Sustainable development challenges of contemporary technologies

(Nigeria Liquefied-Natural-Gas project as a case study)

S.A. OLUWOLE

20907648

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Supervisor: Prof PW Stoker

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Abstract

The way people view development is changing. The world now advocates for a development that also considers future generations. There is a paradigm shift towards sustainable development - a development in today's lifestyle without destroying the resources for tomorrow generations. Sustainable development is a broad concept that addresses how human activities impact on the economic, environmental and social well-being of an ecosystem; however, practical application of the sustainability concept is complex because its objective assessment is elusive.

It is often said that the effect of technology on society has never been more profound than today. As mankind develops in science and technology to improve on his well-being, certain impacts are made on the systems that support human existence. Liquefied natural gas (LNG) technology, like gas-to-liquid (GTL) technology, is a latest innovation conceived to 'fight' the problem of gas flaring, and help contribute to the social and economic growth of the people; but it is necessary for man to know if these contemporary technologies are sustainable.

This dissertation critically appraises the impact of the LNG project on the community of Bonny Island in Nigeria from a holistic perspective. The approach to the research work is three-fold: an appropriate sustainability framework is selected based on certain criteria; sustainability indicators are developed from the chosen framework; and the sustainability indicators are used to assess the impact of the project on the flora and fauna of the community.

To have a clear picture of the impact of Nigeria LNG on its host community, Epe-Waterside is chosen as a control community because of its similar socio-geographical outlook to Bonny Island community. The control community is then subjected to the same set of sustainability indicators for a comparative analysis. The outcome of the research work shows that, though the economic and social conditions of Bonny Island seem much better, its environmental status remains a challenge. In other words, it can be concluded that the present approach to the operation of the LNG technology is not sustainable.

Key Words

Agenda 21
Associated Natural Gas
Carbon Footprints
Carrying Capacity
Cleaner Production
Emission Trading System
Framework
Green House Gases
Green Technology
Indicator
Non-Associated Natural Gas
Ozone Layer
Sustainability
Sustainability Indicator Framework
Technology Forcing

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List of Acronyms

AG	Associated Gas
AIM	Action Impact Matrix
BCOT	Bonny Crude Oil Terminal
CBA	Cost Benefit Analysis
CFC	Chlorofluorocarbon
DESD	Decade of Education for Sustainable Development
ESD	Education for Sustainable Development
ETS	Emission Trading System
FEPA	Federal Environmental Protection Agency
GDP	Gross Domestic Products
GNP	Gross National Products
GHG	Green House Gases
GTL	Gas To Liquid
GTS	Gas Transmission System
IIS	International Implementation Scheme
IISD	International Institute for Sustainable Development
ISO	International Standard Organization
LA21	Local Agenda 21
LNG	Liquefied Natural Gas
MCA	Multi-Criteria Analysis
MDMS	Making Development More Sustainable
MDGs	Millennium Development Goals
NGO	Non Governmental Organization
NGT	Nominal Group Technique
NLNG	Nigeria Liquefied Natural Gas
NNPC	Nigerian National Petroleum Cooperation
NPC	National Population Commission of Nigeria
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
SCIP	Sustainable Community Indicators Program
SDA	Sustainable Development Assessment
SDI	Sustainable Development Indicators
SI	Sustainability Indicators

SIF	Sustainability Indicator Framework
SPA	Sustainability Performance Assessment
SPDC	Shell Petroleum Development Company
SPI	Sustainability Performance Indicator
SPMS	Sustainability Performance Management System
UN	United Nations
UNCED	United Nations Conference on Environment Development
UNCHE	United Nations Conference on Human Environment
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
US EPA	United State Environment Protection Agency
WSSD	World Summit for Social Development

Chapter One

Introduction

1.0 Background

"I never think of the future, it comes soon enough." - Albert Einstein

Sustainability is a word coined from the verb 'sustain', and it means a property of a process, state or system that can be maintained at a particular level indefinitely (Wikipedia[1], 2007). In its environmental usage, Daly and Cobb (1989) refer to sustainability as "the potential longevity of vital human ecological support systems, such as the planet's climatic system, systems of agriculture, industry, technology, forestry, and fisheries, and human communities in general and the various systems on which they depend".

In recent years, some academics have termed sustainable development to mean how long human ecological systems can be productively useful. Many authors had written in the past that complex human societies died out, sometimes due to their own growth and associated impacts on ecological systems that support them. This means that modern industrial society, which continues to grow in scale and complexity, can not be sustainable and will also collapse with time (http://en.wikipedia.org).

Man's desire is to have a system that produces indefinitely, or that is 'sustainable'; for example, 'sustainable agriculture' expects agricultural systems to last forever, whilst 'sustainable technology' is supposed be one that does not impact negatively on people. Some commentators also relate sustainable development to longevity of natural ecosystems and reserves that are distinct from human species; but the focal point has been on human systems and anthropogenic problems - such as anthropogenic climate change, and the depletion of fossil fuel reserves (Wikipedia, 2007).

1.1 What is Sustainable Development?

One reason many writers consider sustainability difficult to define, is because of many sustainability definitions that abound. These competing definitions of the term sustainability exist because of its popularity and a number of isolated attempts by

[1] Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc.

governments and other stakeholders to commence sustainability programs. The often uttered argument that there "is no agreed-upon definition of sustainability" results from this divergence (Daly & Cobb, 1989).

A number of definitions from different schools of thoughts are as follows:

- *Michael Pollan (2007) defines an unsustainable system simply as "a practice or process that can't go on indefinitely because it is destroying the very conditions on which it depends".*

- *Sustainable development is defined, by Munasinghe (1992), as a "process for improving the range of opportunities that will enable individual human beings and communities to achieve their aspirations and full potential over a sustained period of time, while maintaining the resilience of economic, social and environmental systems".*

- *Lyn Arscott (Sept., 2003) says "Sustainable development involves the balancing of society's values for economic prosperity, environmental quality, and social justice".*

- *The term is defined by The 1995 World Summit on Social Development as "the framework for our efforts to achieve a higher quality of life for all people", in which "economic development, social development and environmental protection are interdependent and mutually reinforcing components" (http://en.wikipedia.org).*

- *Bojo, Maler, and Unemo (http://scholar.lib.vt.edu), also submit a definition of sustainability - "Economic development in a specified area (region, nation, the globe) is sustainable if the total stock of resources--human capital, physical reproducible capital, environmental resources, exhaustible resources--does not decrease over time".*

The World Commission on Environment and Development (http://www.ecoeco.org), developed a popular definition of sustainable development in their 1987 report – 'Our Common Future' - to address the issue of conflicts between environment and development goals, as stated below:

"Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission-UN, 1987).

This definition clearly states that sustainable development also involves thinking of the future. In the use of sustainable development concept, the three generally recognized aspects are economic, environmental and social sustainability as depicted in figure 1-1. These three parameters must be present before a system is said to be sustainable.

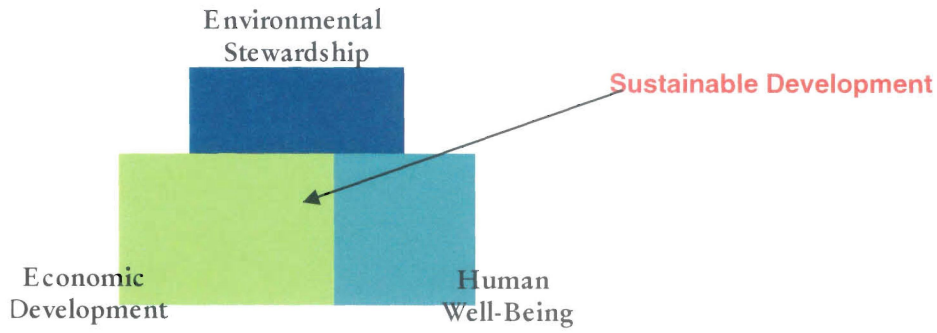


Figure 1-1: Sustainable Development Parameters Nexus *(Rowledge, Barton, Bradley, Fava, Ligge & Young, 1999).*

• **Economic:** According to Jonathan Harris (2000), a system is said to be economically sustainable if it can "produce goods and services on a continuing basis, to maintain manageable levels of government and external debt, and to avoid extreme sectoral imbalances which damage agricultural or industrial production" (http://ase.tufts.edu).

• **Environmental:** An environmentally sustainable system is one that maintains "a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions, and depleting non-renewable resources only to the extent that investment is made in adequate substitutes. This includes maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources" (Harris, 2000).

• **Social:** A system is socially sustainable if it can achieve "distributional equity, adequate provision of social services", which include "health and education, gender equity, and political accountability and participation" (Harris, 2000).

These three elements of sustainability – economic, environmental and social – bring in a number of possible complexities to the initial plain definition. The new paradigm demands that sustainability goals are multidimensional. This raises the concern of how to balance the objectives, and assess success or failure (Harris, 2000). For instance, provision of stable electricity to a community may require construction of dams which affect biodiversity. Sustainable development concept is how to simultaneously satisfy all these objectives; but in reality, we can rarely avoid trade-offs, and as Richard Norgaard (1994) points out that we can "maximize" only one objective at a time. He concludes in his statement that:

> *"it is impossible to define sustainable development in an operational manner in the detail and with the level of control presumed in the logic of modernity."*

However, it is instructive to appraise sustainability issues from multi-disciplinary perspectives because its goals require multiple approaches. Since the three parameters of sustainable development cannot be practically analyzed at once; and as proposed in Balaton's Group report (Bossell, 1999) on Sustainability Indicators, each parameter must first be considered separately. It is contained in the report that:

> *"The total system of which human society is a part, and on which it depends for support, is made up of a large number of component systems.*
> *The whole cannot function properly and is not viable and sustainable if individual component systems cannot function properly. . .sustainable development is possible only if component systems as well as the total system are viable. Despite the uncertainty of the direction of sustainable development, it is necessary to identify the essential component systems and to define indicators that can provide essential and reliable information about the viability of each and of the total system."*

The statements above imply that different indicators are needed to measure different dimensions of sustainability. The sustainability of a system may then be determined from an integrated assessment of these indicators.

1.2 About the Nigeria Liquefied Natural Gas Project

Regardless of the associated environmental hazards, Nigeria is still one of the major 'flarers' of natural gas. However, in an effort to combat the problems of flaring, the government has set a target of zero flares for December, 2008. Nigeria is a nation endowed with "massive reserves of associated and non-associated gas, estimated in excess of 160 trillion cubic feet". Its proven natural gas reserves, which are estimated to last for 109 years at the present production rate, is ranked amongst the 10th largest in the world (http://www.nigerialng.com).

"In 1998 only, Nigeria flared 21 bcm of associated gas (AG) which accounted for about 20% of the world's gas flaring estimates that year and 38% among OPEC[2] member countries" (Shell Group Approach to Global Environmental Standards, 1998). It is expected that when all the Nigeria liquefied natural gas (NLNG) trains are running at design capacity, it will help put out the flaring of this associated gas.

The Nigeria LNG plant site is on the western coast of Bonny Island, south of Port Harcourt, Rivers State, Nigeria. The plant is between the Bonny crude oil terminal (BCOT) - operated by the Shell Petroleum Development Company of Nigeria Ltd. (SPDC[3]) - and the Mobil/NNPC[4] OSO condensate recovery plant. Besides the LNG complex, there is a permanent residential area, which provides accommodation for the plant's workforce located approximately 3 km away on the southern coast of Bonny Island (NLNG, 2003).

The potential for an LNG project was first conceived in 1969, but it was not until the 1980s that it came into limelight when Philips Petroleum developed proposals for the project to be based at Bonny Island. The project was not pursued further at this time until March 1985, when the Nigeria LNG project was established with the formation of an LNG Working Committee, involving the Federal Government of Nigeria, Shell, Elf (now TotalFinaELF) and Agip who signed the framework agreement to exploit the substantial gas reserves in Nigeria. The company was incorporated under Nigerian law in September 1989 with the shareholding comprising: Nigerian National Petroleum Company (NNPC) 49%, Shell Gas B.V (Shell) 25.6%, TotalFinaELF Limited (Elf) 15.0%

[2] OPEC (Organization of Petroleum Exporting Countries) is the international organization primarily concerned with coordinating crude-oil policies of its member states (*Microsoft® Encarta®* 2006).
[3] SPDC is the leading operator of NLNG; others are NNPC, TotalFinaElf and Agip International.
[4] NNPC is a government oil & gas parastatal that oversees the activities of other oil & gas companies in Nigeria.

and Agip International N.A.N.V (Agip) 10.4% and Nigeria LNG Limited (http://www.nigerialng.com).

"A series of environmental studies were undertaken for the base project, culminating in the preparation of baseline reports and environmental impact assessments (EIA) for both the LNG plant and the gas transmission system (GTS) in 1995. Subsequently, a section of the GTS was re-routed and further baseline and impact assessments were prepared for the GTS revised route. The project received the appropriate environmental permits from the Nigerian Federal Environmental Protection Agency (FEPA)[5]" (http://www.nigerialng.com). Plant construction was commenced in 1996. Construction of the GTS was completed in 1998, and a phase of the project was completed in 1999.



Figure 1-2: Nigeria LNG Plant in Bonny Island
(http://www.nlng.com/NLNGnew/news/picturegallery/The+Plant.htm)

1.3 Problem Statement and Substantiation

The globe is faced with the problem of sustainable development. The advent of the industrial revolution in the 18th century had not occurred in isolation without any associated challenges. Industrialization is often connected to environmental issues such as deforestation, destruction of wild life, water pollution, and industrial release of green house gases[6] (GHG) and ozone-layer depleting chemicals resulting in climate change, global warming, melting of the glaciers, high sea level, skin cancers, eye cataracts, loss of immune system etc.

[5] FEPA is a department in the Ministry of Environment saddled with the responsibilities of control and regulation of environmental issues in Nigeria.
[6] GHG are gases that cause ozone-layer depletion and, hence global warming. They are carbon dioxide, halocarbons, methane, and nitrous oxide.

In a bid to use technological solutions to mitigate against the consequences of flaring, major oil exploration and production companies in Nigeria came together, under the auspices of Nigerian National Petroleum Corporation (NNPC), to incorporate a natural gas processing company –Nigeria LNG Ltd. Operators of Nigeria LNG led by Shell Producing and Development Company (SPDC) embarked on the construction and operation of the plants in phases to meet the set deadline of December 2008 for a zero flare. The project startup witnessed much unrest in the host community, claiming on disturbance of their ecosystems.

It is often argued that developmental projects have inherent challenges of sustainability in spite of an onward quest for technological development that is gaining momentum. The impact of the LNG project on the community of Bonny Island, from the perspective of the need for the project to be sustainable, is not known. It is thus imperative to assess the impact of the project on its host community, using sustainability indicators, with a view to establishing baselines for developmental projects in the country. This will help promote positive change towards sustainability.

1.4 Scope

The research work is focused on the appraisal of the impact of Nigeria LNG plant on the community of Bonny Island in Rivers State, Nigeria to establish if the project is sustainable.

1.5 Research Aims and Objectives

The following are the aims and objectives of this research work:

- To evaluate various sustainable development indicator frameworks available and select an appropriate one to the research study;
- To draw-up sustainability indicators based on the chosen framework;
- To measure and assess the performance of the Nigeria LNG project in Bonny Island against some selected indicators; and
- To carry out a comparative analysis by subjecting a control community to the same set of sustainability indicators in order to establish if the Nigeria LNG project has impact on Bonny Island community.

