Haaga-Helia
University of Applied Sciences

Improving Packaging of Sacheted Pure Water in Nigeria

Oghenekaro Ekrake

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Author
Oghenekaro Ekrake

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Clean and drinkable water is an important resource for the sustenance of humanity and generally living things. Biodegradable packaging is an emerging concept in the field of water packaging. Therefore, this thesis provides an alternative way of packaging sacheted pure water in Nigeria in order to reduce wastes and complement the peculiar challenges of recycling in Nigeria. The packaging materials introduced in this thesis will be mainly biodegradable ones. However, there are comparison of polyethylene as a form of packaging to the biodegradable form of packaging.

To make this thesis beneficial to the case company, the author divided the research project into two main impacts of environmental and economic nature. These two main groups are necessitated to introduce a sense of sustainability in the market and to create profitability for the company.

The research method used in this thesis is qualitative. The collection of data was mainly in the form of interviews on the management level, environmental workers and everyday consumers as well as observation of the environment.

The research findings show that, the introduction of biodegradable bags for the production of sacheted pure water will be economically and ethically beneficial to the case company. It also reduces government responsibility for creating a better environment.

The introduction of an additive in this research, further helps to understand the importance of a biodegradable product that quickly removes on-sight litter with no harmful residue after degradation.

Keywords
Packaging, Biodegradable, Degradable, Polyethylene, Compostable, Non-biodegradable, Greenhouse gases, Landfill, d2w additive

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1 Introduction

Sacheted pure water is a popular type of water packaging of drinkable water that has reduced the economic hardship of the large majority of Nigerians who cannot afford to buy the bottled drinkable water. Sachet pure water can be defined as water that is intended for human consumption. It is normally sealed in a plastic bag and contains no ingredient except safe and suitable fluorides. (Narasimhan & Himabindu 2010, 582-588.)
Small and medium scale entrepreneurs introduced sacheted pure water bags in small nylon which are heated at both ends. It is mostly patronized by members of the public with low socio-economic class (Narasimhan & Himabindu 2010, 582-588.)

The difficulty of recycling sacheted pure water in Nigeria has necessitated the need for a green packaging solution. Ecological considerations are growing in importance with concentration on packages materials that are biodegradable and less dependent on polyvinylchloride (Arjan & Weele 2010, 373-374).
Based on a blog by Benzoni (2013), metropolitan authorities in Accra, have not been able to install new water connections nearly fast enough to keep up with the rapid population growth. As a result, the public themselves have to turn to the private sector to seek answer to their water challenges. (Benzoni, 8 December 2003).

Observations conducted by the thesis author as shown in Figures 2&10 on pages 4 and 29 respectively, shows that settlements in Nigeria especially in the rural areas, suffers environmental challenges due to the inability of recycling companies or government agencies to effectively manage recycling of these sacheted pure water bags or come for pickup of wastes. As a result, there are millions of this sachet pure water littered everywhere that choke drainages and also act as a source of breeding ground for mosquitoes. The attitude of Nigerians as we shall see during this research has also contributed to this problem. The indiscriminate disposing of this sacheted bags has further compounded the problems.
This act and others has led to continuous flooding issue (Figure 2, page 4) and increased cases of death due to malaria infection that is facing Nigeria today (World Malaria Report, 2016).
According to Benzoni, (2013), emphasises the consequences of a possible ban of sachets as part of a larger ban on plastic bags. The report also mentioned that such move as been recommended by the Ghana authority will cause severe marginalisation of significant number of urban poor masses who would struggle to get access to drinkable water. (Benzoni 8 December 2013.)

1.1 Thesis background

Nigeria population is 189,715,355 as of Wednesday, January 25 2017, based on the latest United Nations estimates (World Population Review 2016).
With a yearly percentage change of 2.59%, this figure ranks Nigeria as the most populous country in Africa and seventh worldwide (Worldometers 2017). This figure therefore puts Nigeria as the most populous country in Africa.
Part of this environmental challenges facing Nigeria today, is due to the inability of recycling companies to carry out recycling of this 'Sachet Pure Water' as it is popularly called in Nigeria.
As a result, this research will focus on green packaging using biodegradable materials in other to achieve off-site litter in the shortest possible time, and with a friendlier end-of-life. This practice is in line with current trends of packaging which is generally aimed at providing solution both environmentally and economically. However, there are challenges that abound, for example been too expensive to be adopted and lack of scientific innovations are all hindering the process at the moment..

