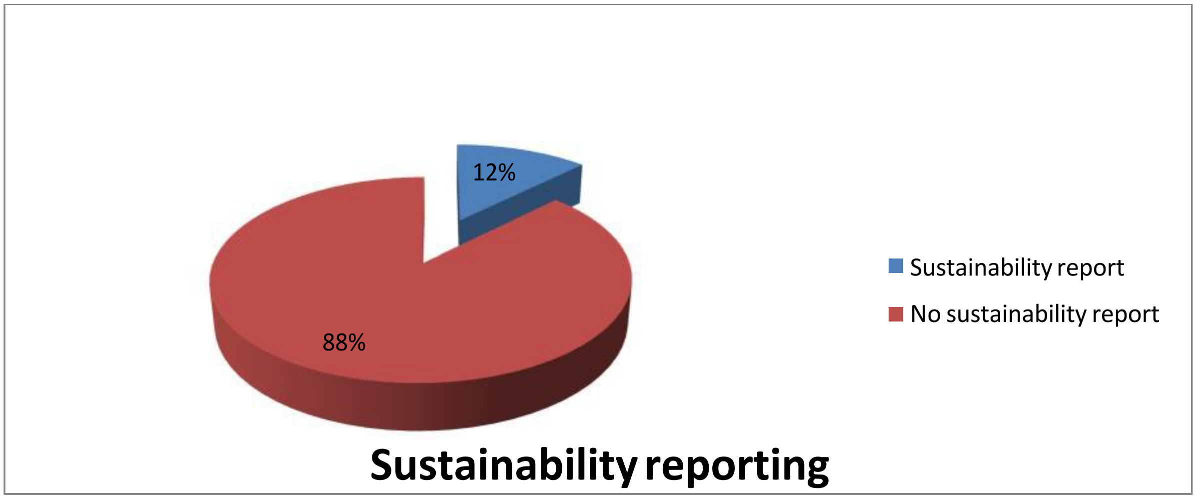


Figure 7.15: Sustainability reporting

7.17 Combined efforts to mitigate the impact of material sourcing

Figure 7.16 shows that the sixteen organisations utilised a few methods regarding air, noise pollution and vibration, landscape damage, harm to flora and fauna, water, waste and energy to mitigate the impact of material sourcing.

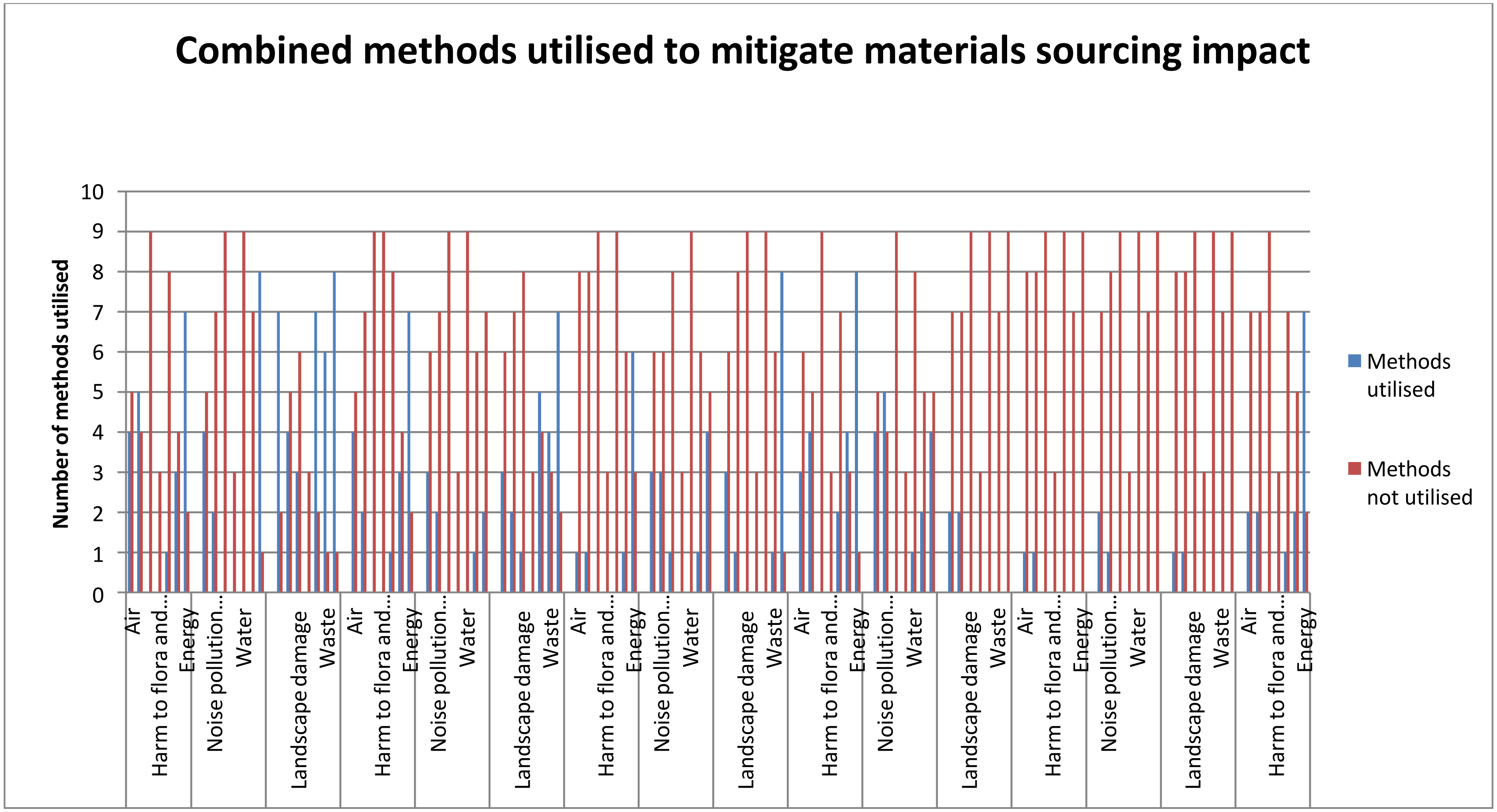


Figure 7.16: Methods utilised to mitigate the material-sourcing impact

7.18 Combined efforts to mitigate the impact of material transportation

Figure 7.17 reveals that the sixteen organisations utilised a few methods to mitigate the impact of material transportation regarding air, noise pollution and vibration, landscape damage, harm to flora and fauna, water, waste and energy.

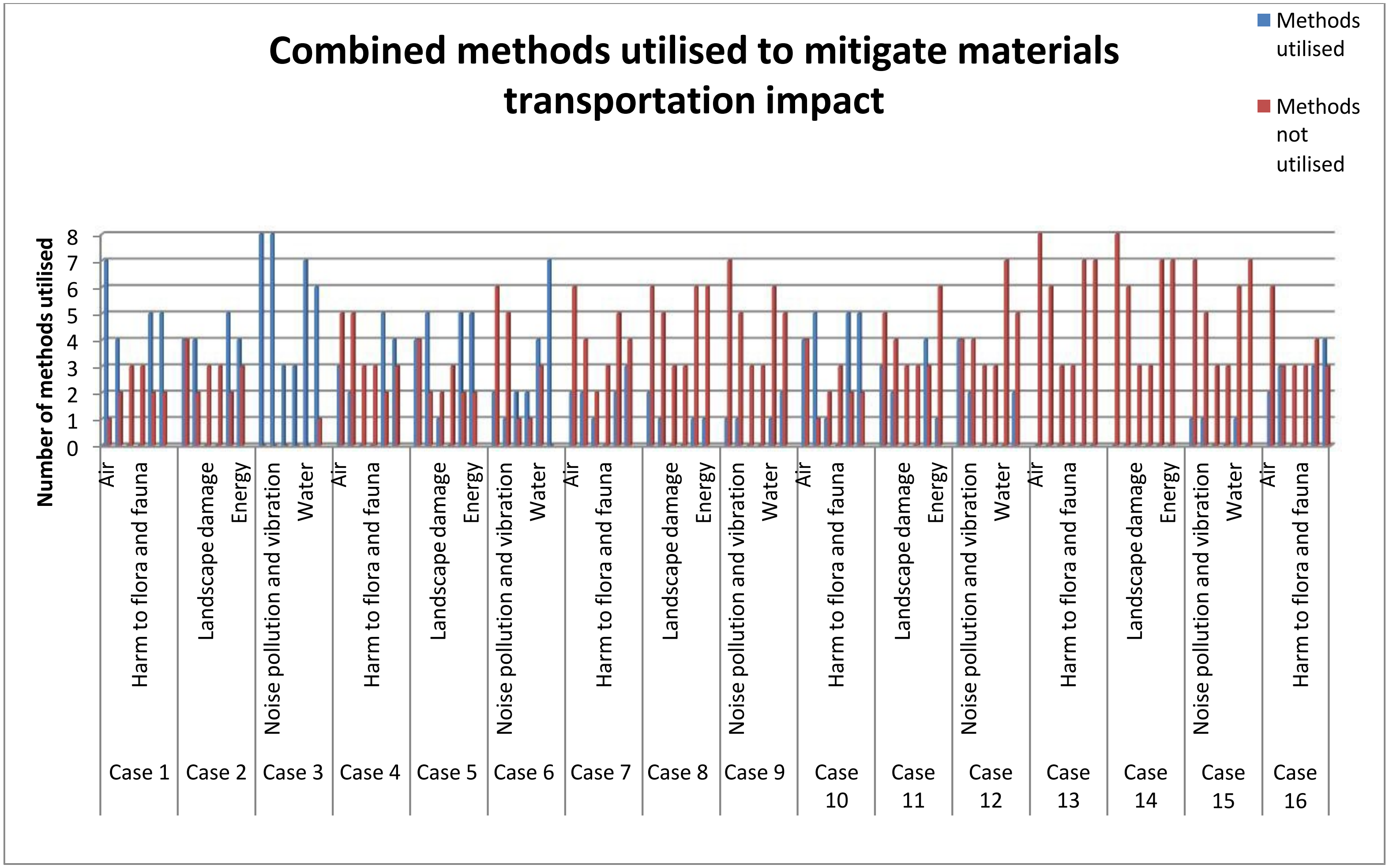


Figure 7.17: Combined methods utilised to mitigate the material-transportation impact