1.6 Research Outline

The introductory chapter provides a background to the subject topic of sustainable development and the question under research. It gives a brief write-up on the LNG plant sited in Bonny Island of Nigeria. The chapter also highlights the research objectives as well as the scope of the research work.

Literature survey focuses on an expository review of scholarly work that has been done by outstanding researchers on the subject topic. This chapter critically evaluates most up-to-date research, as well as enumerates the drawbacks of out-dated ones.

The methodology section describes the analytical technique and option adopted to substantiate or nullify the research question raised in the introduction – If the Nigeria LNG project is a sustainable development for the host community. This section provides logical scientific procedures carried out to develop and assess sustainability indicators. The scientific work includes the selection of sustainability framework, development of sustainability indicators, collection of applicable data from Nigeria LNG operational area through questionnaires and archives, and testing of these data against sustainability indicators. The section also gives justification for the preferred methods of scientific research, stating both their advantages and limitations.

Chapter four is on presentation of results, outlining a set of findings which make original scientific contribution to the investigated subject area; while chapter five interprets, validates, and discusses the results of the research work carried out.

Conclusions and Recommendations is the last chapter which concludes on the novelty of the research findings, and provides recommendations. The chapter also highlights on areas that require further research work.

Chapter Two

2.0 Literature Survey

This chapter presents a thorough review of the contribution of other scholars, renowned authors, government agents, and non-governmental organizations (NGOs) to the field of sustainable development. Moreover, critical analysis of previous and current work by different writers is also carried to establish the relevance of their work to present sustainability issues.

2.1 Towards Sustainable Development

Many decision makers in the world today are confronted with the traditional challenges of economic stagnation, hunger, illness, and persistent poverty; as well as issues relating to environmental damage and globalization. One important concept that has evolved over the years is the construct of sustainable development or simply 'development which lasts' (Encyclopedia of Earth, 2007).

The idea of 'development that is sustainable', which emerged from the 1987 report of Brundtland Commission - *Our Common Future* – did not become accepted worldwide until after the 1992 Earth Summit in Rio de Janeiro and the adoption of the United Nations' Agenda 21. In addition, "International events like the 2000 Millennium Development Goals (MDGs), and the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, have also helped to maintain the impetus" (Encyclopedia of Earth, 2007).

Some key milestones relating to the evolution of recent thinking on sustainable development include:

1. The 1972 United Nations Environmental Summit in Stockholm (United Nations Conference on the Human Environment),
2. 1987 Brundtland Commission report,
3. 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro,
4. 1995 World Summit for Social Development in Copenhagen,
5. UN Millennium Summit and Millennium Development Goals (MDGs) in 2000,

6. 2002 World Summit on Sustainable Development (WSSD) in Johannesburg,
7. UN Millennium Development Project approved as a follow-up to MDG in 2005, and
8. UN Decade of Education for Sustainable Development (2005-2014).

2.1.1 United Nations Conference on the Human Environment

The United Nations Conference on the Human Environment, termed as the *Stockholm Conference,* was an international conference convened under the auspices of United Nations, and it was held in Stockholm Sweden, from June 5-16, 1972. "It was the UN's first major conference on international environmental issues, and marked a turning point in the development of international environmental politics" (Baylis & Smith, 2005).

The conference addressed the state of the global environment, and thus triggered the beginning of modern political and public awareness of global environmental problems. At the end of meeting, the conference came up with a communiqué that had a Declaration containing 26 principles concerning the environment and development; an action plan with 109 recommendations, and a resolution. Issue on chlorofluorocarbons (CFCs), which was suspected to be responsible for the depletion of the ozone layer, was addressed. Concerns on global warming were also raised (McCormick & Wiley, 1995).

Many authors argued that the Stockholm conference encouraged collaborative participation of many countries in research on global warming, which later led to such accords as Kyoto Protocol (McCormick & Wiley, 1995).

2.1.2 Brundtland Commission

The Brundtland Commission, formally termed as the *World Commission on Environment and Development (WCED),* and famous by the name of its Chair Gro Harlem Brundtland, was convened by the United Nations in 1983.

The commission was formed to critically address growing concern "about the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development"

(http://en.wikipedia.org). "In establishing the commission, the UN General Assembly recognized that environmental problems were global in nature and determined that it was in the common interest of all nations to establish policies for sustainable development" (Brundtland, 1987).

The Report of the Brundtland Commission, *Our Common Future*, which was released by Oxford University Press in 1987 addressed issues of sustainable development and the radical changes needed in the political arena to achieving sustainability. The Brundtland's definition, as stated in section 1.1, is now the most popular definition of sustainable development.

2.1.3 United Nations Conference on Environment and Development - Earth Summit

The United Nations Conference on Environment and Development, *Rio Summit or Earth Summit,* took place in Rio de Janeiro, Brazil between June 3 and June 14, 1992. According to the summit reports (http://en.wikipedia.org), the following issues were addressed, amongst other things:

- "systematic scrutiny of patterns of production — particularly the production of toxic components, such as lead in gasoline (Tetraethyl lead – leaded petrol), or poisonous waste including radioactive chemicals;
- alternative sources of energy to replace the use of fossil fuels which are linked to global climate change;
- new reliance on public transportation systems in order to reduce vehicle emissions, congestion in cities and the health problems caused by polluted air and smog;
- the growing scarcity of water"

Another landmark of the summit was an accord on the Climate Change Convention which subsequently led to the Kyoto Protocol. It was also agreed upon that such activities that could result in environmental degradation or be culturally improper may not take place on the land of any community (McCormick & Wiley, 1995).

At the end of the summit, the following documents were turned out:

- *Rio Declaration on Environment and Development*
- *Agenda 21*
- *Convention on Biological Diversity*
- *Forest Principles*
- *Framework Convention on Climate Change (Kyoto Protocol)*

2.1.3.1 Agenda 21

Agenda 21 is a plan of action to be adopted by the United Nations' member states in every aspect of endeavors where man impacts on the environment. It is a sustainable development programme run by the UN (http://en.wikipedia.org).

Agenda 21 has 40 chapters, which are divided into four different sections as follows:

Section I: Social and Economic Dimensions

Section II: Conservation and Management of Resources for Development

Section III: Strengthening the Role of Major Groups

Section IV: Means of Implementation

It can be argued that the recommendation of Chapter 28 in the execution of Agenda 21 programme at local or community level – 'Local Agenda 21' or 'LA21' – has not been successful because the United Nations lacks the mechanism to monitor and possibly enforce its implementation.

2.1.3.2 Kyoto Protocol

The objective of the Kyoto Protocol is to ensure that emissions of greenhouse gases are reduced in a bid to prevent anthropogenic climate change. The protocol was an accord made under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) to the international Framework Convection on Climate Change. Countries that endorse the protocol commit to reducing the emission of green house gases, with the aim of stabilizing "greenhouse gas concentrations in the atmosphere at

a permissible level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1997).

According to a press release from the United Nations Environment Programme (http://en.wikipedia.org/wiki/Kyoto_Agreement):

> "*The Kyoto Protocol is an agreement under which industrialized countries will reduce their collective emissions of greenhouse gases by 5.2% compared to the year 1990 (but note that, compared to the emissions levels that would be expected by 2010 without the Protocol, this limitation represents a 29% cut). The goal is to lower overall emissions of six greenhouse gases - carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons - averaged over the period of 2008-2012. National limitations range from 8% reductions for the European Union and some others to 7% for the US, 6% for Japan, 0% for Russia, and permitted increases of 8% for Australia and 10% for Iceland*"

The adoption of emission trading system (ETS), where nations or companies whose emissions are below set limit (cap) sell their credits or allowances to heavy polluters, is a compromise on the objective of the Kyoto Protocol. This approach will not effectively deter the industrialized nations from releasing GHG, and other pollutants to the environment at the detriments of the ecosystem.

2.1.4 World Summit for Social Development

An agreement on the need to put people at the centre of development was reached at the World Summit for Social Development (WSSD), which took place in Copenhagen in March 1995. The summit emphasized the need to base developmental objectives on poverty reduction, job provision, and social integration (International Institutes for Sustainable Development Bulletin, 1995). The following declarations were released at the end of the meeting:

- "Create an economic, political, social, cultural and legal environment that will enable people to achieve social development;
- Eradicate absolute poverty by a target date to be set by each country;

- Support full employment as a basic policy goal;
- Promote social integration based on the enhancement and protection of all human rights;
- Achieve equality and equity between women and men;
- Attain universal and equitable access to education and primary health care;
- Accelerate the development of Africa and the least developed countries;
- Ensure that structural adjustment programmes include social development goals;
- Increase resources allocated to social development;
- Strengthen cooperation for social development through the UN" (http://en.wikipedia.org).

2.1.5 UN Millennium Summit and Millennium Development Goals (MDGs)

United Nations Millennium Declaration adopted by 189 nations in September, 2000 was the framework from which The Millennium Development Goals (MDGs) were drawn. The global issue in the 1990s demanded that developmental goals and targets be set against 2015. The criterion for assessing improvement is therefore based on the situations in 1990 (Cutler Cleveland, 2007).

Cleveland (2007) referred to these Millennium Development Goals "as the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions—income poverty, hunger, disease, lack of adequate shelter, and exclusion—while promoting gender equality, education, and environmental sustainability". He also stated that the goals include 'basic human rights', which are the rights of every individual to good health, qualitative education, housing, and security.

By the close of the summit, the delegates have agreed on the following eight MDGs (http://www.un.org):

a) Eradicate Extreme Hunger and Poverty

b) Achieve Universal Primary Education

c) Promote Gender Equality and Empower Women

d) Reduce Child Mortality

e) Improve Maternal Health

f) Combat HIV/AIDS, Malaria and other diseases

g) Ensure Environmental Sustainability

h) Develop a Global Partnership for Development

It is debatable that all these goals are practically unattainable with the current trend in the global issues. For example, Nigeria has nothing to show for its 'Education for All by The Year 2000' goal, even eight years after the target date.

2.1.6 World Summit on Sustainable Development (WSSD) – Earth Summit 2002 (Rio +10)

The World Summit on Sustainable Development which took place from 26 August to 4 September 2002, at the Sandton Convention Centre in Johannesburg, South Africa was convened by the United Nations. The summit coincidentally marked the 30th anniversary of the United Nations Conference on the Human Environment (UNCHE) that was held in Stockholm, Sweden in 1972; and the10th anniversary of the United Nations Conference on Environment and Development (UNCED), known as the Earth Summit, which was held in Rio de Janeiro, Brazil in 1992. The 2002 summit is informally tagged "Rio+10" (Adam Sibley, 2007).

The gathering was to further discuss issues of sustainable development. A principal outcome of the Summit was the Johannesburg Declaration, which was a collection of general political statements, reaffirming a commitment to agreements made at the Rio de Janeiro summit and at the Stockholm Summit on the Human Environment. Several key points were outlined towards building a sustainable future. These include International cooperation, decreasing world poverty, special attention for developing nations, empowering women, and maintaining biodiversity, amongst other things. The document was meant to serve as a contract for the participants of the summit, binding them to the outlined agreements (Cutler Cleveland, 2007).

According to Cleveland (2007), the summit developed a plan of implementation which laid down more specific goals for the participated nations and organizations. Some of these goals include:

- To establish a solidarity fund to wipe out poverty. The fund would be sustained by voluntary contributions; however, developed nations were urged to dedicate 0.7% of their national income to this cause.
- To cut the proportion of the world's population living on less than a dollar a day to half by 2015. This was a reaffirmation of a UN Millennium Summit goal.
- To reduce the number of people who lack access clean drinking water and basic sanitation to half by 2015.
- To substantially increase the global share of renewable energy against non-renewable.
- To significantly reduce the rate at which rare plants and animals are becoming extinct by 2010.
- To restore, where possible, depleted fish stocks by 2015, and
- To halve the proportion of people suffering from hunger.

2.1.7 UN Millennium Development Project – 2005 World Summit

The 2005 World Summit, held from 14 to 16 September 2005, was a follow-up summit meeting to the United Nations' 2000 Millennium Summit that produced the Millennium Development Goals (MDGs). This meeting gave rise to the World Summit Outcome Document (Wikipedia, 2008). The document contained the following important steps:

- "A pact to protect populations suffering gross human rights violations;
- A blueprint for the establishment of a peace-building commission; and
- An accord to equip the UN with a new 'Human Rights Council' to strengthen its ability to promote and protect human rights around the world" (http://en.wikipedia.org).

As many governments are not implementing the right policies towards achieving the MDGs, and the gap between the rich and the poor continues to widen (Global Policy

2.2 Sustainable Development Measures

According to Barjoveanu, Teodosiu and Jorgensen (2004), sustainable development is nowadays more than a future objective; it is also a management process. Therefore, ability to measure and assess changes in relevant aspects of sustainable development is crucial. These measurement and assessment rely on the use of Sustainable Development Indicators (SDI).

2.2.1 Understanding Indicators

Many definitions of indicator exist. For example, an indicator is defined by the Dictionary of Environment and Sustainable Development (Gilpin, 1996) as:

> *"A substance or organism used as a measure of air or water quality, or biological or ecological well-being."*

An environmental indicator is put, by the International Standard Organization 14000 (ISO, 1999), as:

> *"A specific expression that provides information about an organization's environmental performance, efforts to influence that performance, or the condition of the environment."*

The Organization for Economic Co-operation and Development (OECD, 1993) simply defines the word as:

> *"A parameter or a value derived from parameters, which provides information about a phenomenon."*

"Indicators have been widely used for monitoring and assessment of numerous environmental impacts of operations, and are increasingly used in social and economic arenas. To date the emphasis of the vast majority of indicators has been placed on reporting, rather than management of impacts" of activities and operations "on sustainable development. Consequently, the most important criteria that define useful indicators are the capacity to simplify, quantify, analyze and communicate otherwise

complex and complicated information, and the ability to make particular aspects of a complex situation stand out and thus reduce the level of uncertainty in the formulation of strategies, decisions or actions" (Warhurst, 2002).

Indicators have, in recent years, come to be regarded as tools for communication and reporting, even though they were initially developed from the management perspective. Warhurst (2002) explains that using indicators as a communication tool will provide the stakeholders with necessary information on the problems and trends that need to be addressed in the society. Keeping stakeholders abreast of sustainability issues enhances their senses of responsibilities. UK's Local Government Management Board (LGMB) concludes that:

> *"Indicators can challenge people to explore how the way they live affects their community/world and thus move the indicators in one direction or another. Indicators can illustrate how each individual can make a difference"* (http://www.natural-resources.org).

Hamilton (1995) argument supports Warhurst's point in his conclusion that "the role of information as a tool for system improvement holds true whether the feedback loop remains internal to the organization - for example, in the form of internal reporting within a corporate management system - or whether the loop extends beyond the organization into society at large - as in external reporting and the disclosure of environmental and social performance information to stakeholders".

Cormier, Magnan, and Morard (1993) also confirms that the purpose of developing and disseminating performance information to stakeholders through indicators is to facilitate actions towards improvement. Indicators can be used to develop strategic targets, set milestones towards achieving these targets, and then help in assessing and reporting progress clearly and efficiently to the relevant stakeholders.

Indicators have been found very useful in the assessment, management and monitoring of impacts of projects or operations on sustainable development goals if developed within a Sustainability Performance Management structure (UNCED, 1992).