Figure 1: Pure Water Bag of 500 milliliters of water per bag (Benzoni 2013)

As we can see in Figure 1, it is a common practice of selling sachet water in cooling containers and on the head by the side of the street. Roadside shops sell sachets individually from the refrigerators or in wholesale bags of thirty sachet water per bag. Flatbed trucks

and three-wheeled carts loaded with bags of sachet water are common sights on the motorways. Empty sachets litter the roadsides and the gutters, clogging drains and making their way to the ocean. (Benzoni 8 December 2013.)

Justin (2015), revealed that “the rise of sachet water has created a huge urban economy, its very own black market, an environmental disaster and a private-sector-driven public health coup” (Justin, 2015).

Figure 2: Pure Water bags amongst plastic containers blocking drainages in Osubi Town (Ekrake, 2015)

Figure 2 illustrates the level of sachet water menace and the need for urgent action. The implementation of this project will help in reducing litter, reduction of malaria parasites by reducing breeding ground for mosquitoes, and illnesses associated with conventional sachet bags if ingested. It is important to know that, the sale of sachet pure water in Nigeria will still continue for a long while. This is because sachet pure water has been able to provide an alternative source of drinkable water that is affordable to the poor masses. But the packaging choice as you can see in Figure 1 page 3, raises a lot of questions at the moment. This is mainly because of the environmental consequences associated with it, and also due to the lack of recycling of the empty bags which constitute enormous amount of litters.

From observation and as shown in Figure 1 page 3, the majority of sachet pure water production is packaged with plastic bags. These plastic bags usually take longer time to degrade from eye sights Table 4 and also has health impact. “Litter is an eye pollution, an eyesore that regulations and educational programs have failed to eliminate” (Packaging Knowledge, 2015).

Also, most times people seem to be satisfied when we no longer see materials on the surface provided they are out of sight. However, that does not mean they are toxic free when they are broken down or degraded to an invisible units or microscopic granules (Packaging Knowledge, 2015).

Keying into current practices of sustainability and long term cost effectiveness, “His Divine Table Water” company will be in a forefront position in the business of packaging of sacheted pure water in Nigeria using biodegradable materials. This will no doubt signal a rethink to other competitors who may stand the risks of boycott of their age-long plastic packaging. In addition, customer concerns of the environmental impacts, and gradual comparing of the price of buying one sachet water made of biodegradable material and plastic bags, will within a matter of time change the trends of packaging.

1.2 Research question

The reason for this research is to show the reason why biodegradable packaging should be considered as a better option in the packaging of sachet pure water in Nigeria. In other to achieve this, a main question is being asked followed by several investigative questions as follows:

“What are the driving force of green packaging as a preferred substitute to non-biodegradable packaging?”

Investigative Questions

IQ 1. What are the environmental impacts of biodegradable packaging of sachet water?

IQ 2. What are the economic impacts of bio-degradable packaging of sachet water?

IQ 3. How would end users perceive and accommodate biodegradable packages?

Overlay matrix designed in a tabular form illustrates the connections between investigative questions, research methods, theoretical frame work and results as shown in Table 1, page 6.

Table 1. Overlay matrix of investigative questions and data collection process

Investigative Question	Theoretical Framework	Methods	Results
What are the environmental impacts of biodegradable packaging of sachet water?	1.5, 1,9	Environmental observation, Qualitative interview	4.1
What are the economic impacts of biodegradable packaging of sachet water?	1.5, 1,9, 1.10, 2.1.4	Qualitative interview	4.2
How would end users perceive and accommodate biodegradable packages?	2.0	Interviews	4.3

1.3 Demarcation

This research will focus mainly on the time it will take for a biodegradable package to disappear from sight and the eventual effect of the end products with respect to non-biodegradable materials on the environment. This focus is mainly to show that biodegradable materials takes lesser time to decompose from sight with lesser effects on plants and animals and the environment at large. This project will not recommend a particular biodegradable material as a suitable replacement rather it will focus on a more general approach. This is because researches and legislative policies are still ongoing.

This research is geared towards companies in Nigeria and indeed the Western part of Africa that produces sachet water as a form of drinkable water. Most sachet water companies are seen to dominate within the Western Africa countries. The focus is to key into the current practices of green packaging which aimed at reducing greenhouse gases and eventually save cost. It will also give sachet pure water bag manufacturers a sustainable business environment while increasing profits at the long run. This is so because, attention is shifting from petrochemical type of package to a more bio-based package.