Figure 7.18 shows that the sixteen organisations utilised a few methods to mitigate the impact of material production regarding air, noise pollution and vibration, landscape damage, harm to flora and fauna, water, waste and energy.

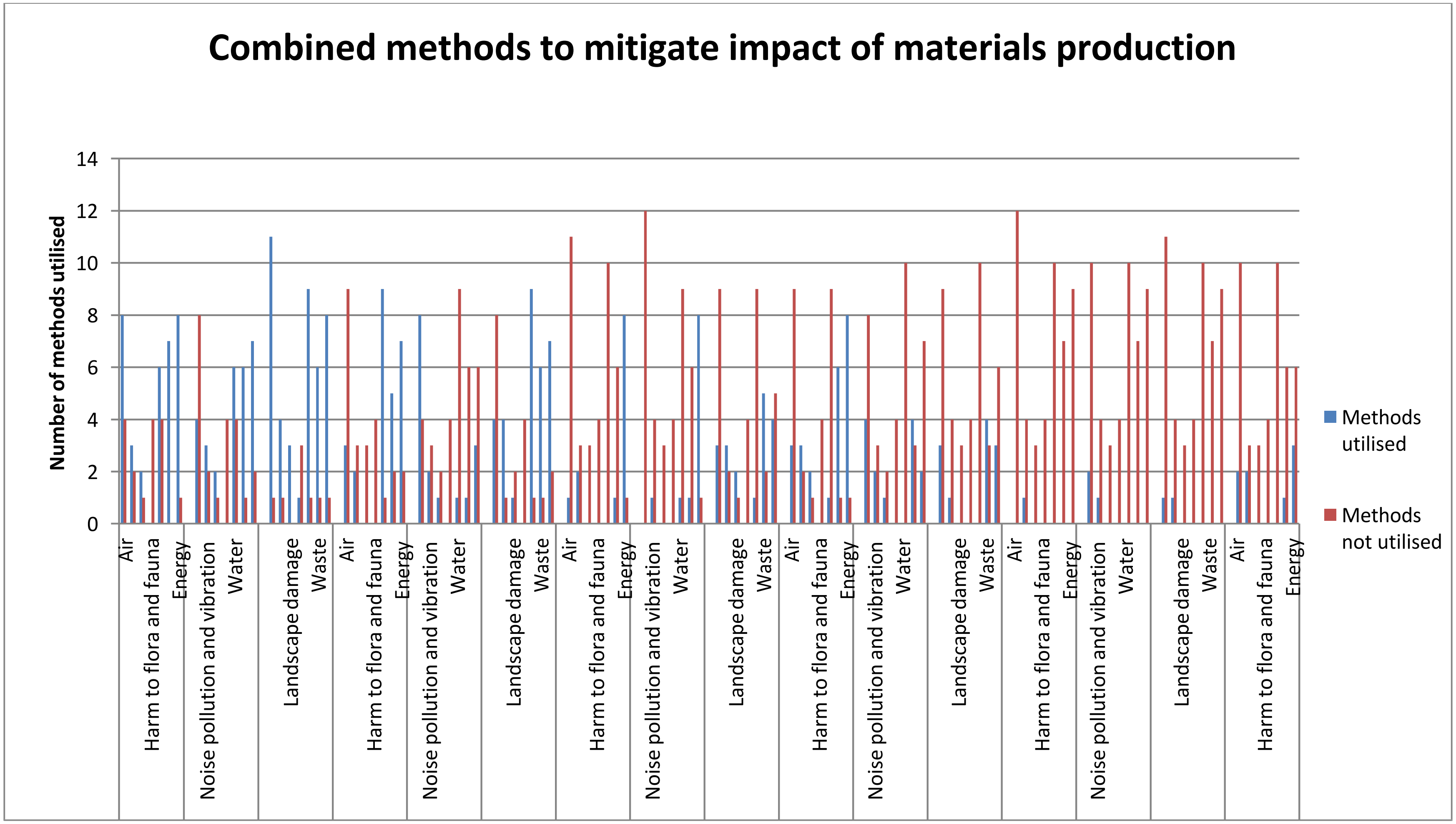


Figure 7.18: Combined methods to mitigate the impact of material production

7.19 Conclusive remarks

This chapter has presented and discussed the combined results emanating from the findings collected from the sixteen (16) cases studies. In the next chapter, the interpretation of the data and the discussion of the research findings are presented in detail.

Chapter 8: Interpretation of the data and discussions on the research findings

8.1 Introduction

This chapter connects the aim and objectives of the research to the data obtained from the field work. It also discusses the results of the study in the light of the existing body of knowledge presented in the literature review.

8.2 Objective one

This is the first objective of the research work; and it was actualised by examining the material-sourcing process for eight construction materials across 16 organisations. Details of the results are presented in sub-sections 8.2.1 to 8.2.10

8.2.1 Site location

The sites at which raw materials are sourced were critically observed, in order to assess their individual status, whether, or not, they were located around an ecologically sensitive area. From the observations, it was noted that the majority of the sites for sourcing raw materials for the production of construction materials are not located around an ecologically sensitive area.

8.2.2 Distance of material-extraction sites from the built-up areas

The purpose here was to examine whether the extraction sites constituted risks to humans and their settlements. The field investigations revealed that the majority of the sites (94%) were far away from buildings and human settlements; hence, they constituted no risks to them.

8.2.3 Mode of sensitization adopted prior to material extraction

An analysis of the mode of sensitization carried out prior to resource extraction by the 16 organisations, revealed that 82% of the organisations, as seen in Figure 7.3, do not carry out sensitization prior to material extraction; either by public campaign awareness, communiqués to the public, media briefing and other available methods of sensitization.

8.2.4 Time of operation

There are certain times of the day which the organisations utilize to extracting raw materials from the earth's crust. These times range from early morning, mid-morning, early afternoon, mid-afternoon, to late afternoon and evening. It was observed that the majority of the organisations operate during early morning, mid-morning, early afternoon, mid-afternoon and late afternoon. Only a very few organisations carry out their extracting process in the evenings.

8.2.5 Method of resource extraction

Natural resources have to be extracted from the earth crust before they can be processed. The methods used for resource extraction are often determined by factors, such as: the type of technology available, cost, nature of environment, and laws and regulations of host communities and government. Methods available for material extraction include: open pits, underground and surface methods. Each of the methods used to extract resources has its own negative impact on the environment, such as disfiguring the landscape, disturbance of inhabitants with noise and dust from blasting; as well as plant operation, soil erosion, water pollution, destruction of flora and fauna.

The findings revealed that 89% of the organisations adopted the open-pit method for material extraction; and this has negatively affected the environment. These negative impacts include: landscape damage, water pollution, air pollution and harm to flora and fauna. These findings are in agreement with the research findings of Ajibola (2013: 276) and Spiegel and Meadows (2012: 36), who revealed the negative impact of resource extraction on the environment to include: landscape damage, water pollution, air pollution and harm to flora and fauna.

8.2.6 Mode of plant and equipment operation

A result regarding the mode of the plant and equipment operation revealed that the majority of the organisations plant and equipment are operated mechanically, as stated in section 6.9 of this study. However, very few organisations use manual methods or the combination of both (mechanical and manual) for their various operations. The implications of the findings regarding the majority of the organisations operating their plant and equipment mechanically, is that energy (fuel) demand and consumption are high. Furthermore, such operations also release green-house gases into the atmosphere. This finding is supported by that of Spiegel and Meadows (2012: 36), that the operation of plant and equipment mechanically increases the energy (fuel) demand; and this also results in the release of greenhouse gases into the atmosphere.