2.2.3 Characteristics of Effective Indicators

An indicator helps to timely identify an issue or condition. It helps to reveal how well a system is performing, and assists in determining what direction to take to attend to any problem. Indicators are as varied as what they assess; however, Warhurst (2002) says that all effective indicators must have some common characteristics in common as follows:

- Effective indicators must be relevant to the system they are used for;
- It should be easy to understand effective indicators, even by people who are not experts;
- They must be reliable - the information they provide must be dependable; and
- They must be based on accessible data - the information is available or can be gathered within a fair time-frame.

2.2.4 Sustainability Indicators: Problems of Integration

Sustainability indicators are gaining acceptance as vital tools in the implementation of sustainable development strategies. Many suggested sustainable indicator (SI) lists and matrices abound, but the challenge is how these diverse indicators can be integrated into providing a solution as to whether a state or condition is sustainable or not. Though some researchers have adopted a quantitative integration approach where SIs are given numerical values and integrated mathematically to produce a value for sustainability, an element of 'qualitative integration' incorporating value judgements and subjectivity is inevitable with a concept such as sustainability. Morse, McNamara, Acholo and Okwoli (2001) argue that sustainability indicators are "primarily a product of development intervention rather than a desire to understand, and as a result carry with them the desired characteristics, from the donor perspective, of efficiency and accountability". Appendix A contains a working list of indicators of sustainability developed by United Nations.

2.2.5 Characteristics of Sustainability

In recent years, environmental, social and economic sustainability are concepts that have had growing attentions, and it is widely accepted that they are all inter-related and

2.2.2 Indicators of Sustainability

"Trying to run a complex society on a single indicator like the Gross National product is like trying to fly a 747 with only one gauge on the instrument panel ... imagine if your doctor, when giving you a checkup, did no more than check your blood pressure."
- Hazel Henderson, Paradigms of Progress (http://futurepositive.synearth.net)

According to OECD (1993), much effort has gone into the development of Sustainability Indicators (SIs) in recent time of which several independent initiatives in this regards have come from the UN, the European Union, national governments, NGOs, academia and the business community. The relevance of sustainability indicators is gaining an impetus due to the increasing need to develop tools for interpreting sustainability concept and goals into measurable and assessable formats for stakeholders. Its applications used to be at the local level for 'sustainable community' projects, but it has now grown to include regional, national and international matters.

Furthermore, the work of Maureen (2006) differentiated indicators of sustainability from traditional indicators that only evaluate economic, social, and environmental progress without any recognition for their interdependence. These traditional indicators, such as stockholder profits, asthma rates, and water quality, measure changes in one part of a community as if they were mutually exclusive of the other parts. Sustainability indicators, on the other hand, reflect the reality that the three different segments are tightly interconnected, as shown in figure 2-1 below. For example, indicators of a sustainable community show links that should exist in the interactions among the economy, environment, and society.

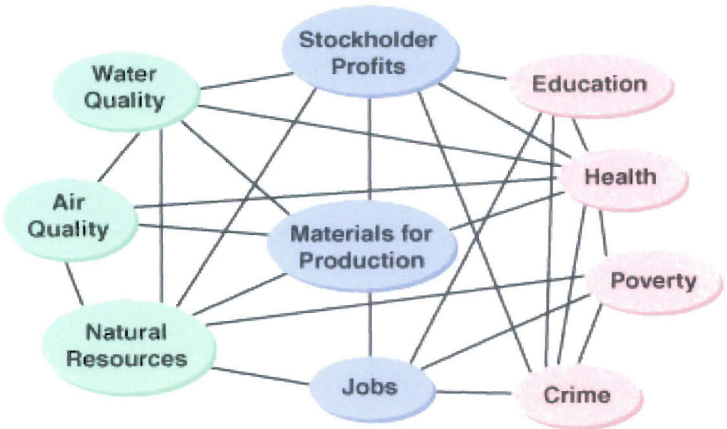


Fig. 2-1: Community Web of Interactions *(Source: Maureen Hart, 2006)*

Forum, 2005), it can thus be debated that the Millennium Development Goals may not be achieved in three decades' time, let alone 2015.

2.1.8 UN Decade of Education for Sustainable Development (2005-2014)

In view of the importance of Education for Sustainable Development (ESD) towards sustainability, the United Nations General Assembly (UNGA) pronounced 2005-2014 as the UN Decade of Education for Sustainable Development (DESD). The United Nations Educational, Scientific, and Cultural Organization (UNESCO[7]) was asked to champion this cause, and develop an International Implementation Scheme (IIS) for the decade (UNESCO, 2005).

The IIS (http://en-wikipedia .org) identified two goals for the Decade as:

a) "To enhance the vision of, and transition towards, sustainable development, through all forms of awareness - education, publicity and training.
b) To boost the profile of the roles that education and learning can play in the advancement of sustainable development."

While the objectives of the DESD (http://en-wikipedia .org) are:

- "To help promote mutual relationship among ESD stakeholders;
- To further encourage qualitative teaching and learning of ESD;
- To assist countries towards achieving Millennium Development Goals through ESD campaigns;
- To provide opportunities for countries to incorporate ESD into their education reform efforts."

It is perceived that the objectives of DESD declaration would be better achieved if countries could incorporate curricula on sustainable development into their education systems. The UNESCO also needs to put in place an effective mechanism for monitoring implementation of ESD strategies.

[7] UNESCO is an agency of the UN created in 1946 to promote world peace by focusing on the areas of culture and communication, education, natural science, and social and human sciences.

essential for a sustainable development. Key characteristics of sustainability are described below and summarized in Figure 2-2, which may serve as a useful starting point for communities or municipalities attempting to develop their own conceptualizations of sustainability and specific sustainability goals (Michael Ditor, 2001).

- ***Inter-Generational Equity***

The term "sustainable development" was made famous by the World Commission on Environment and Development (1987) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." A significant aspect of this definition is the concept of fairness, which stresses that the needs of future generations are equally as important as the needs of the present generation.

- ***Intra-Generational Equity***

Intra-generational equity has two important components, which are social equity and geographical equity. "Social equity" refers to the equal distribution of the benefits and costs of natural resource use and environmental protection. It considers basic human needs such as food, shelter, employment, public facilities and services (Ditor, 2001). "Geographical equity" was a term coined by Haughton and Hunter (1995) to "underline the undesirability of achieving economic growth, or a higher quality of life, in one community at the expense of environmental degradation in another." It also implies that, sustainable communities reduce their carbon footprints and minimize their contribution to global environmental problems, such as global warming and ozone-layer depletion, to support global sustainability (Ditor, 2001).

- ***Minimal Impact on the Natural Environment***

According to Ditor (2001), all types of waste - emissions to the air, water effluents, and the disposal of solid waste - should not exceed the assimilative capacity of the natural environment. He defined 'assimilative capacity' as "the capacity of physical, biochemical and geochemical processes in the ecosystem to decompose and render inert certain types of waste products". Michael Ditor also states that habitat and natural ecosystem functions must also be preserved by minimizing impacts due to development and management practices.

- ***"Living off the Interest" of Renewable Resources***

A natural system can said to be sustainable if the depletion rates for renewable resources do not exceed the regenerative capacity of that system (Ditor, 2001). This concept gives rise "carrying capacity", which is defined as "the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a given region without progressively impairing the functional integrity and productive activity of relevant ecosystems" (Rees, 1992).

- ***Minimal Use of Non-Renewable Resources***

Consumption of non-renewable resources is said to be unsustainable because the resources diminish with time. Therefore, the best approach is to minimize their use, or utilize them as efficiently as possible, through reduction, reuse and recycling, while exploring substitutes that are renewable (Michael Ditor, 2001).

- ***Efficiency***

The need to extract additional resources can be minimized by improving on its efficient utilization. This practice reduces burden on the resources, and thus signal a movement towards sustainability (Michael Ditor, 2001). An example is the recent campaign on the use of power-saving light bulbs to conserve energy.

- ***Long-Term Economic Development***

One of the essential components of community sustainability is when economic vitality or well-being lasts long; a condition that is also termed as economic "prosperity" (Ditor, 2001).

- ***Diversity***

According to Ditor (2001), heterogeneity in the make-up of community system - economic, biological and cultural – favours its ability to adapt to change, and so enhances its sustainability.

- ***Individual Well-Being (or Quality of Life)***

Physical, social and mental well-being, are some of the attributes that measure an individual's 'quality of life'. Development of human potential contributes to his well-

being, and thus helps in meeting fundamental physical and economic needs (Michael Ditor, 2001).

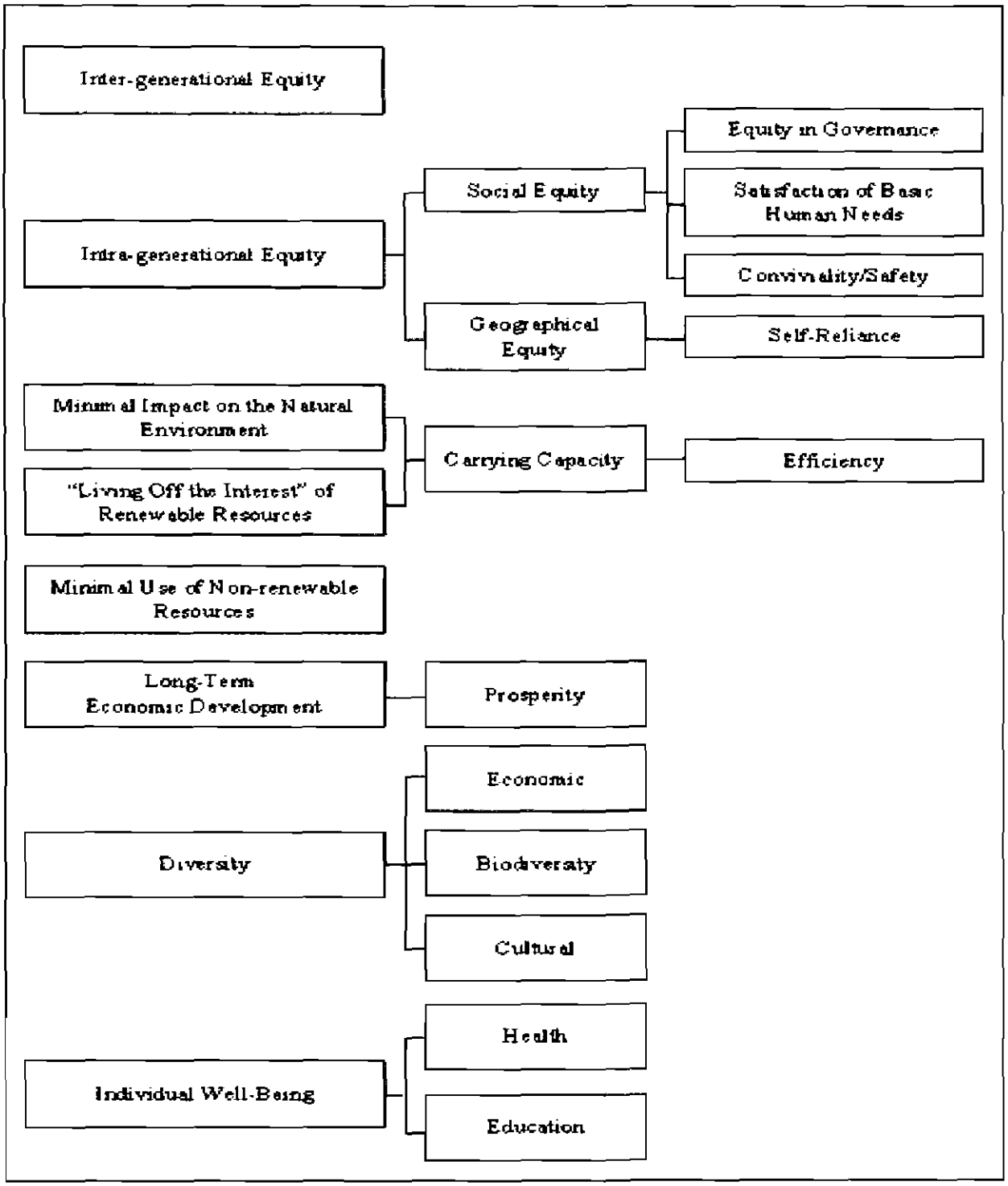


Fig. 2-2: Characteristics of Sustainability

Source: Maclaren (1996).

2.3 Sustainability Indicator Framework Selection and Rationale

"Sustainability is not an absolute, independent of human conceptual frameworks. Rather it is always set in the context of decisions about what type of system is to be sustained and over what spatio-temporal scale." - Allen and Hoekstra, 1994

According to the United States Environmental Protection Agency (US EPA, http://www.epa.gov/greenkit/index.htm), indicators can help set reference points for "communities to measure progress towards or away from becoming a Green Community". These indicators help to benchmark and monitor the sustainability trends in the community. It is often said that many "generations have consumed more than their" shares of "the nature gifts (US EPA, 2007). Since society can either live with nature or make nature live with it, it is then necessary to link people with the ecosystems that support their existence using the right tools. While Indicators are needed to show trends and to measure progress towards sustainability goals, the selection of appropriate ones is crucial. (US EPA, 2007).

2.3.1 Frameworks for Developing Sustainability Indicators

The concept of sustainability is wide and multi-faceted; hence, the task of selecting key indicators to monitor for sustainability can be onerous. Receiving relevant feedback information - which depends largely on establishing the appropriate criteria and selecting the right indicators - from sustainability monitoring is essential. According to Maclaren (1996), frameworks are conceptual models "from which relevant indicators can be developed and selected". It is also emphasized (Farrell, 1998) that the most desirable conceptual model is the framework that integrates diverse system components and avoids isolated indicators. Consequently the best chosen framework should not only assist in the selection of right indicators but also form a basis for synthesis, to guide the analysis that provides some meaning to monitoring data (http://www.fs.fed.us/institute/monitoring/).

It is said frameworks do "not only sort indicators but they also help balance the many issues facing communities" (US EPA, 2007). Maclaren (1996) identified some frameworks, which have now found different applications in the development of sustainable indicators. These include:

- ***Issue-Based Frameworks***

This type of framework organizes indicators according to problems within the area of study. The framework deals with situations highly visible to the public and specific user groups, which make it more popular than other types of frameworks. "However, its shotgun approach to developing indicators may lack the structure provided by the explicit links to sustainability or policies found in other frameworks and will probably be limited in use to examining only known issues" (Maclaren, 1996).

- ***Goal-Based Frameworks***

As the name implies, indicators developed from this framework are based on the sustainability objectives derived from a stated vision or set of goals. While the strength of a goal-based framework is that it reduces the necessary indicators to just those relating to specific sustainability objectives (US EPA, 2007), its disadvantage is that it may not specifically provide linkages between goals or include other concepts of sustainability (Maclaren, 1996). See appendix B for examples of goal-based indicators framework.

- ***Sector-Based Frameworks***

The sector-based framework classifies indicators into relevant areas of work responsibility, e.g. the oil & gas sector, the mining sector. The framework (Maclaren, 1996) is best applicable when the main target audience is internal to management wherein the "sectors can be tied to individual departments". A shortcoming of sector-based frameworks is that "they compartmentalize the indicators, which is not very effective for showing linkages across different areas, particularly when operating within an ecosystem management environment" (Wright, Alward, Colby, Hoesktra, Tegler & Turner, 2002).

- ***Ecosystem Component-Based Frameworks***

This framework is often used to develop indicators for each ecological component, which includes soil, water, and biota; and sometimes applied to an entire ecosystem (Maclaren, 1996). In its application, component-based framework focuses on particular ecosystems of concern; "however, issues of scale and the boundaries and interactions between ecosystems create bottleneck in analyzing relationships and interactions"

(Maclaren, 1996). This framework is less effective for developing indicators for social and economic concerns, which are not typically restricted to a specific ecosystem component nor to specific ecosystems (Wright et al, 2002).