1.4 International Aspect

Many countries today have embraced the idea of sustainable production and consumption to reduce wastes and improve social and economic values. Current practices of sustainable supply chain management are largely dominated in most parts of the Western world. This is mainly an attempt to reduce greenhouse gas emission and improve economic value. For instance, Eurostat (2015) monitoring, reveals that EU is within the reach of meeting the Europe 2020 target of reducing greenhouse gases (GHG) emission by 20% (Eurostat 2015). Africa countries contribute 3.5% equivalent CO2 of total world greenhouse gases and of which Nigeria and indeed West African play a major part (Economic Statistics Bulletin, 2008).

Today, from observation there are thousands of sachet pure water factories in Nigeria alone, and Ghana, Togo and Benin Republic. Depending on which part of Nigeria, a bag of 30 pieces of sachet water is sold on average of 120 Naira (0.39 US dollars). Therefore, the production of a biodegradable bags for pure water package will not only help in protecting the environment, but also help to reducing on-sight wastes and increase social and economic values.

1.5 Anticipated Benefits

In practice, many of the measures that reduce the environmental impacts of logistics also saves money and improved social implications (McKinnon, 2015, 4). This thesis aim is to prove that biodegradable packaging of sacheted pure water bags can have an enormous benefit on the environment, social, economy and better health. The anticipated benefits of this thesis for the case company cannot be over emphasised. If eventually implemented by the case company, in cases where there are tax payments, depending on the level of pollution, plastic bags will usually attract more tax fees because, it takes more time to disintegrate and particles left behind are more toxic than biodegradable bags (subchapter 3.1.1). Also, it is challenging to get these plastic sachet bags for recycling because they are usually made in small sizes (Figure 1, page 2) and the quantity produced in a day are running into millions. In addition, Individuals are not so interested to return sachet bags after use because the value of money attached for returning is not worth the stress. Therefore, the introduction of a biodegradable package will save costs accrued to recycling coupled with a healthier environment.

Biodegradable packages usually break down much faster than non-biodegradable packaging and therefore easily absorbed by earth. Biodegradable packaging is made up of biomass, and they offer less greenhouse gases and harmful carbon emissions to the environment (Subchapter 4.1).
Biodegradable package is an excellent way of positively promoting a company's image and also making products of companies ecofriendly. This is typically in line with supply chain practices today with the popular trend of 'Green Logistics'. Packages that are biodegradable could be used as an important marketing tool to promote products.

Consequently, "His Divine Table Water" as a case company, will be on track in areas of business ethics of sustaining the environment, reduced costs of tax payable to environmental agencies, and an important marketing tool to promote its product as ecofriendly. Also, there is positive impact in the safety of millions of consumer's health. This will also help save money spent on medical treatment and save economic time (Subchapter 4.2).

During the process, the thesis author had the opportunity to understand how business ethics means sacrifice and responsibilities.

1.6 Key Concepts

In other for better clarification and understanding, some important concepts that are used in this thesis are defined below.

Packaging: According to Wessel & et al. (2009, 267)**,** packaging is the art and technology of enclosing and protecting goods for distribution, storage, sale and use. Packaging is also the material used to wrap a product and to convey information to the customer. The main logistics functions of packaging are to apportion, contain, protect/preserve, unitise, transport and inform/sell. (Wessel, Pienaar & John 2009, 267.)

Degradable: Degradation is a process whereby very large molecules are broken into smaller molecules or fragments (Packaging Knowledge, 2004.)
This could be simply put as break down or to reduce something. This can be achieved naturally or by deliberate means.

Biodegradable: Biodegradation is the process by which microorganisms such as bacteria, fungi or algae convert materials into biomass, carbon dioxide and water (Packaging Knowledge, 2004.). Also, as stated by Andreas et al (2016) "A polymer is biodegradable if

it is metabolized by microorganisms (bacteria, yeasts, algae, filamentous fungi) in their natural environment (e.g., surface or sea water, soil or compost) to energy, biomass, water, and carbon dioxide or methane within a given time period (e.g., in composting standards: six months)" (Andreas & et al., 2016, 21.)

When a plastic is biodegradable, it can be digested, so that the carbon atoms in the chains of the polymer are broken apart and can actually participate in the creation of other organic molecules. They can be processed by, and become part of, organic living things. This returns them to nature in a very real sense: they become part of the carbon cycle of the ecology of the earth. (Green Plastic, 2012.)