8.2.7 Method of material loading

After the material-extraction processes, material loading commences. A closer look at the method of loading of materials revealed that the majority of the organisations adopted a mechanical method for loading the materials. The implications of this results is that, energy (fuel) demand and consumption are high; and furthermore, loading operations also release green-house gases into the atmosphere

8.2.8 Method of material transportation/ haulage

Raw materials, after excavation, are transported to the production plant for further processing. The study assessed the methods used in transporting raw materials from the material-sourcing point to the material-production point/ usage. The findings revealed that the majority of the organisations transported materials largely by road, using lorries and trucks. Only one organization used a conveyor belt for its operations. The use of lorries and trucks could have a negative impact on the environment by increasing the amount of energy (fuel) needed, and the release of the greenhouse gases into the atmosphere. Furthermore, traffic flow is affected when the materials are moved to various locations, causing congestion. This result is in agreement with the work of Nwanya and Offili (2013: 170) and Spiegel and Meadows (2012: 36) and Kamakaté and Schipper (2009: 3747), who all found that, in Nigeria, the majority of materials are transported by road and this uses a great amount of energy (fuel) that, causes air pollution by discharging greenhouse gases that pollute the environment, thereby contributing to climate change.

8.2.9 Methods of material offloading

Regarding the offloading of materials, the research observed that the majority of the organisations use mechanical methods for the offloading process. The mechanical method involves the deployment of plant and equipment for offloading the materials. This process consumes a great amount of energy (fuel); and it releases greenhouse gases that cause air pollution and contribute to climate change. This notion is supported by Spiegel and Meadows (2012: 37) and Calkins (2009: 40), who found that the use of plant and equipment could have a negative impact on the environment, notably the use of fossil fuels, release of greenhouse gases, the depletion of the protective ozone layer.

8.2.10 Methods of material production/processing

Mechanical methods were observed to be the usual method of material production/ processing. Only a few organisations use manual and other methods for production. It can be inferred that a large amount of energy (fuel) would be required to maintain the production/ processing process; and consequently, more greenhouse gases will be released into the atmosphere. This result corroborates the findings of Spiegel and Meadows (2012: 36). These authors found that the material-production process causes air pollution by releasing dangerous gases into the atmosphere, which also contribute to climate change.

8.3 Objective two

The second objective set out to assess the level of stakeholders' awareness regarding the ethical sourcing of materials. To achieve this, the impact of material sourcing, transportation and production on the environment were assessed in terms of air pollution, noise pollution and vibration, water pollution, landscape damage, harm to flora and fauna, waste production and energy consumption. The extent of such impacts reveals the level of the stakeholders' awareness of the ethical sourcing of construction materials.

8.3.1 The impact of material sourcing on the environment

The study revealed that the impact of material sourcing from the organisations' operations was very high regarding air pollution. The air is polluted due to drilling, blasting and the operation of plant and equipment.

Also, the impact of material sourcing regarding noise pollution and vibration during material sourcing, was very high. The noise pollution and vibration emanate from drilling, blasting; and the operation of plant and equipment. This result supports the findings of Halliday (2008: 121), who affirmed that the impact of material sourcing regarding noise pollution and vibration would be high when stakeholders' level of awareness is low.

For water pollution, it was observed that the material-sourcing operations had a very high impact. Water bodies around the sites, where sourcing operations are carried out, are usually highly polluted to various levels.

The study further revealed that landscape damage occurs – due to sourcing operations, such as drilling and excavation. Spiegel and Meadows (2012: 36); Calkins (2009: 272) and Ajayi and Ikporukpo (2005: 356) also supported the finding that material-sourcing operations impact negatively on the environment by defacing the landscape. The result of this research is also in agreement with the work of Oyinloye and Olofinyo (2017: 26), who noted that the drilling, blasting and crushing of materials have negative impacts on the environment.

Regarding harm to flora and fauna, the result indicated that the impact of material sourcing was very high. The degree of damage to the landscape could be attributed to drilling, blasting, felling and excavation operations. These findings agree with those of Calkins (2009: 272) regarding negative the impact of materials sourcing on harm to flora and fauna.

Regarding energy consumption, it was observed that the impact of material sourcing was very high. The high rate of energy (fuel) consumption could be attributed to the high use of plant and equipment during the sourcing operations. This aligns with the findings of Spiegel and Meadows (2012: 36), who noted that very large amounts of energy (fuel) are consumed during the material-sourcing operation, thereby resulting in an increased demand for fossils fuels.

8.3.2 Impact of material transportation on the environment

After the material-sourcing process has been completed, the next process is the material transportation. Regarding air pollution, the findings revealed that the level of air pollution was very high during material transportation. The level of pollution could be attributed to the high dependency on the transportation of materials by road. This finding is in line with that of Kibwami and Tutesigensi (2016: 65) and Kamakaté and Schipper (2009: 3750), who noted that the air is polluted during material transportation due to the emission of toxic gases from vehicular movement.

The impact of noise pollution and vibration during material operation was observed to be very high. This finding confirms that the level of stakeholders' awareness regarding the ethical sourcing of materials is low.

The result indicated that the impact of material sourcing regarding landscape damage, was very high. This finding is consistent with that of Calkins (2009: 187) regarding landscape damage due to the transportation of materials.

The result regarding water pollution revealed that the impact of material transportation was moderate to various levels.

The impact of energy consumption during material transportation indicated a very high level. The high level of impact could be attributed to the extensive use of lorries and trucks that require regular fuelling and maintenance. This, therefore, increases the demand for fossil fuel, which in the long run causes damage to the climate. This result confirms the findings of Kamakaté and Schipper (2009: 3750), who argued that very high amounts of energy are consumed during material transportation with the use of lorries and trucks; since these vehicles utilise large quantities of fuel.

The level of waste production was observed to be very high, due to damage of materials during transportation. This finding is in line with that of Spiegel and Meadows (2012: 37), who highlighted the fact that very large amounts of waste are generated during material transportation.

Regarding waste production, the result revealed that the impact of material transportation was very high.

8.3.3 The impact of material production on the environment

The production stage was the last stage assessed in the research. This is the stage during which the materials are then processed into the finished products. The level of impact regarding air pollution was observed to be very high. The level of air pollution could be attributed to the lack of adequate policies and plans to mitigate the negative environmental impact. This finding agrees with the research carried out by Lin and Xu (2017: 980) and Roosa (2008: 89) who noted that large amounts of pollutants are released into the atmosphere during material production. The long-term impact of air pollution would cause climate change, the melting of ice glaciers, an increase in the ocean water level, and desertification amongst other consequences.

Regarding noise pollution and vibration, the impact of material production was very high. Further credence to the findings regarding air pollution was presented by Dalal-Clayton and Bass (2002: 9), who submitted that the level of noise pollution and vibration is very high during material production.

On water pollution, the result indicated that the level of impact regarding material production was very high.

For landscape damage, the data showed that the level of impact regarding material production was very high. In support of this finding, Zenebe (2016: 38) confirmed that material sourcing for the construction industry has a very high negative impact on the landscape.

Regarding harm to flora and fauna, the study revealed that the level of impact due to material production was very high.

On waste production during the material production, it was observed that the level of waste production was moderate.

Regarding material production, the result indicated that the level of energy consumption was very high. This finding is in line with that of Ali *et al.* (2011; 2251) and Dalal-Clayton and Bass (2002: 9), on energy consumption, who noted that a very large quantity of fuel is consumed during the material production process.

8.4 Objective three

The third objective was to examine sustainability reporting regarding material sourcing. Sustainability reporting by organizations, is where they report issues not relating to financial matters. Sustainability reports are intended to state efforts made by organisations in minimizing the environmental impact of their operations with respect to: energy use; emissions into the atmosphere; biodiversity and waste generated. The study observed that the majority of organisations do not produce or make any effort to disclose the information relating to the impact of their activities on the environment and other non-financial matters.

Coincidentally, this result validates the findings of Loosemore *et al.* (2017: 15) and Glass (2012: 100) regarding sustainability reporting in the construction industry. A reason why the majority of the organisations do not carry out sustainability reporting was noted by Pactwa and Woźniak (2017: 201) and Lozano and Huisingh (2011: 100) who contended that the non-compulsion of sustainability reporting for organisations has had an impact on the number of sustainability reports carried out. Another reason why the majority of organisations do not produce sustainability information is traceable to the need to focus more on survival and stability, due to stiff competition.

8.5 Objective four

This objective was to assess the methods utilised to mitigate the challenges hindering the ethical sourcing of materials. To achieve this objective, observation was carried out to assess the methods utilised by the organisations in mitigating the impact of material sourcing, transportation and production on air, noise pollution and vibration, landscape damage, harm to flora and fauna, water, waste and energy.

8.5.1 Methods utilised to mitigate the material-sourcing impact on the environment

The organisations in the case studies utilised a few methods (minimising operations during windy periods, increasing distance from nearest building, tapping of drilled holes before blasting and maintenance of plant and equipment) to mitigate the impact of material sourcing on air pollution.

A few methods (maintenance of plant and equipment, early public notification of extremely noisy operation, limiting working time to day light hours and use of modern equipment) were utilised by the organisations to mitigate the impact of material sourcing regarding noise pollution and vibration.