- ***Causal-Based Framework***

The causal-based framework considers the interactions amongst different elements within a system, and then groups indicators into categories of stress, condition, and response as exemplified in figure 2-3.

- ***Stress indicators*** handle why changes are happening, for example, the cause of biodiversity loss;
- ***Condition indicators*** look into what is happening or what is being affected, e.g. community health, air, water); and
- ***Response indicators*** consider management actions or implementation tasks like proportion of population inoculated.

The main challenge with causal-based framework is resolving what the connections are between the categories, because causal links are multidimensional and debatable. This framework shares a similar shortcoming with the issue-based framework, in that it is based on known stressors, thereby ignoring other ecological, social, and economic components that may be relevant to the broader attribute of sustainability (Maclaren 1996).

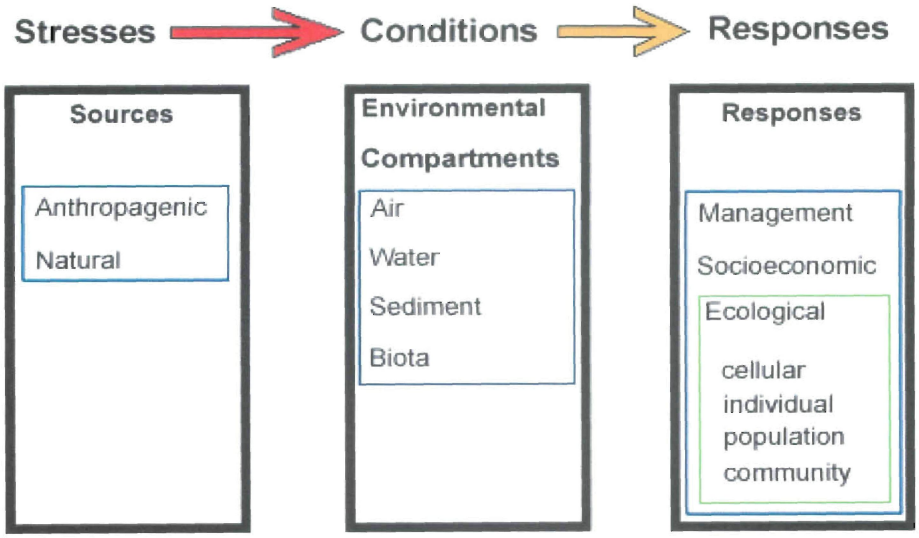


Fig. 2-3: General Stress-Condition-Response Model (Source: Michael Ditor, 2001)

- ***Systems-Based/ Domain-Based Frameworks***

Domain-based or system-based frameworks classify indicators into the three main components of sustainability, which are environmental, economic and social. "It allows for and accentuates the linkages among the three dimensions" (US EPA, 2007).

Since this framework regards the three key dimensions of sustainability and arranges indicators within these domains based on systems theory, it thus suggests that ecological, social, and economic "systems are a group of interrelated, interacting, or interdependent constituents forming a complex whole" (Maclaren, 1996). Maclaren (1996) further states that "a systems-based framework uses the structures and functions of the systems as the organizing tools". He says that a systems approach "focuses on the contexts that allow for the production of goods, services, and opportunities to meet different values"; and that the framework concentrates on the "outcomes or states of systems and not on inputs or outputs". Maclaren then concludes that a domain-based framework is "most effective for ensuring coverage of the three systems from which sustainability emerges and for examining interactions within and among the three main components of sustainability".

It can be inferred from the work of Maclaren (1996), that domain-based framework has a wider range of applicability in the construct of sustainable development indicators than other frameworks earlier mentioned. This is because the domain-based framework develops indicators with an integrated view of the three sustainability parameters – environment, economy and social.

2.3.2 Indicator Development Process Overview

Indicators are developed based on different needs. Frameworks form the basis for developing these indicators, and also help in determining which indicators are chosen and how they relate to one another.

Michael Ditor (2001) gives an overview of the indicator development process, which provides scope for developing indicators program and gives context to the sustainability concepts as highlighted below.

I *The first step is to define and conceptualize the nature of sustainability and the sustainability goals for which indicators are needed.*

- By firstly developing a vision is a useful technique for articulating sustainability objectives and its associated sustainability goals. The expected outlook of the community is agreed-upon by the multi-stakeholder using consensus-based approach, in order for it to be regarded as a sustainable community. These sustainability goals are a function of community, and hence vary with community.
- Then a set of rule is defined for the indicators program.

II *The next step is to Identify the target audience, the associated purpose for which indicators will be used, and the relative number of indicators needed.*

The amount and complexity of indicators to be developed will depend on the intended audience. The audience could be the decision-makers, regulatory bodies, community people or professional bodies.

III *Choose an appropriate indicator framework.*

IV *Define indicator selection criteria.*

In his work on the development of Sustainable Community Indicators Program (SCIP), Michael Ditor (2001) identifies the following indicator selection criteria, which individual community may adapt for choosing a final set of indicators according to their sustainability goals and visions:

1. Scientific Validity / Theoretical Soundness
2. Responsiveness to Change
3. Evident Links of Cause and Effect
4. Representative of Sustainability Issues
5. Accurate Time-Series Data Available or Collectable
6. Cost-Effectiveness
7. Relevant & Understandable to Users
8. Comparable Among Jurisdictions
9. Useful at Large & Small Geographic Scales
10. Comparability to Target, Thresholds or Standards
11. Integrates Social, Economic & Environmental Factors

V *Then, identify a set of potential indicators and evaluate them against the selection criteria.*

According to Ditor (2001), possible indicators are evaluated against the selection criteria; but judgments may sometimes be made about the relative importance of the indicators if they do not satisfy the entire selection criteria simultaneously. In order words, criteria are applied sequentially to the indicators, but may also be necessary to accept trade-offs among them.

VI *Lastly, choose a final set of indicators and test their effectiveness.*

- Check if the chosen indicators measure the relevant situation.
- Unavailability of enough and useful data availability may limit number of indicators in the final set, and iteration of indicator identification process may be required.
- There is need to continuously review this final indicator list with time as more reliable data become available, new goals evolve, or new scientific methods concerning the validity of indicators are discovered (Ditor, 2001).

The work of Michael Ditor on the 'indicator development process' is invaluable, because it provides fundamental guidelines of building sustainable development indicators followed in this dissertation.
Nonetheless, the limitation in his approach is that the work does not consider how these indicators can be integrated into giving an assessable sustainability performance measurement parameter.

2.4 Sustainable Development and Technology

According to Berkel (2000), "technology will have to play an important role in the transition towards sustainable development, and technological changes call for supportive changes in production and distribution systems and consumption patterns". Berkel further stressed that the role of technology in achieving sustainable development may be enhanced by forcing technology to develop in support of sustainability.

Technology forcing (Berkel, 2000) is a "concept for accelerating socially desirable technology innovation" in support of sustainability objectives.

In recent years, there have been several attempts by the United Nations (UN) in promoting advances in the developing countries through active participations in technology transfer in order to bridge the gap in knowledge and material that separates the third-world nations from the developed and industrialized countries (Karl, 1993). Some of these efforts, according to Karl (1993), are the campaigns for "the generation of new knowledge through science and the application of that knowledge for development through technology". The United Nations is also known as a forefront crusader of 'bridging the digital divide' (Scholvinck, 2001). It is said that the development of 'right' technologies would be a step in the direction of sustainability. The liquefied natural gas (LNG) and the gas-to-liquid (GTL) technologies are examples of recent innovations in the processing of natural gas; which are aimed at reducing the hazards of gas flaring.

2.4.1 Concept of Cleaner Production

"Cleaner Production is the conceptual and procedural approach to production that demands that all phases of the life cycle of a product or of a process should be addressed with the objective of prevention or minimization of short and long-term risks to humans and the environment" (Zadorsky, 2001). According to him, the concept of cleaner production has consequences for the whole life cycle of a product from raw material extraction to disposal. It provides the opportunity to enhance operating efficiency, and improve on environmental performance by reducing waste from source. Zadorsky (2001) further writes that "cleaner production is achieved by applying know how, by improving technology and changing attitudes".

Besides the concept of cleaner production, there are other drives directed at reducing the impacts of human activities on the environment. These include end of pipe treatment, cradle to grave, cradle to cradle, polluters pay etc (Akeredolu, 2000). Though arguable, a more recent approach ratified by signatories to Kyoto Protocol in order to mitigate global warming is 'carbon credits'. Here, a producer whose permissible green house gases emission quota has not been used up sells the surplus to buyers in form of emission credits (http://en.wikipedia.org/wiki/Carbon_credit).

It is evident from the work of Zadorsky that cleaner production concept is targeted at minimizing industrial wastes and effluents, and thus improving on the environment through the application of 'green technology' in line with the current trend on sustainability campaigns. The author also emphasizes the need to have a right attitude towards attaining sustainable living.

2.5 Sustainomics Framework: Making Development More Sustainable

According to the Encyclopedia of Earth (Munasinghe, 2007), sustainomics framework refers to sustainable development as "a process for improving the range of opportunities that will enable individual human beings and communities to achieve their aspirations and full potential over a sustained period of time, while maintaining the resilience of economic, social and environmental systems". In other words, economic, social and ecological systems will grow only if the 'set of opportunities' for their improvement is preserved. Munasinghe (2007) also asserts that a system will be more sustainable if its resilience and adaptive capacity is enhanced. This fundamental statement led to the emergence of a practical approach towards making development more sustainable, which addresses the need to optimally utilize natural resources in improving the present quality of life with equal consideration for future generations. Many scholarly activities have made significant input to sustainomics concept. Figure 2-4 represents the sustainable development triangle that is based on sustainomics approach.

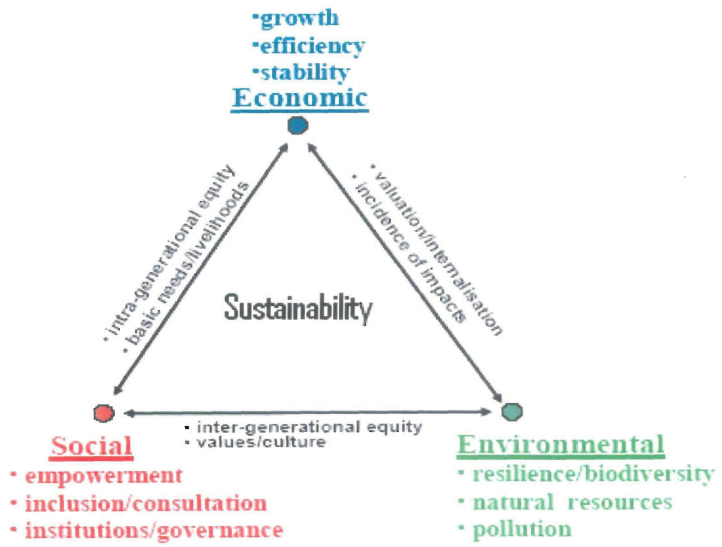


Fig. 2-4: Sustainomics Concept of Sustainable Development Triangle *(Source: Munasinghe 2007)*

Munasinghe (2007) identifies that sustainomics framework relies on some basic principles and methods as highlighted thus:

i "Making development more sustainable (MDMS);
ii Sustainable development triangle and balanced treatment;
iii Transcending conventional boundaries for better integration; and
iv Full cycle application of practical analytical tools and methods, from data gathering to policy implementation and operational feedback. These elements include optimality and durability, issues-policy mapping, policy tunneling, action impact matrix (AIM), sustainable development assessment (SDA), environmental valuation, extended cost-benefit analysis (CBA), multi-criteria analysis (MCA), etc."

Sustainomics framework provides an integrated approach to sustainability issues because it considers the three elements of sustainability – environmental, social and economic – as well as their interactions. However, it is apparent from Munasinghe's work that sustainomics framework is still an evolving area of sustainable development concept. It thus becomes essential to improve on the sustainomics framework through collaborative research work for it to be capable of adequately defining constantly changing sustainable development issues.

The contributions of many scholars and authors, as evident in this chapter, show the importance of the sustainable development concept; and the needs for a continuous effort towards sustainability.

The chapter that follows presents the experimental procedures taken to assess the sustainability of the liquefied natural gas technology.

Chapter Three

3.0 Empirical Investigation

The main purpose of this chapter is to report the procedural techniques employed to assess the sustainability of the liquefied natural gas process as a contemporary technology.

3.1 Strategy Overview

For this study, Nigeria liquefied natural gas plant located in Bonny Island, Port Harcourt, Nigeria is used as a case study to appraise the sustainability challenges of contemporary technologies. The research work is hence based on determining the impact of the project on its host community. To assess the project's impact, sustainable development indicators were employed as a tool.

The initial strategy was to gather empirical data that span over a period of, at least, five years on the sustainability indicators. This method would have provided data that will give a clear drift in the conditions of the community with time.

Nonetheless, due to the unavailability of these trend data on sustainability indicators for time-series analysis, another community with similar socio-geographical outlook to Bonny Island is chosen to provide control data for comparison. Epe-Waterside is selected for the control experiment because of its significant similarity to Bonny Island as justified in table 3-1.

Table 3-1: Similarities in Bonny Island and Epe-Waterside

Bonny Island	Epe-Waterside
▪ It is an island located in outskirt of Rivers State, Nigeria. ▪ The region is surrounded by Atlantic Ocean. It is then called a 'riverine' area. ▪ Main occupations are fishing, subsistence faming and trading.	▪ It is a peninsula located in outskirt of Lagos State, Nigeria. ▪ Most of the land mass is bounded by Atlantic Ocean. It is also referred to as a 'riverine' area. ▪ Main occupation prior to the advent of NLNG was fishing, subsistence

▪ The population was 104,703 as at 1991 (National Population Census) ▪ It has got only public and private nursery, primary and secondary schools. No tertiary institutions. ▪ It is made up of dispersed settle.	farming and trading. ▪ A relatively matching population of 111,464 as at 2007 (National Population Census) ▪ It has got only public and private nursery, primary and secondary schools. No tertiary institutions. ▪ It has dispersed settlement style.

The only substantial difference between the two communities, which is crucial for the comparison, is the presence of Nigeria LNG plant in Bonny Island. This thus helps to accurately assess the impact of the plant on Bonny Island community

3.2 Selection of Sustainability Indicators Framework

A domain-based framework is chosen to develop the sustainability indicators. The domain-based framework (Maclaren, 1996) is preferred to other frameworks because of the following reasons:

- It addresses the three key sustainability parameters, which are – environmental, social, and economic;
- It adequately provides for linkages among these key parameters;
- It is relevant to developing community sustainability indicators program because its approach is system based i.e. it is all encompassing in approach to issues.

To further substantiate the rationale for choosing a domain-based framework in developing the sustainability indicators, a SWOT analysis was carried out on some commonly used frameworks as shown in table 3-2. SWOT is an acronym of "Strengths-Weaknesses-Opportunities-Threats". It is an analysis procedure used in decision support by providing basis for the choice made.