Polyethylene: An artificial resin that is easily moulded and is resistant to other chemicals. It can be repeatedly softened and hardened by heating and cooling, and it is used for many purposes, such as making containers, tubes, and packaging. (Houghton, 2014.)

Non-biodegradable: Ordinarily means materials that cannot decompose when exposed to micro-organisms. Those materials which cannot be broken down or decomposed into the soil by natural agents are labelled as non-biodegradable. (Surbhi, 2014.)

Compostable: That undergoes degradation by biological processes, during composting to yield CO2, water, inorganic compounds, and biomass at a rate consistent with other known compostable materials and that leaves no visible, distinguishable, or toxic residue. (Rhodes, 2009, 12).

Greenhouse gases: These are gases that absorb some of the energy radiated from the earth and trap it in the atmosphere. These gases essentially act as a blanket making the earth surface warmer than it otherwise would be. (Earth system Research Library, 2016.) The measure of total amount of carbon dioxide and other greenhouse gases (expressed in CO2 equivalent) emitted directly and indirectly from an entity is refered to as carbon footprint. (McKinnon, Browner, Piecyk & Whiteing 2015, 56-57.)

Landfill: The European commission on Environment (1993) defined landfill as waste disposal sites for the deposit of waste onto or into land. The objective is to prevent or reduce as far as possible negative effects on the environment, in particular on surface water, groundwater, soil, air, and on human health from the landfilling of waste. (European Commission, 1993.)

D2w Additive: D2w is an additive formulation that renders conventional polyolefins oxo-biodegradable. Products containing d2w additives are tested to monitor degradation through changes in the Aesthetics, Chemical and Mechanical properties of the product as described in ASTM Standards. (Higgs, 2011.)

1.7 Case Company

In the course of this research, I shall work closely with the company name “His Divine Table water”. Figure 3 is a pictorial view of Divine Sachet water presently used.

Figure 3: His Divine table water 15cm by 13cm in size (Ekrake, 2016)

Interview with the company general manager Solomon (2 February 2016) reveals that “Divine Table Water” is a pure water manufacturing and packaging company with a total work force of 30 persons. It is situated in the outskirt of Warri city – known for its popularity in oil and gas and the heartbeat of the Nigerian economy. Divine table water is established in approximately 15years ago but became functional a year later. It is headquartered in Ugolo community in Okpe Local Government area of Delta State, Nigeria. Situated in a serine environment, it produces and packages an average of 1.2million sachet of pure water daily in other to meet up its daily consumers output. At the moment, divine table water is locally based but also considering a possible expansion in the nearest future. (Solomon, 2 February 2016).

From the company point of view, it is a known fact that the ministry of environment in Nigeria is facing challenges to get rid of the remains of this sachet water bags. This water bags unfortunately do not have a replacement at the moment because of the power of affordability by the common poor masses. His Divine Table Water Company is also very much interested in seeing that the re-packaging of its water bags is made to work in a way that is affordable to both the company and the general masses.

1.8 Risks in the thesis process

The uncertainty of accepting biodegradable package as a new package will no doubt raise some form of distraction and uncertainties. This mind set was reduced by presenting the negative effects of the current plastic packaging to the case company. The financial cost involved which the case company was eager to know even at the preliminary stage of this project was been avoided, by making the case company see that whatever cost there is, the various stakeholders involved directly or indirectly will benefit at the long term. This is because of the environmental friendliness of using a biodegradable package. Openness in the availability of data from concern ministries and parastatals was also seen as a risk factor in making sure this research achieves its ultimate goal. Therefore, part of the intention is to use environmental field workers who are readily available to give useful information.

1.9 Degradable / Biodegradable Packaging of Sachet Pure Water in Nigeria

The main objective of this thesis is to complement the huge tasks of recycling sachet pure water bags in the Nigerian environment by using one of the most recent packaging features. Also, bearing in mind the economic implications of sustaining small to medium businesses that embark on the business of manufacturing plastic bags for the purpose of packaging of drinkable water. This is important because the usual plastic bag currently used today do not easily break down or completely disintegrate to non-harmful substances or materials. Plastic breakdown is not only slowly but also anything contained within them may not reach their full degradation potential. This results in a needless waste of valuable landfill space. (Packaging Knowledge, 2004.)