Regarding landscape damage, few methods (slope stabilisation through vegetation planning, application of fertilizer, lime, tillage and re-vegetation and reduced-impact logging) were utilised by the organisations to mitigate the impact of material sourcing. This finding is also consistent with those of Tietenberg and Lewis (2016: 319), who noted that only a few methods are generally utilised to mitigate landscape damage during material sourcing.

Only a method (continuous monitoring to maintain pH levels) was utilised by the organisations to mitigate the impact of materials regarding the harm to flora and fauna.

On methods utilised by the organisations in mitigating the impact of materials sourcing regarding water, a few methods (recycling of water, protection plan, design of mining approaches that exclude water and management of surface water) were utilised.

Regarding waste, a few methods (use of modern plant and equipment for sourcing/ extraction and installation of a mobile crushing/ grinder- pulverisation unit at quarry site and recycling of waste) were utilised by the organisations to mitigate the impact of material sourcing. This finding also supports those of Rauschmayer *et al,* (2015: 212), who established that only a few methods were utilised to mitigate the impact of material sourcing regarding waste.

8.5.2 Methods utilised to mitigate the impact of material transportation on the environment

Regarding methods utilised by the organisations to mitigate the impact of material transportation, the findings illustrate that few methods (transport pooling/ limiting hauling, selection of suitable routes; wet suppression and maintenance of plant and equipment) were utilised to mitigate the impact regarding air.

For noise pollution and vibration, the results reveal that few methods (transport pooling/ limiting hauling and selection of suitable routes) were utilised by the organisations to mitigate the impact of material transportation on the environment.

Regarding methods utilised by the organisations to mitigate landscape damage due to materials transportation, it was observed that use of alternative routes was utilised.

None of the proposed methods (buffer strips, watering of soil, covering of transported materials) were utilised by the organisations in mitigating the impact of material transportation regarding harm to flora and fauna.

On methods utilised by the organisations to mitigate the impact of material transportation regarding water, many organisations utilised few methods (selection of suitable routes, proper training of drivers and reducing fuel spills).

Regarding methods utilised by the organisations to mitigate the impact of material transportation regarding energy, it was observed that some methods (use of modern plant and equipment for loading and transportation, educating employees regarding plant and equipment idling. optimising pit and mine design and transport pooling/ limiting hauling) were utilised.

8.5.3 Methods utilised to mitigate the material-production impact on the environment

The organisations in these case studies utilised few methods (increasing distance from nearest building, maintenance of plant and equipment, continuous monitoring and recording of emissions and using water-cooled tools) to mitigate the impact of material production regarding air.

Few methods (limiting working time to normal working hours and maintenance of plant and equipment) were utilised by the organisations to mitigate the impact of material production regarding noise pollution and vibration.

Regarding waste, few methods (re-crushing to form aggregate, use of modern plant and equipment and re-use of fine grained solid rejects for further production) were utilised by the organisations to mitigate the impact of material production.

With respect to energy, it was observed that many methods (implementation of energy saving/ conservation measures for plant and equipment e.g catalysts, reducing fuel spills, regular energy audits and maintenance, minimisation of non- utilised power and educating employees regarding plant and equipment idling and turning off lights) were utilised by the organisations to mitigate the impact of material production.

Regarding water, few methods (recycling of water and use of reclaimed effluent and other recycled water for cooling) were utilised by the organisations to mitigate the impact of material production.

A method (continuous monitoring to maintain pH levels) was utilised by the organisations to mitigate the impact of material production regarding harm to flora and fauna.

On methods utilised by the organisations to mitigate the impact of material production regarding harm to landscape damage, a method (enclosure of fuel and chemical) was utilised.

8.6 Objective five

The fifth objective was to review the existing frameworks on the ethical sourcing of materials. This objective required an examination of the relevant ethical sourcing frameworks. The sources of materials used emerged from journals, books, conference proceedings and internet sources.

The review highlighted the need to promote ethical practices at the local, regional and international level. This requires the support of government, business organisations, non-governmental organisations and private individuals to promote and improve their ethical practices.

The literature identified key areas for ethical sourcing to include: greenhouse gas emissions, energy use, resources used, waste prevention and waste management, transportation management, resource consumption and disclosure of the relevant information.

8.7 Objective Six

This section presents the framework developed for the ethical sourcing of construction materials based on the comprehensive literature review and the outcome of the 5 objectives. The aim of this research is to develop a framework for the ethical sourcing of materials with a view to enhancing sustainability practice in the Nigerian construction industry.

The development of the framework was guided by in-depth data collection, analyses of the result that emerged from the study. Therefore, the concepts relate to materials sourcing, transportation and production. Moreover, this study focuses on increasing awareness for the ethical sourcing of construction materials in Nigeria. The conceptual framework developed gave a guide to the framework developed for ethical sourcing of construction materials.

The framework developed for ethical sourcing of construction covers four (4) key areas which are: sustainable materials sourcing, sustainable materials transportation, sustainable materials production and sustainability reporting. The summary of the salient features of the four (4) key areas supporting the framework developed for the ethical sourcing of construction are presented in sub-frameworks in Figure 8.1, 8.2, 8.3, and 8.4 respectively.

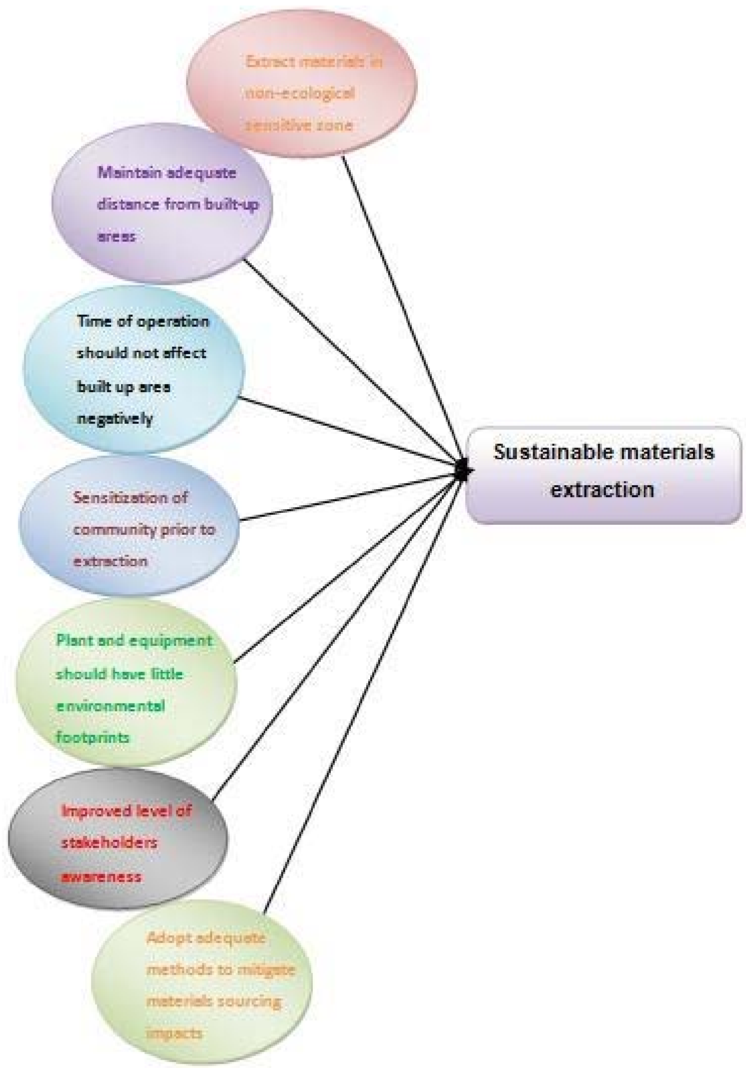


Figure 8.1: Sub-framework for the ethical sourcing of construction materials (sustainable materials extraction)

Source: Researcher's own construct, 2018

The basic factors to be considered for sustainable materials extraction as depicted in Figure 8.1 are:

I. Extract materials in non-ecological sensitive zone;
II. Maintain adequate distance from built-up areas;
III. Time of operations should not affect built up area negatively;
IV. Sensitization of community prior to extraction;
V. Plant and equipment should have little environmental footprints;
VI. Improve level of stakeholder's awareness; and,
VII. Adopt adequate methods to mitigate materials sourcing impacts.