Table 3-2 SWOT Analysis of Some Sustainability Frameworks

Frameworks	Internal Factors		External Factors	
	Strengths	Weaknesses	Opportunities	Threats
Issue-based	▪ It classifies indicators based on the problems to be solved, e.g. acid rain	▪ Reactive, i.e. used for known problems. ▪ It is not flexible. ▪ Narrow to only a known issue.	▪ Applicable in assessing a known problem in a community.	▪ Some of the other types like domain-based can be adapted to serve the same purpose
Goal-based	▪ It organizes indicators according to various goals to be achieved, e.g. 'women empowerments'. ▪ Reduces indicators to those relating to sustainability objectives. ▪ Its approach is proactive, i.e. develops indicators for target goals.	▪ It is not flexible. ▪ Specific to only certain defined goals.	▪ Applicable in assessing progress towards specific sustainability objectives in a community.	▪ Some of the other types like domain-based can be adapted to serve the same purpose
Sector-based	▪ Here, indicators are grouped according to the sectors they relate to; e.g. education sector	▪ It does not show linkages across different areas/sectors.	▪ Relevant to governmental departments, ministries, etc.	▪ Some of the other types like domain-based can be adapted to serve the same purpose

Domain-based	▪ It groups indicators according to each of the 3 elements of sustainable development. ▪ It shows linkages and examines interactions within and amongst the sustainability components. This could be in form of social-environmental, environmental-economy, economy-social, or a combination of the three dimensions. ▪ Domain based framework is central to virtually all other sustainability frameworks ▪ It is proactive in its approach to issue. ▪ Flexibility – it is much easier to add more indicators to each category of sustainability dimensions when	▪ Its approach in the development indicators is too generic i.e. It does not minimize indicators to specific sustainability objectives like goal-based or issue-based frameworks do	▪ It has a wide range of applicability – e.g. for developing community sustainability indicators, assessing technology sustainability etc. ▪ Appropriate for monitoring progresses made by a community towards sustainability ▪ Its presentation format of indicators is best for a wide range of stakeholders - policy makers, professionals, public etc. – because of its simplicity.	▪ Combinations of two or more of other frameworks, which draw on their strengths and downplay their demerits, may make domain-based type of framework less popular.

	the need arises ▪ Most effective for ensuring coverage of the three dimensions on which sustainability concept is based. ▪ It shows if certain policy actions are having impact on the indicators with time.			
Causal-based	▪ It is relevant in developing indicators that assess the cause of a problem; e.g. the cause of river pollution in a community. ▪ It considers the inter-relations between various elements of the community. ▪ It shows why certain indicators are rising or falling.	▪ It is not flexible. ▪ Its approach is reactive, i.e. applicable to a known issue.	▪ It is more useful in monitoring cause-effect relationship than any other frameworks.	▪ Causal links provided by this framework are often debatable and it is making it less popular

It can been observed from the SWOT analysis that a domain-based framework is the most appropriate for this experimental work because its approach to sustainability issues encompasses the three legs on which sustainable development concept is built, amongst other reasons.

3.3 Development of Indicators

An integrated approach was used to develop the indicators according to the guidelines provided by Michael Ditor (2001) and US EPA (2007). It is noteworthy that these guidelines were employed within a domain-based framework as follow:

a) The first step was to identify the target audience – the classes of people for whom the indicators were developed. This was necessary because it informed the relative amount of empirical data needed and the complexity of the reports. The primary target audience is the academia while the experimental outcome would also be of relevance to the community people, the government agents and the policy makers.

b) A list of possible indicators was then worked out from the United Nations Working List of Indicators presented in appendix A. The following indicators selection criteria (Ditor, 2001) were applied in arriving at the selected indicators.

- Relevance to the research needs;
- Measurable;
- Understandable by the target audience and the stakeholders;
- Comparability – can be compared to existing or past measures to define trends or identify differences;
- Data availability;
- Interpretable – can measure movement towards or away from a defined sustainability objective;
- Reliable over a long period of time;
- Flexible to incorporate changes in scientific innovations.

c) For the purpose of this research work, final sets of five most applicable sustainability indicators were chosen, as presented in table 4-1, for each of environmental, social and economic factors vis-à-vis the selection criteria.

3.4 Experimental Design

The experimental design is decomposed into different fragments for ease of work as presented in the sections that follow.

3.4.1 Data Sources

Questionnaire Method and ***Semi-Structured Interview Approach*** were used to gather empirical data for the study. Other sources of data include National Population Commission of Nigeria (NPC) and the Nigeria Liquefied Natural Gas (NLNG).

3.4.2 Empirical Data Collection Procedure

According to Kopac (1991), the process of planning, designing, drafting and administering a questionnaire survey is like setting-up and managing a business. It requires much of technical understanding of the subject topic, determination and soft skills - administrative skill, human management etc. A well formulated questionnaire is thus crucial to the success of any survey activity.

A questionnaire is used for data collection because of the following benefits:

- It enables the researcher to gather only relevant data; thus making it economical.
- It is efficient in collecting information from a large population.
- The researcher does not necessarily need to personally administer the questionnaire.
- A wide array of information can be collected with questionnaire, making it flexible.
- If properly administered, a questionnaire survey method is relatively not prone to many types of errors because of its structured nature.

Nevertheless, some limitations abound in questionnaire survey method, which could be minimized as follows:

- Respondents are often not interested in reading the questions. Brevity is the key in reducing such problems.
- Skewed or biased responses are reduced through random sampling.

- Other identifiable deficiencies such as misunderstood questions, incomplete responses are minimized by either self-administering the questionnaire or through an adequate follow-up.

Since sample selection is of significant importance to validity, acceptability and reliability in data collection; ***Random Sampling Technique*** was employed to gather sustainability data because the technique presents a fair distribution of the sample population. Here, every member of the statistical population has equal chance i.e. it is unbiased.

Two different set of questionnaires were designed and administered, and a semi-structured interview was also conducted as follows:

Questionnaire I

This consists of fifty questionnaires to randomly gather statistical data on the selected indicators. The same type of questionnaires were administered to both communities – i.e. the community under research and the control community - in order to eliminate any fundamental data errors that may set in due to difference in questionnaire format. The questionnaire was designed in such a way to accommodate diversity in the respondents' objectivity. Twenty-five copies were administered in Bonny Island while the remaining twenty-five forms were used to collect data from Epe Waterside for comparison. The data were analyzed and results presented both in tabular and graphical forms. A sample of the questionnaire is in appendix C, and the summary of the empirical data gathered is contained in table 4-2 of chapter four.

Questionnaire II

The purpose of this was to rank the importance of the selected sustainability indicators to the stakeholders. The idea was to obtain one most important indicator from each of environmental, social, and economic sustainability parameters. These results from the ranking were used for statistical analysis and results validation.

To achieve this, a ***Multi-Voting Technique***[8], otherwise known as ***Nominal Group Technique*** (NGT), was employed because of the following reasons:

[8] It is a ranking technique for reaching group consensus when faced with many options.

- The method is most dependable when selecting a best choice among several options or alternatives;
- It gives every participant equal chance of voting;
- The final ranking results obtained are representative.

Multi-voting principle is based on having each participant rank his or her options, and all the participants' rankings are then summed up for each alternative to obtain an aggregate score.

A ***Stratified Sampling Method*** was used in selecting sample population that participated in the multi-voting process. Here, the population sample was a class of people who are well informed about sustainability issues and have lived or stayed in Bonny Island for a period of not less than ten years. Seven questionnaires were distributed to work colleagues that hail from and live in Bonny. The results summary of the ranking is shown in Tables 4-3a, b & c of the next chapter, and the sample questionnaire used is in appendix D.

Semi-Structured Interview

This interview was to collate data on the percentage of students who have access to education grants and/or scholarship as a measure of economic indicator. The target population was high school students. Bonny National Grammar School and Epe Grammar School at Bonny Island and Epe respectively were selected for the study. Approvals were obtained from the school authorities prior to the conduction of the interview with twenty students from each school. The outcome is as presented in Table 4-4 of the chapter that follows.

Chapter Four

4.0 Presentation of Results

While the previous chapter discusses the scientific approach adopted for the experimental design in this dissertation, this chapter presents the findings of the experimental work aimed at assessing the impact of the liquefied natural gas plant on the community of Bonny Island.

4.1 Experimental Results

The outcome of the sustainability indicators developed within a domain-based framework is presented in table 4-1 below.

Table 4-1: Sustainable Development Indicators from Domain-Based Framework

Sustainability Parameters	Indicator	Purpose	Linkages
Environmental	Access to clean portable drinking water	To determine level of pollutants discharge to water body	▪ Aquatic life ▪ Community health ▪ Soil and groundwater contamination
	No. of sickness per annum	To measure how healthy the community is.	▪ Environmental pollution ▪ Health facilities
	Agricultural practices	To preserve productive agricultural land use.	▪ Loss of biodiversity ▪ Encourage 'green community'
	Standard waste management and environment sanitation	To minimize soil contamination	▪ Environmental degradation ▪ Community health
	Air, water and soil quality	To assess environmental pollution	▪ Global warming ▪ Improved health
Social	Percentage of population with basic education	Measures movement towards Millennium Development Goal (MDG) target	▪ Access to education grant and scholarship ▪ Level of literacy ▪ Work force ▪ Economic development

	Access to free or subsidized health care facility	To ensure healthy community	▪ Improved health ▪ Reduction in health care cost ▪ Maternal mortality ▪ Child mortality
	Crime rate (crime prevalence)	Measures community safety	▪ Unemployment ▪ Community unrest
	Access to information technology systems	To monitor the availability of modern facilities	▪ Literacy level ▪ Skilled labour
	Access to good transportation	Measures mobility	▪ Employment ▪ Community development
Economic	Percentage in paid employment	Determines number of available jobs	▪ Standard of living ▪ Work force
	Percentage of household than can afford 3 square meal daily	To eradicate hunger and poverty according to MDG	▪ Employment ▪ Cost of living
	Percentage of students with education grants and/or scholarship	To determine level of education subsidy	▪ Literacy level ▪ Skilled labour
	Access to credit facilities	Measures the degree of entrepreneurship	▪ Gross Domestic Product (GDP) ▪ Poverty level
	Percentage of household paying ≤ 20% of income on rent	To determine the cost of living	▪ Income adequacy ▪ Standard of living

Table 4-2 below presents the abridged results of the survey carried out at Bonny Island and Epe communities. The table also shows the relative percentage calculation of each outcome.

Table 4-2: Summary of Data from Sustainability Assessment Questionnaire

		Bonny		Epe Waterside	
Parameter	**Scale**	**Outcome**	**Percentage**	**Outcome**	**Percentage**
	Male	10	50	11	55
Sex	Female	10	50	9	45
	Bonny/Epe	16	80	17	85
Indigene	Others	4	20	3	15
Years of Residence	<10	4	20	3	15

	10-20	1	5	1	5
	>20	15	75	16	80
	<20	1	5	1	5
	20-30	8	40	5	25
Age (yrs)	>30	11	55	14	70
	None	0	0	0	0
	Primary	2	10	4	20
	Secondary	5	25	7	35
	Tertiary	11	55	8	40
Education	Post Graduate	2	10	1	5
	None	3	15	2	10
	Self-employed	6	30	5	25
Employment	Paid Employed	11	55	13	65
	<20	8	40	9	45
	20-30	7	35	6	30
House Rent (% of Income)	>30	5	25	5	25
Three Square Meals	Yes	15	75	13	65
	No	5	25	7	35
Cost of Living	High	15	75	11	55
	Moderate	5	25	9	45
	Low	0	0	0	0
	Yes	11	55	12	60
	No	9	45	8	40
Access to Credit Facilities	Not Sure	0	0	0	0
	Yes	14	70	7	35
	Somewhat	4	20	11	55
Environmental Pollution	No	2	10	2	10
No. of Sickness per Year (Σfx)		48		40	
	Yes	12	60	18	90
	No	7	35	2	10
Health Infrastructure	Not Sure	1	5	0	0
	Excellent	0	0	0	0
	Good	7	35	9	45
	Fair	9	45	9	45
Waste Management	Poor	4	20	2	10
Access to Clean Drinking	Yes	14	70	17	85
Water	No	6	30	3	15
	Excellent	0	0	0	0
	Good	6	30	7	35
	Fair	11	55	10	50
Transportation System	Poor	3	15	3	15
	Yes	12	60	11	55
	No	8	40	8	40
Access to ICT	Not Sure	0	0	1	5
	Yes	9	45	12	60
	No	9	45	6	30
High Agricultural Practices	Not Sure	2	10	2	10
	Yes	15		9	
No. of Crime (Σfx) per Year	No	13	65	14	70

Results of the Multi-Voting Technique process are presented in tables 4-3a, b & c. The tables show the outcomes of the ranking from seven participants. Each indicator was scored by all the respondents and the row scores summed up as shown below.

Table 4-3a: Output of Multi-Voting Technique Session on Environmental Indicators

Respondents / Indicators	1	2	3	4	5	6	7	Total
Access to Clean Drinking Water	3	2	5	5	4	2	2	23
Air, Water & Soil Quality	5	4	3	2	3	3	4	24
Frequency of Sickness	4	5	4	1	5	5	5	29
Waste Management	1	1	2	4	2	1	1	12
Agricultural Practices	2	3	1	3	1	4	3	17

Table 4-3b: Output of Multi-Voting Technique Session on Social Indicators

Respondents / Indicators	1	2	3	4	5	6	7	Total
Free or Subsidized Health Care	3	3	2	4	2	4	4	22
Access to Information Technology System	2	1	1	1	3	1	2	11
Good Transportation	1	2	3	2	1	2	1	12
Basic Education	5	4	5	5	4	3	3	29
Crime Prevalence	4	5	4	3	2	5	5	28

Table 4-3c: Output of Multi-Voting Technique Session on Economic Indicators

Respondents / Indicators	1	2	3	4	5	6	7	Total
Availability of Credit Facilities	2	3	1	1	1	2	1	11
Ability to Afford 3 Square Meals per Day	5	4	4	5	5	4	5	32
Employment	3	5	5	4	4	5	3	29
Cost of Housing	1	1	3	3	3	1	2	14
Education Grant and Scholarship	4	2	2	2	2	3	4	19

Table 4-4 presents the outcome of the interview conducted with high school students at Bonny National Grammar School and Epe Grammar School. It gives representative data of how education grant and scholarship are available to students from the two communities.

Table 4-4: Outcome of Interview with Students

Student	Education Grant and/or Scholarship?					
	Bonny Island (Bonny National Grammar School)			Epe Waterside (Epe Grammar School)		
	Yes	No	Source	Yes	No	Source
1	√		Chevron		√	Parents
2	√		NLNG		√	Parents
3	√		NLNG		√	Parents
4		√	Parents		√	Parents
5	√		NLNG		√	Parents
6	√		Chevron	√		Lagos State Bursary
7	√		NLNG		√	Parents
8	√		Shell		√	Parents
9		√	Parents		√	Parents
10		√	Parents		√	Parents
11	√		NLNG		√	Parents
12	√		NLNG		√	Parents
13	√		NLNG		√	Parents
14	√		Shell		√	Parents
15	√		NLNG		√	Parents
16		√	Parents		√	Parents
17	√		Chevron		√	Parents
18	√		NLNG		√	Parents
19	√		NLNG		√	Parents
20		√	NLNG		√	Parents

Figures 4-1, 4-2 and 4-3 are respective graphs depicting environmental, social and economic sustainability indicators of Bonny Island and Epe communities. The cluster bar charts help to make adequate comparison between the two communities for each of the indicators.