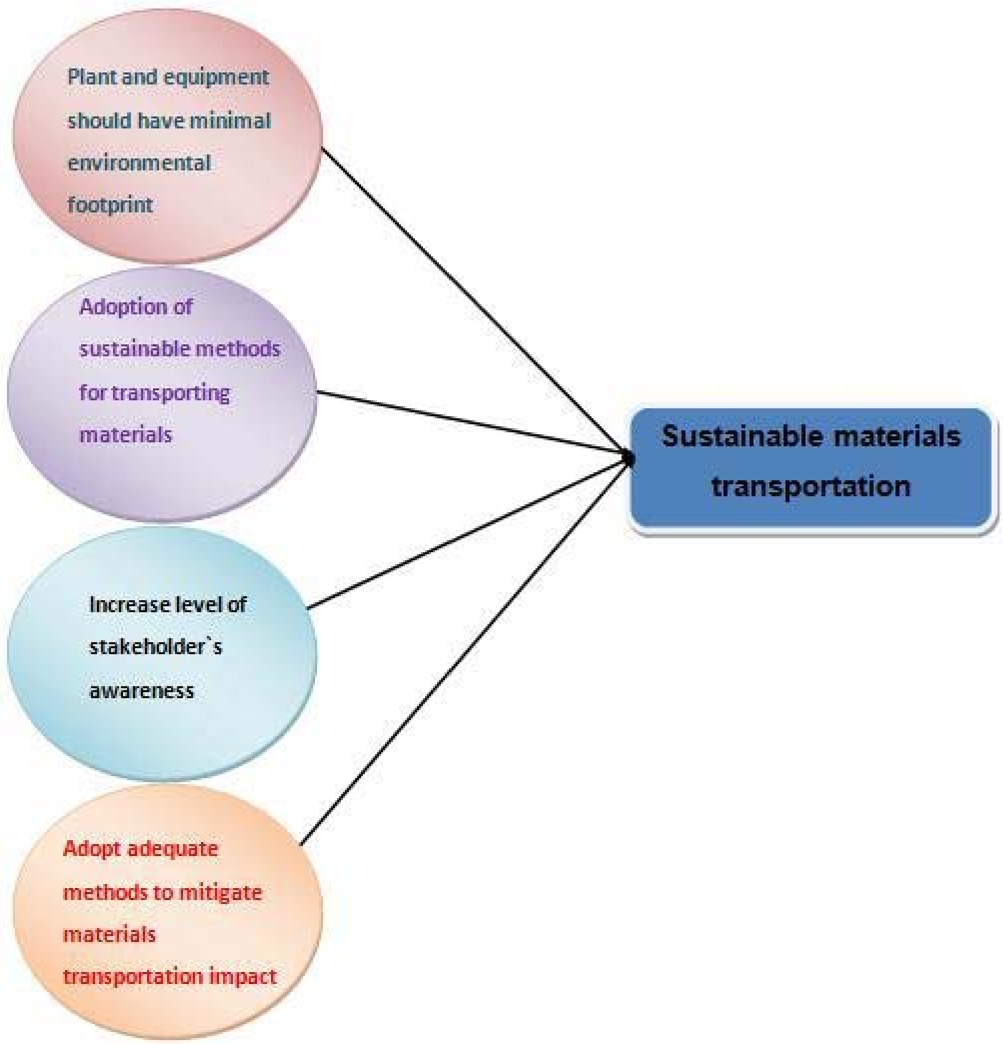


Figure 8.2: Sub-framework for the ethical sourcing of construction materials (sustainable materials transportation)

Source: Researcher's own construct, 2018

Regarding sustainable materials transportation sub-framework for ethical sourcing of construction as show in Figure 8.2, key items to be noted are:

I. Plant and equipment should have minimal environmental footprint;
II. Adoption of sustainable methods for transporting materials;
III. Increase level of stakeholder`s awareness; and,
IV. Adopt adequate methods to mitigate materials transportation impact.

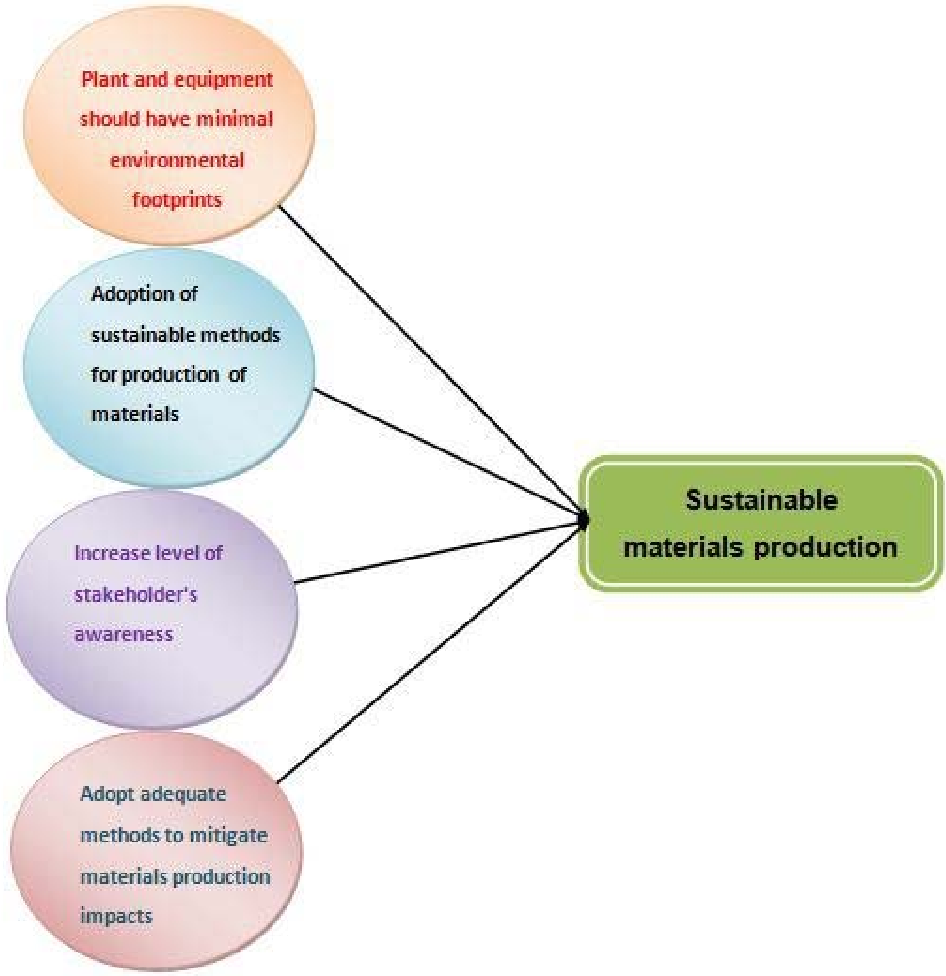


Figure 8.3: Sub-framework for the ethical sourcing of construction materials (sustainable materials production)

Source: Researcher's own construct, 2018

The sustainable material production sub-framework for ethical sourcing of construction materials is presented in Figure 8.3, the key items to be taking cognizance of are:

i. Plant and equipment should have minimal environmental footprints;
ii. Adoption of sustainable methods for production of materials;
iii. Increase level of stakeholder`s awareness; and,
iv. Adopt adequate methods to mitigate materials production impacts.

Figure 8.4: Sub-framework for the ethical sourcing of construction materials (sustainability reporting)

Source: Researcher's own construct, 2018

The sustainability reporting sub-framework for ethical sourcing of construction materials is presented in Figure 8.4, major points to be noted regarding sustainability reporting are:

I. Report organisations environmental performance and impacts;
II. Report organisations economic performance and impacts; and,
III. Report organisations social performance and impacts.