Figure 4-1: Environmental Sustainability Indicators of Bonny Island and Epe Communities

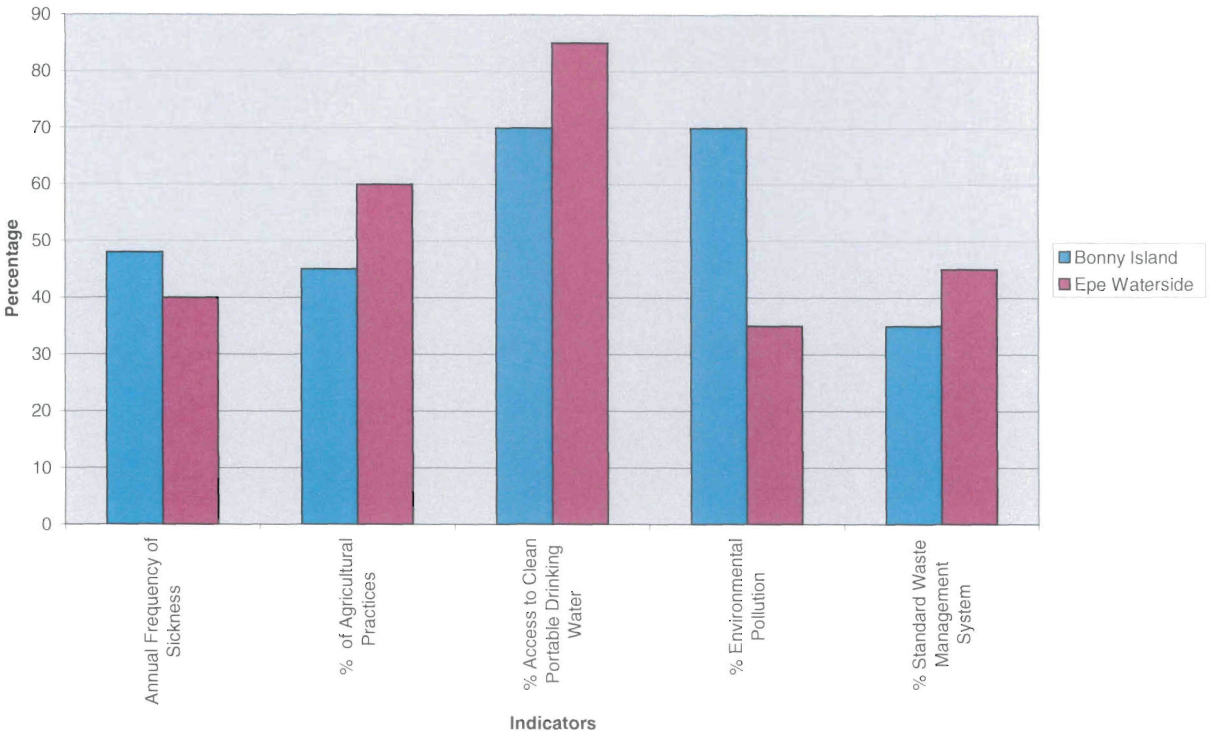


Figure 4-2: Social Sustainability Indicators of Bonny Island and Epe Communities

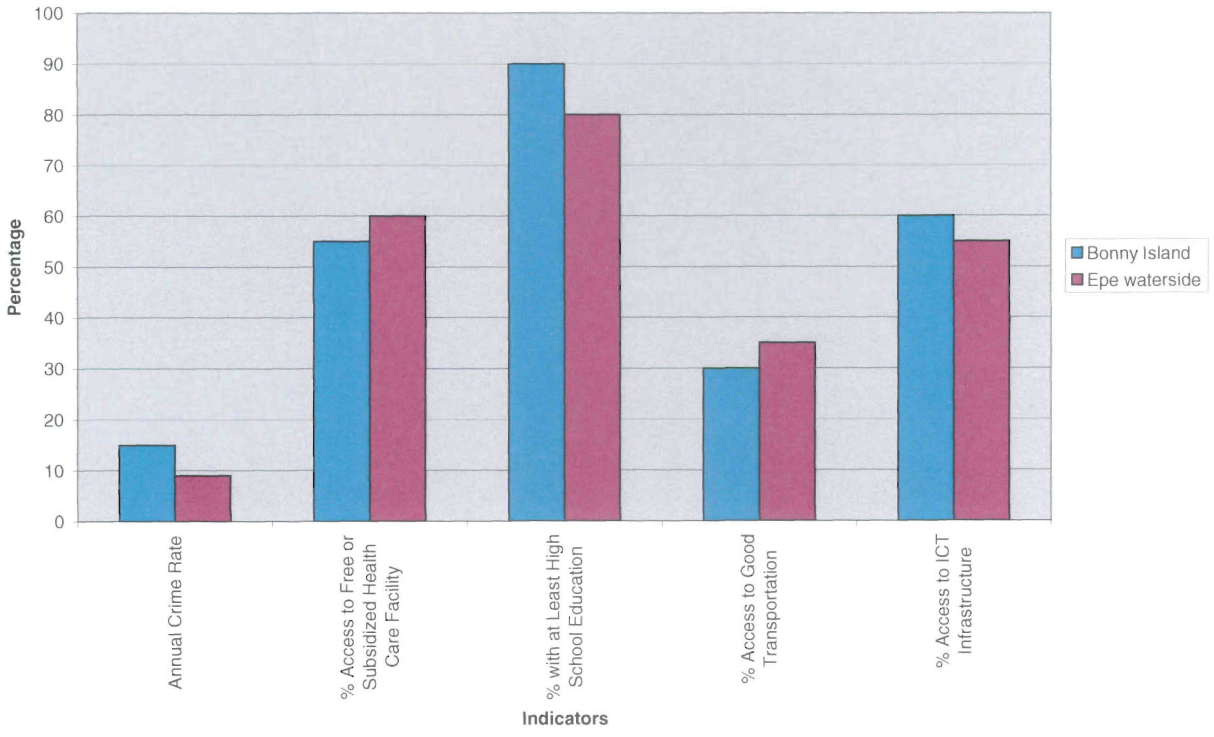


Figure 4-3: Economic Sustainability Indicators of Bonny Island and Epe Communities

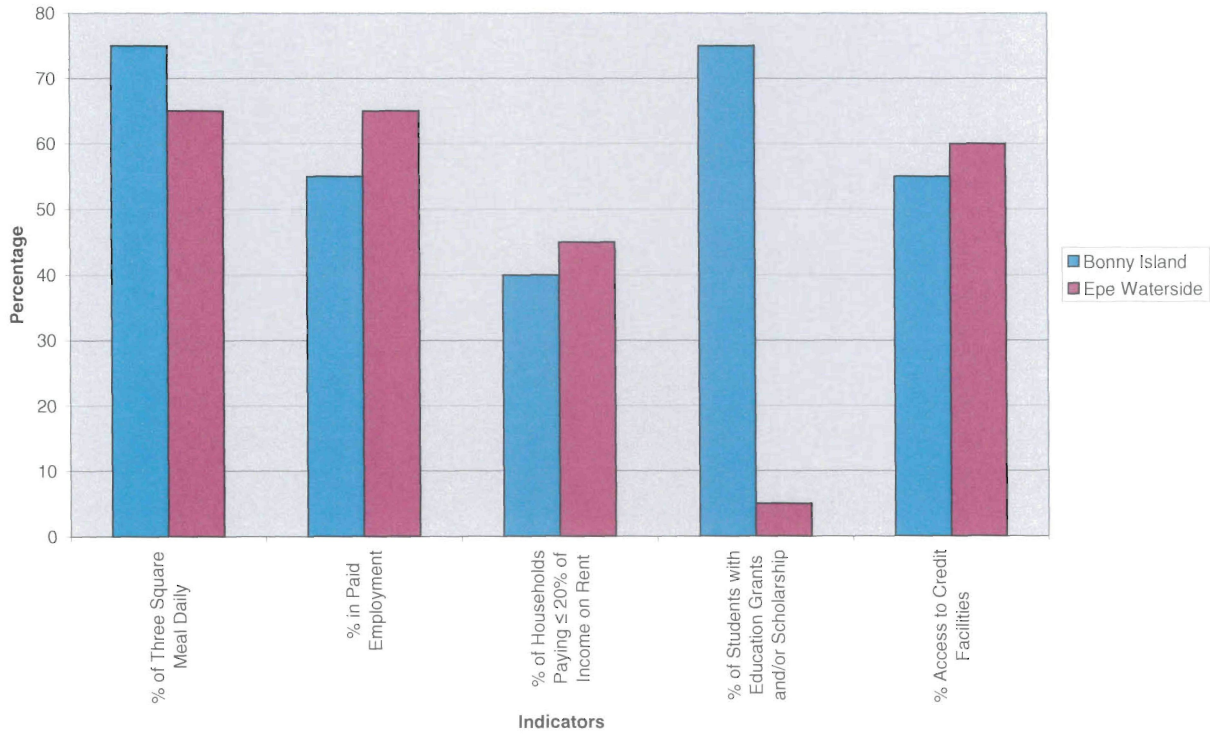


Table 4.5 was extracted from the questionnaire survey. It contains respondents' feedback on the indicators – each from the three sustainability factors - that were ranked highest in the Multi-Voting Technique. Weights were attached to the level of education to convert it to a quantifiable and measurable format as done in table 4.5a.

Table 4-5: Extracted Survey Data for Statistical Analysis

	Environment		Social		Economic	
Causal Agents	Environmental Pollution				Income	
Effects	No of Sicknesses/year		Level of Education		No. of Balanced Meals/day	
	Bonny Island	Epe Waterside	Bonny Island	Epe Waterside	Bonny Island	Epe Waterside
Interviewee 1	3	3	2	2	2	2
Interviewee 2	2	4	3	2	3	2
Interviewee 3	4	1	3	3	3	3
Interviewee 4	3	1	3	3	3	3
Interviewee 5	1	2	4	3	3	3
Interviewee 6	3	2	3	2	2	2
Interviewee 7	2	4	2	2	3	3
Interviewee 8	1	1	3	3	3	3
Interviewee 9	3	3	2	2	2	3
Interviewee 10	3	3	3	2	3	2
Interviewee 11	2	1	3	2	3	2
Interviewee 12	2	1	3	4	3	3

Interviewee 13	2	1	2	3	3	3
Interviewee 14	1	3	3	1	3	2
Interviewee 15	4	2	1	3	2	3
Interviewee 16	4	2	2	2	2	3
Interviewee 17	1	2	4	3	3	2
Interviewee 18	2	1	3	3	3	3
Interviewee 19	2	1	3	3	3	3
Interviewee 20	3	2	3	2	3	3
Mean μ	**2.4**	**2**	**2.75**	**2.5**	**2.75**	**2.65**
SD (Standard Deviation)	**0.99**	**1.03**	**0.72**	**0.69**	**0.44**	**0.49**

Table 4.5a Weighted Levels of Education

Level of Education	Weight
No Formal Education	0
Primary / Elementary School	1
Secondary / High School	2
Tertiary	3
Post Graduate	4

4.2 Results of Statistical Analysis

The results that follow are the output of student's t test of software from www.graphpad.com based on the data in table 4-5.

Unpaired* t *test results (using Quickcalcs from graphpad software - www.graphpad.com)

(a) Environmental Indicator t-test (Frequency of sickness between Bonny Island and Epe communities)

P value and statistical significance:

The two-tailed P value equals 0.2183

By conventional criteria; this difference is considered to be statistically significant.

Confidence interval:

The mean of Bonny Island minus Epe Waterside equals 0.40

95% confidence interval of this difference: From -0.25 to 1.05

Intermediate values used in calculations:

t = 1.2518

df = 38

standard error of difference = 0.320

No. of Sickness

Group	Bonny Island	Epe Waterside
Mean μ	2.40	2.00
SD	0.99	1.03
SEM	0.22	0.23
N	20	20

Where, SD - Standard Deviation,

SEM – Standard Error of Mean

N – Number of analyzed data

(b) Social Indicator t-test (Level of education between respondents from Bonny Island and Epe communities)

P value and statistical significance:

The two-tailed P value equals 0.2675

By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

The mean of Bonny Island minus Epe Waterside equals 0.25

95% confidence interval of this difference: From -0.20 to 0.70

Intermediate values used in calculations:

t = 1.1255

df = 38

standard error of difference = 0.222

Level of Education

Group	Bonny Island	Epe Waterside
Mean μ	2.75	2.50
SD	0.72	0.69
SEM	0.16	0.15
N	20	20

(c) Economic Indicator t-test (Comparison between the number of times respondents from Bonny Island and Epe communities can afford meals daily)

P value and statistical significance:

The two-tailed P value equals 0.5027

By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

The mean of Bonny Island minus Epe Waterside equals 0.10

95% confidence interval of this difference: From -0.20 to 0.40

Intermediate values used in calculations:

t = 0.6766

df = 38

standard error of difference = 0.148

No. of Balanced Meals per day

Group	Bonny Island	Epe Waterside
Mean μ	2.75	2.65
SD	0.44	0.49
SEM	0.10	0.11
N	20	20

Figures 4-4 & 4-5 are charts showing an observed trend that exists among the indicators. The trend depicts a significant correlation in the three sustainability indicators under observation.

Figure 4-4: Graph Showing Interactions Among Environmental, Social and Economic Indicators (Bonny Island)