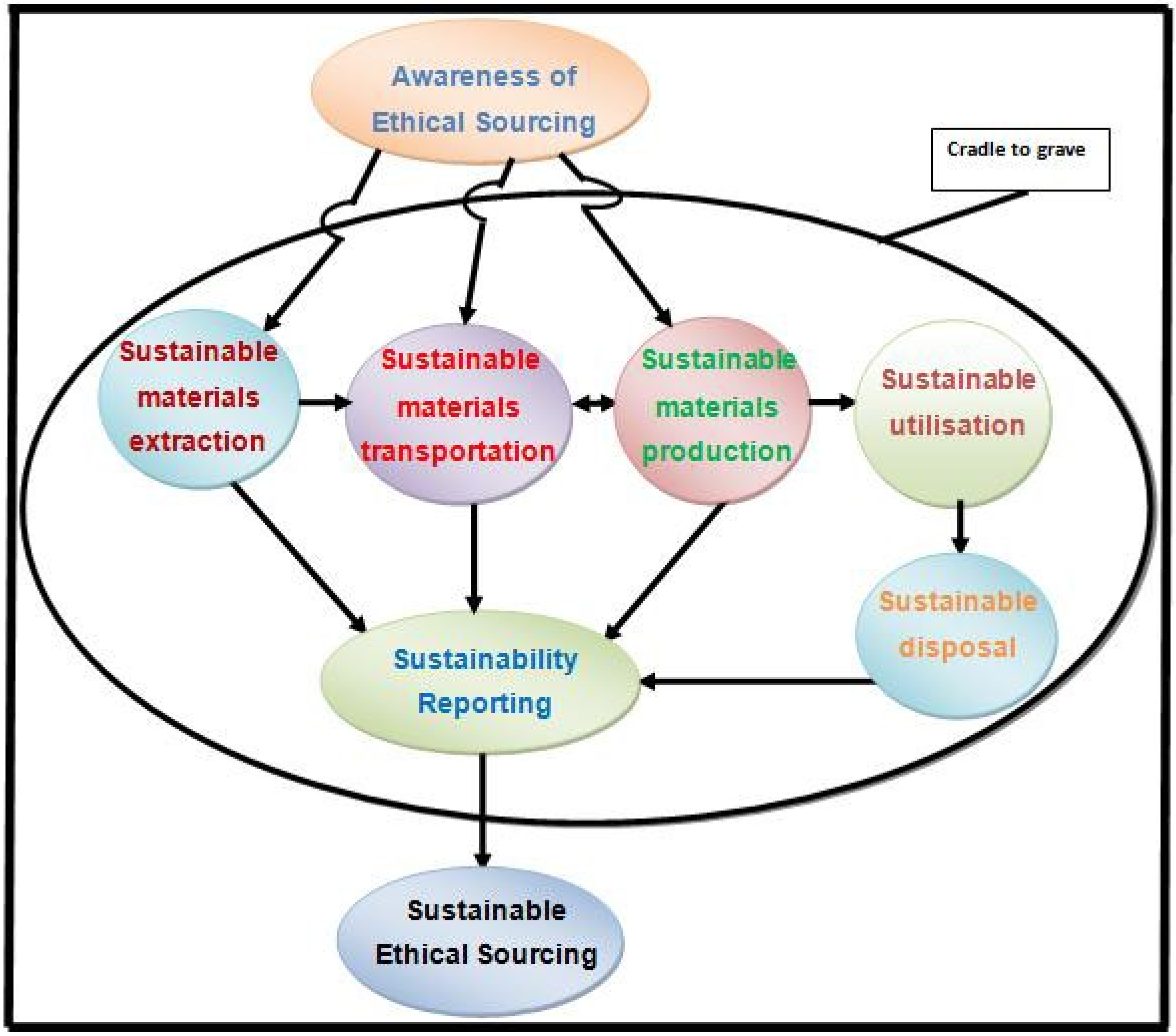


Figure 8.5: Framework for the ethical sourcing of construction materials in Nigeria

Source: Researcher's own construct, 2018

The framework in Figure 8.5 emerged from outcomes of the five (5) objectives of the study. The framework also depicts the links between the sub-frameworks as shown in Figures 8.1, 8.2, 8.3, and 8.4.

Firstly, there is the need for awareness of ethical sourcing relating to sustainable materials sourcing, sustainable materials transportation; and sustainable materials production. The next step entails carrying out: sustainable utilisation, sustainable disposal, and then sustainability reporting for all the previous activities carried out with regards to sourcing of construction materials.

The combination of all the sub-frameworks will enable materials to be ethically sourced in the Nigerian construction industry.

8.15 Conclusive remark

This chapter has discussed the findings of the research with respect to the objectives of the study. In the next chapter, the summary, conclusions, recommendations and contributions to the body of knowledge will be presented.

Chapter 9: Summary, Conclusions and Recommendations

9.1 Introduction

The summary of the research findings, the conclusions, as well as the recommendations to various stakeholders and the contributions of the research to the existing body of knowledge are presented in this chapter. The chapter also brings to light the limitations of the study; and then it suggests some areas for further academic inquiry.

9.2 Summary of the Research

The research aimed at developing a framework for the ethical sourcing of construction materials – with a view to enhancing sustainability practice in the construction industry. This was borne out of criticisms and calls for the construction industry to operate sustainably due to the negative environmental impact its operations have on the environment, particularly in developing countries, such as Nigeria. The negative impact, if left unchecked, could affect present and future generations. The research reviewed the extant literature on sustainability, sustainable development, environmental management; and it identified the concepts relating to sustainability in the construction industry. These led to identification and selection of the main constructs, the research question and the objectives for the research.

9.2.1 Research Problem

There is little and disparate research-based evidence to show that construction materials are ethically sourced in Nigeria.

9.2.2 Research Hypotheses

H1.1: The sourcing methods adopted lead to environmental and health challenges in the Nigerian construction industry.

H2.2: The lack of knowledge on ethics leads to challenges in the sourcing of construction materials.

H3.3: The lack of knowledge and commitment to sustainability reporting results in the unethical sourcing of materials in the construction industry.

H4.4: The scarcity of methods utilised lead to suboptimal mitigations of the challenges in the environment.

H5.5: A framework would enable the ethical sourcing of materials.

H5.6: A framework would guide the way for the development of such a framework.

9.2.3 Research Objectives and Aims

The objectives of this research are to:

i. Examine the methods adopted for material sourcing for the construction industry;
ii. Assess the level of stakeholder's awareness regarding the ethical sourcing of materials;
iii. Examine sustainability reporting in materials sourcing;
iv. Assess the methods utilised to mitigate the challenges hindering the ethical sourcing of materials;
v. Review the existing frameworks on the ethical sourcing of materials;
vi. Use the outcomes of the first five objectives above to develop a practical and feasible framework that can address the challenges of the ethical sourcing of materials in the Nigerian construction industry.

The aim of this research is to develop a framework for the ethical sourcing of materials with a view to enhancing the practice of sustainability in the Nigerian construction industry.

9.2.4 Research methodology and sampling techniques

The literature reviewed in Chapters 2 and 3 illustrated that sustainable construction is an area that is accorded insufficient attention in the construction industry – particularly from the perspective of the developing countries.

An assessment of the problem critically revealed that the research required a qualitative approach. The Epistemological position of the research is subjectivist; and it requires the observation of events critically.

The research studied sixteen organisations by using a case-study approach; they were purposively selected and a non-probabilistic sampling technique was adopted; because it chose the most revealing subject / entity that represents the other observable facts.

9.2.5 General summary

This section discusses the general summary of this study from Chapters 1 to 9.

Chapter 1 discussed the contribution of the construction industry to the social-economic growth of a nation. Sustainability and sustainable development needs were discussed in the lens of the negative impacts that the construction industry has on the environment. Ethical conduct by the relevant stakeholders in the construction industry was also briefly discussed as a possible solution to environmental issues.

Chapter 2 presented an overview of Nigeria, with respect to its demographic, environmental policies and legislation.

Chapter 3 discussed ethics, the sources of ethical theories, the approaches to ethical theories and the most common unethical practices in the construction industry. The study identified and discussed the existing frameworks for ethical sourcing, notably: BES 6001 Framework Standard for the Responsible Sourcing of construction products, Operational Context Space (OCS) Framework and United Global Compact Framework, among others.

In Chapter 4, a theoretical framework was developed by using environmental sustainability, sustainable reporting, materials production and materials transportation as the constructs for the study. The theoretical framework led to the development of a conceptual framework, which encompasses sustainable sourcing, ecological footprints and environmental ethics. Ethics was the common ground between the constructs in the conceptual framework. The chapter further discussed sustainability, sustainable development, sustainability assessment and indicators, environmental challenges, climate change and the factors influencing climate change. Again, the study highlighted the issues relating to sustainable construction, the existing framework for evaluating sustainable construction, and the barriers to achieving construction. The chapter also discussed various international policies and global milestones for reducing the impacts of climate change.

The research methodology and techniques used for the study were presented and discussed in Chapter 5. To achieve the research aim and objectives, the rationalist viewpoint was chosen in line with subjective epistemology. A qualitative research method was used, due to the subjective characteristics of the study. A research instrument was designed that was used to observe how the activities relate to sourcing, transportation and the production of materials for the construction industry. The study also assessed the efforts adopted to mitigate the impact of materials sourcing, arshar, M., 20 and the production of materials for the construction industry.

In Chapter 6, the data collected from the individual case studies were presented and discussed, using descriptive statistics. Bar and pie charts were used to present the results of each case study.

In Chapter 7, a combined approach was used to present and discuss the combined case studies. The results were presented using bar and pie charts.

For Chapter 8, interpretation of the data and the discussions of the research findings in line with the research objectives were conducted. A framework for the ethical sourcing of materials for the construction industry was presented in Chapter 8.

9.2.7 Summary of the overall findings

In this section, a summary of the overall findings is presented.

An empirical study was conducted to determine the impacts of the activities of companies involved in sourcing, transportation and the production of construction materials have on air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna, waste management and energy consumption. Furthermore, the study assessed the efforts adopted to mitigate the impacts of their activities on air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna, waste management and energy consumption.

The study revealed that material sourcing, transportation and production are having a negative impact on the environment. The study further presented evidence of inadequate efforts utilised in mitigating the impacts of their activities on air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna, waste management and energy consumption.

9.2.8 Fulfilment of the research objectives

The fulfilment of the research objectives is presented in this section.