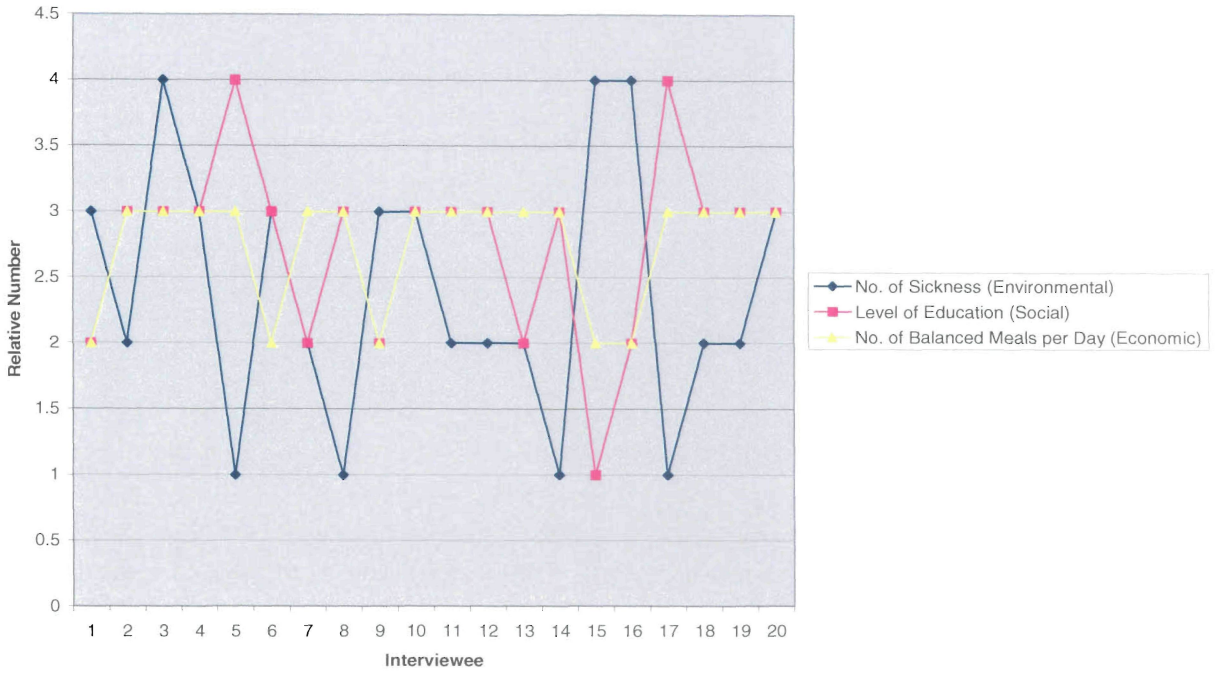
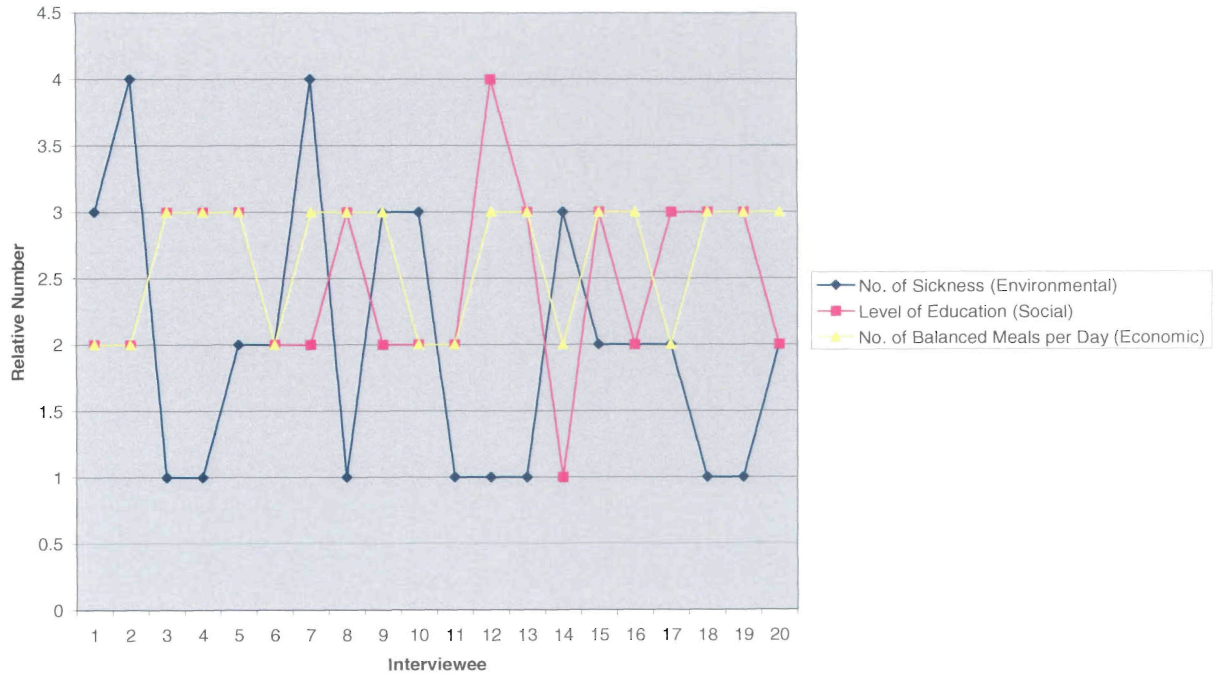


Figure 4-5: Graph Showing Interactions Among Environmental, Social and Economic Indicators (Epe Waterside)



The chapter that follows interprets and provides explanations to the various results obtained from the experimental procedures. It also offers valid scientific arguments for the observed trends, correlations and anomalies in the experimental results.

Chapter Five

5.0 Analysis and Discussion of Results

This chapter analyses the results of the experimental work carried out to assess the impact of the Nigeria liquefied natural gas operation on its host community. A domain-based framework was chosen for the development of the sustainability indicators because of its holistic approach to the three dimensions of sustainable development – environmental, social and economic sustainability.

The outcome presented in table 4-1 consists of five indicators each for the three parameters of sustainable development. These indicators were deduced from the United Nations Working List of Sustainable Development Indicators (Appendix A) according to their relevance to the research needs and scope. The table also shows the purpose of each indicator and its relationship or linkage to other sustainability pointers.

5.1 Survey Results Analysis

Tables 4-2 and 4-4 show the results of the questionnaire survey and the interview conducted in the two communities under survey. Twenty questionnaires were duly completed and received back from each of the communities within an acceptable time frame.

Findings show that 50% of the sample population in Bonny is male, while Epe has male proportion of 55%. A sizable percentage (40%) of the respondents in Bonny Island is youth between the ages of 20-30 years. It is reported that this age class is mostly responsible for the agitation against the NLNG operations, and the incessant attack on other oil companies' facilities within the community and its environs.

Indigenes of Bonny Island and Epe communities constitute 80% and 85% of the total respondents respectively. These proportions favour the research target because it represents a good number of the population who are familiar with the fundamental problems of their respective communities. In addition, survey shows that about 80% of the respondents have lived or stayed in their individual community for at least 20 years,

thus affording Bonny respondents the knowledge of the community's states prior to the inception of the LNG project.

5.1.1 Environmental Indicators Performance

As depicted in figure 4-1, findings reveal that 20 respondents fall sick 48 times in total per annum in Bonny Island while Epe records an aggregate of 40 times per year. In other words, illness prevalence is about 20% more in Bonny Island than Epe community. This is a significant difference considering the size of the sample population. In addition, sustainability Indicators show that Bonny Island performs comparatively lower when assessed in terms of community's agricultural practices, environmental pollution, waste management system, and accessibility to clean portable water. These are issues that may in the long run impact on the community's 'carrying capacity' (Rees, 1992).

It is evident that the aforementioned shortcomings are, by and large, as a result of the presence of the NLNG plant in Bonny Island. A large arable land used for the plant site, and soil degradation resulting from its operations, all have effects on farming activities. Industrial pollution is still a global issue which can, at present, only be minimized. It could also be inferred from the study that massive migration of people in search of greener pasture in and out of Bonny is largely responsible for poor planning on the part of the local authority. This consequently has adverse effects on waste management and provision of clean potable water to the community dwellers.

5.1.2 Social Indicators Performance

Figure 4-2 graphically presents the performance of chosen social indicators in Bonny Island as compared to Epe community. Crime rate is observed to be higher in Bonny Island; which is suspected to be partly attributed to frequent youth agitation, and large influx of job seekers. These socio-cultural instability and incessant unrest are possible explanations for the observed social setback in Bonny Island. In addition, the community falls short when measured in terms of health care facility adequacy and transportation system. Too much dependence on the existing social infrastructures to support an unpredictably growing community population is a suspect.

However, Bonny Island community does achieve superior performance on the indicators that assess the percentile of the level of education, and how easily accessible the information communication and technology (ICT) systems are. Though survey shows that more people in Bonny have basic education as defined by the Millennium Development Goals (MDG), it was observed that a vast majority of the natives do not pursue further academic careers because of the temporary succor provided by the NLNG project, particularly during the construction phase. The presence of the NLNG plant is also believed to have contributed to higher growth in ICT infrastructures in within the community.

5.1.3 Economic Indicators Performance

To assess the impact of the NLNG operations on the economic sustainability of Bonny Island, comparisons were made with the control community (Epe Waterside) based on some suitable economic indicators as shown in figure 4-3. It is clear from the chart that many more people in Bonny Island are economically comfortable even though at a higher cost of living. As presented in table 4-2 and figure 4-3, survey reveals that Bonny is healthier in economic prosperity because of the NLNG activities, which provide about 35% direct and over 20% indirect jobs with adequate income to the populace. Thus, it can be said that a relatively good proportion of Bonny Island inhabitants can afford balanced meals, which is one of the objectives of the MDGs.

Besides, outcome of the interviews held with high school students presented in table 4-4 show a remarkable difference in the availability of educational grant and scholarship between the two communities under study. It is evident from findings that students in Bonny Island enjoy these financial supports mainly from the petrochemical companies operating in the area. Table 4-4 also shows that about 55% of this financial assistance comes from the NLNG management as part of its host community's human capital development. Another way by which NLNG operations has impacted positively on its host community is through provision of low-interest-rate and no-collateral credit facilities to the people through registered community-based groups. Even though the control community marginally performs better in indicator that measures this quality, a singular effort by the NLNG management to encouraging entrepreneurship cannot be underestimated.

5.2 Validation of Results

In an effort to substantiate the accuracy and reliability of the results obtained from the research study, a combination of statistical approach and literature citation are adopted to validate the findings.

5.2.1 Statistical Analysis

From the results of the Multi-Voting Technique in tables 4-3a, b & c; it is shown that frequency of sickness, level of education and affordability of daily meals were ranked highest as indicators for environmental, social and economic sustainability respectively. According to Engineering Statistics Handbook (n.d.), a two-sample t test is used to determine if two population means are equal or if the difference in their means is equal to zero. Hence, to further compare the sustainability indicators performance of the two communities, the independent unpaired empirical data extracted into table 4-5, were subjected to two-sample student's t tests with the following assumptions:

Assumptions for Student's t test

- The data in each sample set were randomly selected from a population.
- The population sample is normally distributed
- It is assumed that the data are sampled from population that follows Gaussian distribution, i.e. the variances are assumed equal for both data sets.
- The sample groups are independent.

Null Hypothesis, H_o is:
The NLNG project has no impact on environmental, social and economic sustainability.

i.e. $H_o: \mu_1 = \mu_2$

While the Alternative Hypothesis, H_a is:

$H_a: \mu_1 \neq \mu_2$

Where μ_1 – is mean value from Bonny Island, and μ_2 – is mean value from Epe.

Results from t-test analysis in section 4.2 of the previous chapter, caption 'results of statistical analysis', were obtained using Quickcalcs from Graphpads Software (www.graphpad.com). The outputs of the comparative analysis show some significant

statistical differences between the sustainability indicators of Bonny Island and Epe communities. i.e. the test demonstrated that the alternative hypothesis is true. Though the social and economic conditions of Bonny Island tend to be better as provided by the experimental outcome, its environmental sustainability remains a challenge.

5.2.2 Literature Citation

Various views have been presented in the past by different authors and scholars to provide explanations why the current approach of technology, as a panacea to developmental issues, is not sustainable. Akeredolu (2000) submits that it is practically impossible to concurrently achieve environmental, social and economic sustainability without a balanced combination of an appropriate technology and a right attitude. He emphasizes the need for the people to embrace an attitude of sustainable living.

Roger Baud (2000) supports Akeredolu's argument in his claim that "the future of mankind on this planet will not be possible through technological innovation alone. We need behavioral change and, cuts in material and resource consumption..." He further stresses the need for man to adapt to nature, and not vice-versa, for a development that is sustainable.

Chaudhari P. (2000) also acknowledges that "science and technology are necessary but certainly not sufficient for a sustainable future. Sustainability is a virtue that must be encouraged, perhaps taught, and assimilated at all levels."

There is another school of thought with a divergent view that man's interior motive for developing technology is for economic gains with no adequate consideration for the environment, which thus makes the concept of sustainable development a mirage. According to G. Martine (1997), many countries still strive to improve the quality of life of its citizens through development that is dominated by a market-based economic growth.

David Baird (1995) also states that "the industrialized world engages in technological practices that produce wealth and comfort for 20 percent of the world population while drawing down the productive capital of the globe." He writes that much of the current efforts on technological innovations are geared towards optimizing production capacity at the detriment of the environment.

Another source (http://ag.arizona.edu/~lmilich/susdev.html) also reports that "after a century of unprecedented economic growth as well as scientific and technological triumphs, there are more poor, illiterate, and unemployed people now than ever before."

Furthermore, a report on a similar LNG project in Indonesia (http://www.hydrocarbons-technology.com/projects/) asserts that the various processes involved in the conversion of natural gas to liquid, and back to natural gas for end-users emits as much carbon dioxide as a coal plant. These emissions occur when "extracting the gas from the earth, processing the gas to meet client standards, transporting it through pipelines, chilling it, shipping it overseas, and then converting it back to natural gas". All these activities also utilize one form of nonrenewable energy or the other. "In the end, LNG is a major source of greenhouse gasses", and thus not a sustainable technology.

5.3 Observed Relationship among Sustainability Indicators

In the course of the research work, a particular trend was observed in the data collected for the indicators as plotted in figures 4-4 and 4-5. The graphs show that the economic indicator is directly proportional to social indicator but these two factors are inversely proportional to environmental indicator either jointly or independently.

In other word, it means that an economic sustenance often leads to social sustainability but at the detriment of the environment. Further work could be pursued in this regard to verify the correlation since it is outside the scope of this dissertation.

5.4 Summary

This chapter has submitted the outcome of comparative analysis carried out on Bonny Island and Epe communities using the relevant sustainability indicators. The outcome of the experiment provides scientific evidence to the question raised by this dissertation theme concerning the impact of Nigeria LNG operations on its host community. It has shown through empirical analysis that the environmental, social and economic factors of the principal community and the control community are significantly different.

Chapter Six

6.0 Conclusions and Recommendations

This chapter draws conclusion from the findings of the research work that assesses the impact of Nigeria liquefied natural gas project on Bonny Island community. Recommendations are also made based on these conclusions with a view to promoting the concept of sustainable development. In addition, the chapter highlights areas where further research is needed.

6.1 Conclusions

The purpose of this dissertation was to carry out an empirical research on the sustainable development challenges of the contemporary technologies. The Nigeria liquefied natural gas (NLNG) project sited in Bonny Island was chosen as a case study. Its impacts on the host community were assessed using sustainability indicators and then compared with the outcome of another community of a similar socio-geographical structure.

From the research results, it is obvious that the NLNG project has had both positive and negative effects on its area of operation. The economic capacity and social well-being of the community dwellers have improved comparatively through job provision, good credit facilities, favorable business environment, and qualitative life style. Other areas where the project is seen to have impacted positively on its host include an enhancement in the ICT infrastructures of the community and provision of education assistance to the students within the region.

Nonetheless, the key challenges of the NLNG project, as identified by the study, are more of environmental in nature. These problems include industrial release, farmland encroachment, aquatic life destruction, and waste management issue. Another significant problem is the crime prevalence in the community suspected to have been caused by the immigrated job hunters and the militant youth requesting for ransom because of environmental degradation.

Having appraised the impact of the NLNG project on its host community using sustainability indicators, it can be deduced from the aforementioned points that the project has a number of challenges, largely, in terms of environmental sustainability. Since the core principle of sustainable development is the acknowledgement of the interdependence and interactions of environmental, social and economic sustainability, hence lacking in one upsets the balance. It can then be concluded that the liquefied natural gas technology is not sustainable based on the current operational approach.

It can also be inferred from the field work that some of these sustainable development issues are global in nature. For example, problems of ozone-layer depletion, deforestation, and climate change are consequential. The need for all hands to be on deck for sustainable living cannot be overemphasized.

6.2 Recommendations

The necessity to promote a development that is sustainable in all human endeavors cannot be overstressed. Man must develop science and technology, which do not exhaust finite natural endowments, destroy the environment, or undermine the economic and social structures that the future generations will build there lives on. To this end, the following recommendations are made based on the research conclusions:

- In general, the need for a paradigm shift from the traditional way of project impact assessment is imperative. The present use of Environmental Impact Assessment (EIA) as a baseline for project approval and its performance measurement is inadequate. Implementation of Sustainability Indicators (SI), otherwise called Sustainability Performance Indicators (SPI) or Sustainability Performance Assessment (SPA), which integrates environmental, social and economic factors into project impact assessment, is recommended.
- Specifically, the Nigeria LNG management should develop a Sustainability Performance Management System (SPMS) to help in the continuous assessment, management and monitoring of the impacts of its activities on the flora and fauna.
- It is important to involve other stakeholders – community leaders, youth, labor union, government representatives, etc – in the development of the SPMS.
- The impact of NLNG operations on the environment could be minimized through an improved waste management and disposal system. The operational process could

be enhanced to ensure that the emission and the effluent discharged into the environment are within permissible limits.

- The NLNG management should support the local community in the provision of adequate subsidized health care facility to the community dwellers. This will help control the frequent occurrence of sickness.
- The recurring agitation by the community youth can be resolved through dialogue, and provision of gainful employment to keep the 'warring' youth productive. This will significantly help reduce the menace of crime within the community and its environs.
- Evidence from literature shows that many national governments are not doing enough to advance the cause of sustainable development. It is recommended that government enact policies that incorporate sustainability objectives in national development strategy. A regulatory body that ensures that projects are managed within the sustainable development goals should be constituted.
- Finally, this research approach had to be modified due to lack of past data on sustainability indicators. The quality of future research work can be improved if record keeping and archival systems in the country is improved. The Federal Environmental and Protection Agency of Nigeria (FEPA) should live up to its responsibility in this regard.

6.3 Further Research

Sustainable development is an evolving concept – there is a need for continuous research. Further research work should possibly consider gathering data for sustainable development indicators over a period of time to be able to accurately measure project progress towards or away from sustainability.

The experimental work also reveals that a particular trend exists amongst the environmental, social and economic indicators data. It is observed that social and economic factors thrive at the expense of the environment and vice versa. It is therefore suggested that further research work is carried out to investigate this interesting relationship that possibly exists.

Appendix A

Table: United Nations Working List of Indicators of Sustainable Development

Social aspects of sustainable development		Environmental aspects of sustainable development (subdivided into water, land, atmosphere & waste)		Economic aspects of sustainable development	Institutional aspects of sustainable development
Access to safe drinking water	Unemployment rate	Groundwater reserves	Agricultural education	GDP per capita	Sustainable development strategies
Life expectancy at birth	Head count index of poverty	Wastewater treatment coverage	Wood harvesting intensity	Net investment share in GDP	Mandated Environmental Impact Assessment
Adequate birth weight	Poverty gap index	Annual withdrawals of water	Forest area change	Sum of exports and imports as % GDP	Prog. integrated environmental & economic accounting
Infant mortality rate	Squared poverty gap index	Density of hydrological networks	Managed forest area ratio	Annual energy consumption	National councils for sustainable development
Maternal mortality rate	Gini index of income inequality	Biochemical oxygen demand in water bodies	Protected forest area as a percent of total forest area	Share of manufactured goods in total merchandise exports	Potential scientists and engineers per million population
Nutritional status of children	Ratio of average female wage to male wage	Domestic consumption of water per capita	Threatened species as a percent of total native species	Environmentally adjusted Net Domestic Product	Scientists and engineers engaged in R & D per million population
Immunization against infectious childhood diseases	Population growth rate	Concentration of faecal coliform in freshwater	Protected area as a percent of total area	Share of natural resource intensive industries in manufacturing value-added	Representatives of ethnic minorities and indigenous people in national councils for sustainable development
Contraceptive prevalence	Net migration rate	Population growth in coastal area	R & D expenditure for biotechnology	Proven mineral reserves	Expenditure on R & D as a percent of GDP
Proportion of potentially hazardous chemicals monitored in food	Total fertility rate	Discharges of oil into coastal waters	National bio-safety regulations or guidelines	Proven fossil fuel energy reserves	Ratification of global agreements
National health expenditure devoted to local health care	Population density	Releases of nitrogen and phosphorus to coastal waters	Emissions of greenhouse gases	Lifetime of proven energy reserves	Implementation of ratified global agreements
Total national health expenditure related to GNP	Rate of change of school-age population	Maximum sustained yield for fisheries	Emissions of sulphur oxides	Intensity of material use	Main telephone lines per 100 inhabitants
Rate of growth of urban population	Primary school enrolment ratio	Algae index	Emissions on nitrogen oxides	Share manufacturing value-added (GDP)	Access to information

Per capita consumption of fossil fuel by motor vehicle transport

Human and economic loss due to natural disasters

Percent of population in urban areas

Area and population of urban formal and informal settlements

Floor area per person

Infrastructure expenditure per capita

House price to income ratio

Secondary school enrolment ratio (gross and net)

Basic sanitation: % population with adequate excreta disposal facilities

Children reaching grade 5 of primary education

School life expectancy

Difference between male and female school enrolment ratios

Women per hundred men in the labour force

GDP spent on education

Adult literacy rate

Land use change

Changes in land condition

Decentralized local-level natural resource management

Population living below poverty line in dry-land areas

National monthly rainfall index

Sustainable use of natural resources in mountain areas

Population change in mountain areas

Land affected by desertification

Satellite derived vegetation index

Welfare of mountain populations

Use of agricultural pesticides

Use of fertilizers

Irrigation percent of arable land

Energy use in agriculture

Arable land per capita

Area affected by salinisation and water-logging

Consumption of ozone depleting substances

Ambient concentrations of pollutants in urban areas

Expenditure on air pollution abatement

Generation of industrial and municipal solid waste

Household waste disposed per capita

Area of land contaminated by hazardous wastes

Waste recycling and reuse

Municipal waste disposal

Chemically induced acute poisonings

No. chemicals banned or severely restricted

Generation of hazardous wastes

Imports and exports of hazardous wastes

Expenditure on waste management

Expenditure on hazardous waste treatment

Generation of radioactive wastes

Share of consumption of renewable energy resources

Net resources transfer / GNP

Total ODA given or received as a percentage of GNP

Debt / GNP

Amount of new or additional funding for sustainable development

Environmental protection expenditures as % of GDP

Debt service / export

Capital goods imports

Foreign direct investments

Share of environmentally sound capital goods imports

Technical co-operation grants

Programmes for national environmental statistics

Representation of major groups in national councils for sustainable development

Contribution of NGOs to sustainable development

Appendix B

Examples of Goal-Based Sustainability Indicators Framework

(Source: US EPA, 2007: Green Communities)

"The strength of a goal-based framework is that it reduces the number of indicators that have to be considered to only those relating to specified sustainability goals.

Sustainability Indicators

Sustainability Indicators represent areas of concern which, if improving over time will lead to a more green community. Although these indicators could be categorized under many different topics, these indicators often can be translated into specific targets or goals.

Indicator	Purpose	Linkages
Percent of population within walking distance of public transportation	To evaluate access to public transportation in an effort to reduce automobile use and dependency;	This links to livability issue, land use, air pollution, etc.
Percent of native plant and animal species endangered vs. secure	To evaluate natural resource diversity in your community; To help ascertain sustainability of natural resources and related functions.	Biodiversity provides links to natural resource protection, land use, recreational opportunities and economic benefits associated with open spaces, greenways and natural areas.
Percent and volume of waste converted back to beneficial uses	To evaluate conservation and pollution prevention efforts of commercial and industrial sectors, as well as, households.	This indicator links to economic savings for the purchase and production of new materials, reduces toxic emissions to air, water and land. Ensures sustainable use of limited resources.
Progress toward goal of 20% reduction in	To measure reduction in water use,	This links to sustainable use of limited

use of potable water	conservation measures implemented. It focuses on solution not problem.	resources resulting in cost savings for homes, business and industry.
Vehicle Miles Traveled	To illustrate the effect of land use patterns on travel needs. Vehicle shows that people are inconveniently located to meet daily needs of work, home, children and recreation.	This indicator strongly links to land use; Other links include air quality, consumption of non- renewable resources and costs (taxes) associated with highway construction and maintenance.

Economic Prosperity

Not until communities can meet their vital needs of shelter, food, clothing, etc will they become aware of the social and environmental problems. When most of the community cannot afford their basic living expenses, they usually do not address the associated social and environmental decline. Economic prosperity stabilizes families and enhances revenues to pay for public services.

Indicator	Purpose	Linkages
% employment in locally- owned and operated businesses	To evaluate investment that stays within the community. A healthy economy results from "plugging the leaks."	Linkages to social well-being, civic participation, education.
Distribution of personal income	To evaluate the disparity between haves and have nots. Communities are weakened by concentrations of poverty and unequal opportunity.	Low incomes can be linked with child poverty, poor health, education levels, levels of civic participation, and inequitable distribution of services and opportunities.
Percent of households paying 30% or less of income on rent	To evaluate affordable housing in the community. Communities' members have diverse needs; adequate affordable housing	Linkages to social well-being, economic stability, health and welfare issues, poverty.

	is necessary to foster economic sustainability.	
Number of enterprises adopting ISO 14000 standards	To measure the progress of industry to incorporate standards to improve processes which lead to greater environmental protection.	Linkages to resource conservation, health, education
Income disparity between urban centers and outlying areas (suburbs)	Indicates urban decay and suburban sprawl	Linkages to land use, resource consumption, education, poverty, crime and safety, environmental justice.

Healthy Community

The health of the community is measured by the physical and mental health of the people who live there. A community's health is vital to a good quality of life. The health of a community can be linked to economic, social and environmental conditions. Emotional health is dependent on recreation abilities, and access to the natural environment and community activities.

Indicator	Purpose	Linkages
Percentage living below poverty line	A healthy community has economic equity. There should not be a disparity between the "haves" and the "have nots".	• crime • child abuse • welfare
Percentage who volunteer at least 50 hrs/year to civic, community or nonprofit activities.	To seek to improve the Quality of Life in our communities.	• Improved condition for poverty • economic renewal
Park & facility space (acres) per capita (1000 people) by district. Within a ¼ mile radius.	To reflect desired land use patterns. To provide well integrated public open spaces in urban districts.	• increase 'livability' in high density residential and commercial areas • urban biodiversity • urban wildlife habitat

		• mental health • tourism • economic renewal • social gathering • air quality • water quality by decreasing impervious surface • reduce temperature • community gardens for produce
Hospitalization for asthma per 10,000 residents		• poverty • housing affordability • indoor and outdoor air quality • lack of health care • societal health costs • home cleanliness
Percent of community with available health insurance	To reflect how much of our financial resources are being allocated toward caring for or preventing illness. To ensure that affordable health care is available to everyone.	• serious problems result in delay in obtaining medical attention. • increase costs to personal, business and government • excessive costs leave less for spending on education and environment
Young female (10-17) pregnancy rate (birth rate/ 1000 female)	To reduce the incidence of teen pregnancy	• increase in prenatal and perinatal complications • impaired child development • cost to society increase welfare dependents

Social Well Being

Community must be a safe place to live. People must have easy and safe access to work, stores and play. The neighborhoods need to be safe from crime. Inhabitants want neighborhoods that are equitable and clean. Until they feel safe with their basic needs of shelter and food, they cannot look forward to improving their environmental and economic health."

Indicator	Purpose	Linkages
Percentage of ethnic groups graduating High school	To produce a good citizen with the basic skills necessary to participate fully in the stewardship of our city and region.	• parental involvement • economic vitality • social equity • public safety
Rate of reported violent crimes (against person) per 1000 people during calendar year. Compare difference of urban and rural communities	To measure the public safety of our community. To make our communities a safe place to live. To live peaceably together	• economic decline by discouraging economic investment • environmental justice • Child poverty • social diversity • Vehicle Miles Traveled • Health care cost • Increase tax burden • Destabilizes communities
Percent of population within walking distance of public transportation	To increase the amount of pedestrian friendly streets. To limit the dependence on car to provide transportation to work and shopping.	• improved health • promotes social interactions • recreational opportunity • expand mobility • air quality • economic renewal

Distribution of affordable housing throughout the community	To provide affordable housing for everyone. To increase community stability and self sufficiency.	• distribution of wealth • impact on biodiversity • child poverty • crime rates • reduced mental health • homelessness

Appendix C

Sustainability Assessment Questionnaire

This questionnaire has been developed in respect of impact of Liquefied Natural Gas plant in Bonny Island, Nigeria on its host community. The data collected is intended for a research on the sustainability performance of the project. Hence, your objectivity is highly required.

Every piece of information given shall be kept confidential.

1. Please indicate your gender. Male Female

2. You are a native of Bonny Epe Waterside Others

3. How long have you lived or stayed in this Community?

1 < 1 year 2 1–5 yrs 3 5–10 yrs 4 10–20 yrs 5 20–50 yrs 6 + 50 yrs

4. How old are you? 1 < 20 year 2 20-30 yrs 3 30-50 yrs 4 +50 yrs

5. What is your highest education?

1 No Formal Education 2 Primary 3 Secondary 4 Tertiary 5 Post Graduate

7. Are you employed in paid work? Yes No

If yes, where? ..... If no, what is your occupation? .....

8. What percentage of your monthly income do you pay on house rent?

1 < 20% 2 ≤30% 3 >30%

9. Will you say that you can easily afford 3 square meals daily? 1 Yes 2 No

10. What can you generally say about the cost of living in this community?

1 High 2 Moderate 3 Low

11. Do you have access to credit facilities in your community? 1 Yes 2 No 3 Don't Know

12. There is no environmental pollution (i.e. high air, water and soil quality) in my area?

Strongly Agree | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Strongly Disagree

13. How often do you fall sick in a year?

Very Frequently | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Never

14. Is there an adequate provision of free or subsidized health care facilities in your community?

1 Yes 2 No 3 Can't Say

15. How will you rate waste management system in your community?

1 Excellent 2 Good 3 Fair 4 Poor

16. How is the transportation system in your area? 1 Excellent 2 Good 3 Fair 4 Poor

17. Do you have easy access to information & communication technology, like internet, telephones and mobiles, in your area?

1 Yes 2 No 3 Can't Say

18. Will you rate agricultural practices in your community high? 1 Yes 2 No 3 Can't Say

19. Have you or any member of your household had crime-related issues like theft, robbery etc in the past one year?

1 Yes 2 No 3 Can't Say

If yes, give an estimate.....

Thank you for taking part in the Sustainability Survey. We appreciate your involvement.

Appendix D

Sustainability Indicators Ranking Questionnaire

The aim of the survey is to rank some selected sustainability indicators through multi-voting technique for purpose of an empirical analysis. The data collected is mainly for research to provide input into the sustainability assessment of the Liquefied Natural Gas plant in Bonny Island, Nigeria. Hence, your objectivity is highly required.

Every piece of information given shall be kept confidential.

1. Please indicate your gender. Male Female

2. You are a native of Bonny Island Yes No

3. How long have you lived or stayed in Bonny Community?

1 <5 yrs 2 5–10 yrs 3 10–20 yrs 4 +20 yrs

4. How old are you? 1 < 20 year 2 20-30 yrs 3 30-50 yrs 4 +50 yrs

5. What is your highest education?

1 No Formal Education 2 Primary 3 Secondary 4 Tertiary 5 Post Graduate

7. Are you employed in paid work? Yes No

If yes, where? ..... If no, what is your occupation? .....

8. Do you know the relevance of sustainability indicators to community existence?

Yes No

Kindly prioritize the following sustainability indicators according to how you feel they are important to the community.

Assign digit from 1 - 5: 1 for most important; and 5 for least important.
Note: You may not rank two indicators from a factor the same. i.e. No two equal rank in a column.

Environmental Factor		Social Factor		Economic Factor	
Indicators	Rank	Indicators	Rank	Indicators	Rank
Access to clean drinking water		Free or subsidized health care		Availability of credit facilities	
Air, water and soil quality		Access to Information Technology system		Affordability of 3 meals per day	
Frequency of sickness		Good transportation		Employment	
Waste management		Basic Education		Cost of housing	
Agricultural practices		Crime Prevalence		Education grant and scholarship	

Thank you for the participation.

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