9.2.8.1 Objectives 1: to examine the methods adopted for material sourcing for the construction industry

To achieve this objective, a field work was carried out.

i. Site location

The study observed that the majority of the sites (94%), where the sourcing of materials is carried out, are not located in an ecologically sensitive area. Analyses were provided in Figure 6.2.

ii. Distance of material-extraction sites from built-up areas

The study revealed that the majority of the sites where raw materials are extracted are far from buildings/homes. The results were summarised in Figure 6.3.

iii. Mode of sensitization adopted prior to material extraction

The majority of the communities and people living around sites where materials are extracted are not sensitised before material extraction takes place. The results were presented in Figure 6.4.

iv. Time of operation

The time of operations regarding material sourcing range from early morning, mid-morning, early afternoon, mid-afternoon to, late afternoon and evening. The result were presented in Figure 6.5.

v. Method of construction materials' extraction

The methods used for resources extraction were: open pits, underground and surface methods. Open pit is the most frequently adopted method for resources extraction. A summary of the results was provided in Figure 6.6.

vi. Mode of plant and equipment operation

Most of the plant are operated mechanically. The results were presented in Figure 6.7.

vii. Method of material loading

The majority of the materials are loaded mechanically. A summary of the results were presented in Figure 6.8.

viii. Method of material transportation/ haulage

Most of the materials are transported by road. The results were presented in Figure 6.9.

ix. Methods of material offloading

The mechanical method is the most frequently used for offloading the material. The results were presented in Figure 6.10.

x. Methods of mechanical production/processing

Mechanical methods for the production/processing were the major methods used. A summary of the result was presented in Figure 6.11. This objective has been achieved.

9.2.8.2 Objective 2: level of awareness of stakeholders regarding the ethical sourcing of materials

The findings of this objective are presented in three sections: impact of materials sourcing on the environment; the impact of material transportation on the environment; and the impact of material production on the environment.

9.2.8.2.1 Level of stakeholders' awareness regarding material sourcing

This section presents a summary of the research on the level of stakeholders' awareness regarding material sourcing. The results were presented in Figure 6.12.

The level of stakeholders' awareness regarding the ethical sourcing of materials for material sourcing on air pollution, noise pollution, water pollution, landscape damage, harm to flora and fauna, waste production and energy consumption is low.

9.2.8.2.2 Level of stakeholders' awareness regarding material transportation

This section presents a summary of the research on the level of stakeholders' awareness regarding material transportation. A summary of the results was presented in Figure 6.13.

There is a low level of stakeholders' awareness regarding the environmental impact of materials transportation on air pollution, noise pollution and vibration, landscape damage, energy consumption, waste production and harm to flora and fauna.

However, the stakeholders demonstrated that they have a moderate level of awareness regarding water pollution.

9.2.8.2.3 Level of stakeholders' awareness regarding material production

This section presents a summary of the research on the level of stakeholders' awareness regarding material production. The result were presented in Figure 6.14.

The level of stakeholders' awareness regarding the ethical sourcing of materials for material sourcing on air pollution, noise pollution, water pollution, landscape damage, harm to flora and fauna, waste production and energy consumption is low. This objective has been achieved.

9.2.8.3 Objectives 3: to examine the sustainability reporting in material sourcing

The study discovered that the majority of the organisations do not produce sustainability reports. The results were presented in Figure 6.15. The study has achieved this objective.

9.2.8.4 Objectives 4: to assess the methods utilised to mitigate the challenges hindering the ethical sourcing of materials

The findings of this objective are presented in three sections: Efforts adopted to mitigate material-sourcing impact on the environment; efforts adopted to mitigate the material transportation impact on the environment and the efforts adopted to mitigate material production impact on the environment.

9.2.8.4.1 Methods utilised to mitigate the material-sourcing impact on the environment

This section presents a summary of the research on the efforts adopted to mitigate material-sourcing impact on the environment. The results were presented in Figure 6.16.

The research findings show that efforts applied to mitigate the impact of material sourcing regarding air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna, water, waste, energy are inadequate.

9.2.8.4.2 Methods utilised to mitigate the material-transportation impact on the environment

This section presents a summary of the research on the efforts adopted to mitigate the material-transport impact on the environment. A summary of the results was presented in Figure 6.17.

The results show that inadequate efforts are applied to mitigate the impact of material transportation regarding air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna, water, waste; and energy are inadequate.

9.2.8.4.3 Methods utilised to mitigate the material-production impact on the environment

This section presents a summary of the research on the efforts adopted to mitigate the material-production impact on the environment. The results were presented in Figure 6.18.

The research findings clearly show that the efforts applied to mitigate the impact of material production regarding air pollution, noise pollution and vibration, landscape damage, harm to flora and fauna, water, waste; and energy were inadequate. This objective has been achieved.

9.2.8.5 Objectives 5: to review existing frameworks on the ethical sourcing of materials.

The fifth objective reviewed existing frameworks relating to ethical sourcing of materials. From the review of literature, important areas relating to ethical sourcing of materials including: greenhouse gas emissions, energy use, resources used, waste prevention and waste management, transportation management, resource consumption and disclosure of the relevant information were discussed. The conceptual, theoretical and ethical sourcing frameworks for construction materials in Nigeria all emerged after reviewing existing frameworks on ethical sourcing of materials. Thus, study has achieved this objective

9.2.8.6 Objectives 6: to use the outcome of the five objectives above to develop a practicable and feasible framework that can address the challenges of the ethical sourcing of materials in the Nigerian construction industry.

The final objective aimed at developing a framework for ethical sourcing of construction materials in Nigeria. The framework developed provides pathways that will increases sustainability practices in the Nigeria construction industry. The framework shown in Fig 8.5 evolved after carrying out empirical studies, review of relevant literature on sustainability and sustainable construction practices and using the outcome of the other five objectives. The framework developed when carefully implemented would enhance sustainability practices in the Nigerian construction industry. The final objective of this research was thus achieved.

It can be concluded that all the six objectives for the study have been achieved.

9.3 General conclusion

From the reviewed literature, the construction industry occupies a strategic position for human development; but it has implicitly or explicitly succeeded in creating problems for the present and upcoming generations. Challenges currently affecting the world have been linked to various operations in the construction industry.

The study concludes that majority of the sites of the organisations studied in the research (94%), where raw materials are sourced for the production of various construction materials are not located in ecologically sensitive areas. Their locations present little risk to environment.

It is also concluded that majority of the organisations (82%) do not carry out sensitization; either by public campaign awareness, communiqués to the public, media briefing and other available methods of sensitization before they commence extraction of raw materials used for the production of construction materials.

The study also concludes that Road transportation using trucks and bulldozers is the most-used means of transporting materials.

The study concludes that the levels of stakeholders' awareness regarding the ethical sourcing for materials sourcing, transportation and production are low.

From the empirical study carried out, it was noted that the majority (88%) of organisations do not produce reports relating to non-financial issues. Hence, the study concludes that sustainability reporting is low in the Nigerian construction industry.

It is concluded that the efforts adopted by organisations to mitigate the impact of materials sourcing, transportation and production on the environment are inadequate.

9.4 Contributions to Knowledge

The results unveiled by this study contribute to a better understanding of the material-sourcing process, with respect to sustainability in the construction industry from the perspective of the developing countries; and from Nigeria, in particular. These include:

1. The research has increased the understanding of the level at which companies engage in sustainability reporting in the construction industry (see Figure 7.15, page 281).
2. The research has developed a clear theoretical framework for an enhanced understanding of the relationship between sustainable environmental-footprint reporting and the ethical sourcing of materials in the construction industry (as shown in Figure 4.1).
3. The research has developed a concise conceptual framework for the ethical sourcing of materials for the Nigerian construction industry (see Figure 4.11).
4. The research has developed a framework for the ethical sourcing of materials for the construction industry in Nigeria.
5. The research has developed a bespoken methodology to examine the ethical sourcing practice in the construction industry.

9.5 Critical review of the methodology adopted

A purposive sampling technique was adopted in the research for the selection of organisations that significantly source construction materials in Nigeria. The study acknowledges the shortcoming associated with use of non-probabilistic sampling techniques, such as is its inability to be generalised; since statistical analyses were not performed. Currently, the results from the study can be said to be hypothetical, owing to the sample size of the case study.

The study might be applicable to countries that share the same developmental status as Nigeria. Furthermore, it can only be adopted if similar materials are considered in the study.

9.6 Recommendations

Based on the research findings that emanated from the study, the following are recommended.

9.6.1 To the government and policy-makers:

I. Sustainability reporting should be made mandatory in the construction industry.
II. Erring organisations, whose operations are found to be polluting the environment should be heavily fined and sanctioned.
III. Tax incentives should be given to organisations that adopt sustainability practices in the construction industry.

9.6.2 To professionals in the construction industry:

I. Only ethically sourced construction materials should be purchased.
II. Professionals should know the various sources of the materials supplied to them.
III. Price should not be the major focus in decision-making.

9.6.3 To organisations engaging in the sourcing of construction materials

I. Sustainability policies should be implemented across the various sourcing units and departments.
II. They should seek ways of achieving environmental sustainability with profit-making in their organisations.
III. The organisations should engage in corporate social responsibility for the host communities.

9.7 Recommendations for further research

I. Research should be carried out on other materials that are used in the construction industry.
II. The socio-economic impact of material-sourcing should be investigated.
III. Investigations should be carried on whether the results of this study are applicable to the developed countries.

9.8 Caution

The research findings are hypothetical in their current form, due to the methodology adopted; hence care must be taken before adopting and implementing the findings.

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Appendix 1: Introduction letter

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25th November, 2016.

Dear Sir/ Madam,

PhD. Research Thesis: Mr Ibrahim, Kabir

I wish to confirm that the bearer of this letter **Mr Ibrahim, Kabir** is a bonafide PhD candidate in the Department of Construction Management in the School of Built Environment, Nelson Mandela Metropolitan University in Port Elizabeth, South Africa. His thesis project is titled " Framework for Ethical Sourcing of Construction Materials".

Mr Ibrahim is at the moment carrying out field studies and requires input from industry/organizations in Nigeria. This letter solicits for your support and cooperation for Mr Ibrahim Kabir in providing him with necessary assistance during his field work. All data sources will be treated as confidential and will be used for research purposes only.

Thank you for the opportunity to introduce Mr Ibrahim. Should you require any further information, please do not hesitate to contact me on the details below.

Yours Sincerely,

Professor W. Shakantu
(Supervisor)
Professor of Construction Management (Materials and Methods)
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Appendix 2: Research instrument

Framework for Ethical Sourcing of Construction Materials

1. Company size in terms of work force

Micro (1- 5)		Small (6- 60)		Medium (61- 300)		Large (300 and above)	

2. Site location

Around ecologically sensitive area		Not around ecologically sensitive area	

3. Distance of materials extraction sites from built-up areas.

Less than 500m		Above 500m	

4. Mode of sensitisation before extraction

Public campaign awareness		Communiqué to the public		Media briefing		Others		None	

5. Time of operation

Early morning		Mid morning		Early afternoon		Mid afternoon		Late afternoon		Working hours		After working hours	

6. Method of construction materials extraction

Open pit		Underground		Surface		Others	

7. Types of plant and equipment

1.______________________________ 2. ______________________________

3.______________________________ 4. ______________________________

5.______________________________ 6. ______________________________

7.______________________________ 8. ______________________________

8. Mode of plant and equipment operation

Mechanical		Manual		Both	

9. Types of Materials involved

1.______________________________ 2. ______________________________

3.______________________________ 4. ______________________________

5.______________________________ 6. ______________________________

10. Method of materials loading

Manual		Mechanical		Both	

11. Method of materials transportation/ haulage

Air		Road		Rail		Water		Others	

12. Method of materials off loading

Manual		Mechanical		Both	

13. Method of materials production/ processing

Manual		Mechanical		Both	

14. Impact of material sourcing on the environment

Parameters	**Very High**	**High**	**Moderate**	**Neutral**	**No Impact**
Air pollution					
Noise pollution and vibration					
Water pollution					
Landscape damage					
Harm to flora and fauna					
Waste production					
Energy consumption					

15. Efforts adopted to mitigate materials sourcing impact

Parameters	**Methods**	**Applied**	**Not applied**
Air	Minimise operations during windy periods		
	Increasing distance from nearest building		
	Wet of suppression		
	Maintenance of plant and equipment		
	Use of chemical dust suppressants		
	Mechanical ventilation		
	Use of dust surfactants		
	Procurement of plant and equipment with less emission		
	Tapping of drilled holes before blasting		
Noise pollution and vibration	Maintenance of plant and equipment		
	Early public notification of extremely noisy operation		
	Use of Baffling silencer		
	Construction of barrier walls		

	Limiting working time to day light hours		
	Use of modern equipment		
	Use of bed of debris to absorb most of the impact energy		
	Mounting of machines on massive foundations		
	Placing sand layers of different thicknesses between the foundations and the natural soil, together with cushioning material		
Landscape damage	Slope stabilisation through vegetation planning		
	Use of rip-rap		
	Re - use of stockpiled soil removed during clearance operation		
	Top soil substitution		
	Application of fertilizer, lime, tillage and re-vegetation		
	Reduced-impact logging		
	Skid trailing		
	Re-contouring of slopes		
	Use of gasification ash to land fill		
Harm to flora and fauna	Addition of buffering agents to mitigate acidic seepage from mining		
	Replacement with saplings		
	Continuous monitoring to maintain pH levels		
Water	Recycling of water		
	Collection and treatment of waste water		
	Protection plan		
	Management of surface water		
	Design of mining approaches that exclude water		
	Use of leak detection systems		
	Monitoring of ground water		
	Contingency planning		
	Buffer strips		
Waste	Use of modern plant and equipment for sourcing/ extraction		
	Proper planning and efficient management		
	Training of employees		
	Use of Ground Penetrating Radars (GPR)		
	Installation of a mobile crushing/ grinder-pulverisation unit at quarry site		
	Recycling of waste		
	Reduced-impact logging		

Energy	Altering processing parameter e.g. belt speed		
	Educating employees regarding plant and equipment idling		
	Optimisation of plant and equipment		
	Minimisation of non- utilized power		
	Reducing fuel spills		
	Regular energy audits and maintenance		
	Implementation of energy saving/ conservation measures for plant and equipment e.g. catalysts		
	Use of renewable energy sources for operation		
	Transport pooling/ limiting hauling		

16. Impact of materials transportation on the environment

Parameters	**Very High**	**High**	**Moderate**	**Neutral**	**No Impact**
Air pollution					
Noise pollution and vibration					
Water pollution					
Landscape damage					
Harm to flora and fauna					
Waste production					
Energy consumption					

17. Efforts adopted to mitigate materials transportation impact

Parameters	**Methods**	**Applied**	**Not applied**
Air	Transport pooling/ Limiting hauling		
	Selection of suitable routes		
	Wet suppression		
	Maintenance of plant and equipment		
	Partial enclosure of transferring and conveying equipments and process		
	Partial enclosure of unloading area		
	Covering of transported materials		
	Procurement of plant and equipment with less emission		
Noise pollution and vibration	Transport pooling/ Limiting hauling		
	Selection of suitable routes		
	Maintenance of plant and equipment		
	Traffic diversion		
	Working with relevant authority to prevent unnecessary traffic congestion		
	Use of plant and equipment with less		

	emission		
Landscape damage	Re-contouring of slopes		
	Use of alternative routes		
	Covering of transported materials		
Harm to flora and fauna	Wetting of soil		
	Covering of transported materials		
	Buffer strips		
Water	Maintenance of plant and equipment		
	Proper training of drivers		
	Covering of transported materials		
	Procurement of plant and equipment with less emission		
	Selection of suitable routes		
	Reducing fuel spills		
	Continuous motoring of ground water		
Energy	Use of modern plant and equipment for loading and transportation		
	Educating employees regarding plant and equipment idling		
	Optimising pit and mine design		
	Regular energy audits and maintenance		
	Transport pooling/ Limiting hauling		
	Reducing fuel spills		
	Use of renewable energy sources for operation		

18. Impact of material production on the environment

Parameters	**Very High**	**High**	**Moderate**	**Neutral**	**No Impact**
Air pollution					
Noise pollution and vibration					
Water pollution					
Landscape damage					
Harm to flora and fauna					
Waste production					
Energy consumption					

19. Efforts adopted to mitigate materials production impact

Parameters	**Methods**	**Applied**	**Not applied**
Air	Use of bag houses		
	Increasing distance from nearest building		
	Use of high temperature filters within gasification process		
	Maintenance of plant and equipment		

	Use of dust suppressants		
	Mechanical ventilation		
	Use of surfactants		
	Procurement of plant and equipment with less emission		
	Continuous monitoring and recording of emissions		
	Initial and periodic compliance testing of pollutants emitted from production process		
	Continuous sampling to eliminate equipments leaks		
	Using water-cooled tools		
Noise pollution and Vibration	Maintenance of plant and equipment		
	Use of Baffling silencer		
	Construction of barrier walls		
	Limiting working time to normal working hours		
	Use of modern equipment		
Landscape damage	Enclosure of fuel and chemical		
	Better design and planning		
	Re-contouring of slopes		
Harm to flora and fauna	Application of fertilizer, lime, tillage and re-vegetation		
	Addition of buffering agents to mitigate acidic seeps from mining		
	Top soil substitution		
	Continuous monitoring to maintain pH levels		
Water	Recycling of water		
	Buffer strips		
	Collection and treatment of waste water		
	Protection plan		
	Management of surface water		
	Control of site drainage		
	Use of leak detection systems		
	Better design		
	Collection in sumps		
	Use of reclaimed effluent and other recycled water for cooling		
Waste	Re-crushing to form aggregate		
	Segregation of fine grained solid rejects		
	Re-use of fine grained solid rejects for further production		
	Treatment of solid reject		
	Use of modern plant and equipment		

	Use of carbon dioxide emission and storage technology		
	Use of innovative cutting tools		
Energy	Use of renewable energy sources for production and operation		
	Implementation of energy saving/ conservation measures for plant and equipment e.g catalysts		
	Regular energy audits and maintenance		
	Reducing fuel spills		
	Minimisation of non- utilised power		
	Educating employees regarding plant and equipment idling and turning off lights		
	Installation of more efficient lighting		