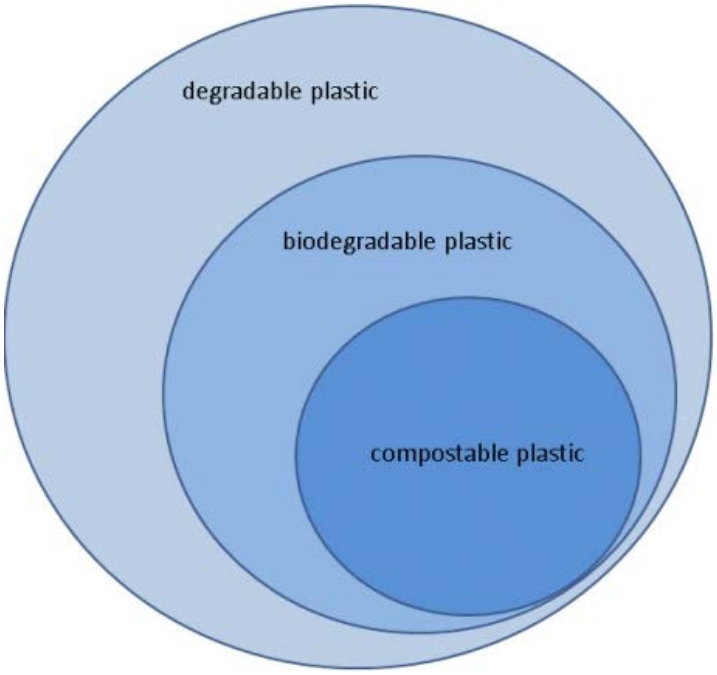

Figure 4. Level of Degradation (Green Plastic, 2012)

Figure 4 shows a degradation pattern from a general level of degradable plastic to a next level of biodegradable plastic and eventually to compostable plastic which is regarded as the most acceptable and environmentally friendly packaging material. We can technically say that all plastic materials are degradable simply by for instance grinding the plastic or using any other means to reduce or breakdown the plastic to smaller units. (Green Plastic, 2012.)

The standards organizations that regulate materials have come up with a series of tests and benchmarks, saying that if a biodegradable plastic will completely biodegrade fast enough in a certain type of environment, then it can be labelled compostable. (Green Plastic, 2012.)

1.10 Green packaging of Sachet Pure Water

Green logistics of which green packaging can be categorised under, is fairly young but rapidly evolving subject (McKinnon & et al 2015, 4).
Over the past 10-15 years, against a background of increasing public and government concern for the environment, companies have come under mounting pressure to reduce the environmental impact of their logistics operations (McKinnon et al 2015, 3). The impact of logistics on climate change has attracted increasing attention in recent years, also because new scientific research has revealed that global warming presents a much greater and more immediate threat than previously thought (McKinnon & et al 2015, 3).

According to findings from Intergovernmental Panel on Climate Change IPCC, 2014, estimates that materials handling is likely to add around 2-3 per cent to the total share of approximately 10 per cent of energy-related CO2 emissions worldwide (McKinnon & et al 2015, 4).
However, it is also important to know that sustainability does not only have an environmental dimension but also the reconciliation of environmental, economic and social objectives (Brundtland Commission, 1987).
Green packaging today uses raw materials ranging from paper, plastic, metal, and glass, which can easily be altered to undertake various shapes and forms. One of the major advantages of green packaging is that it produces fewer toxic emissions. This has resulted in high demand for green or sustainable packaging. TechNavio's, 2015 analysts forecast the Green Packaging Market in the US to grow at a compound annual growth rate of 6.16 percent over the period of 2014-2019 (TechNavio’s, 2015).

In the course of this thesis, I shall focus mainly on biodegradable type of packaging. This is because, it serves as a better option and the sachet water market is very popular in Nigeria and some countries within the Western part of Africa like Benin, Togo, and Ghana of which they share similar environmental conditions and general life style.

From local observation Figures 2 and 10 pages 3 and 30 respectively, the recycling process is faced with huge challenges including infrastructural challenges and customer attitude just to name a few. These challenges have therefore, necessitated the need for research of an alternative way of using a biodegradable packaging to curb the situation to some certain level, in accordance with current packaging practices. Biodegradable package takes lesser time to decompose away from sight.

2 Theoretical Framework

This chapter aims to show and to discuss biodegradable packaging. It shows a framework of the main investigative questions, their challenges and how they benefit the society.

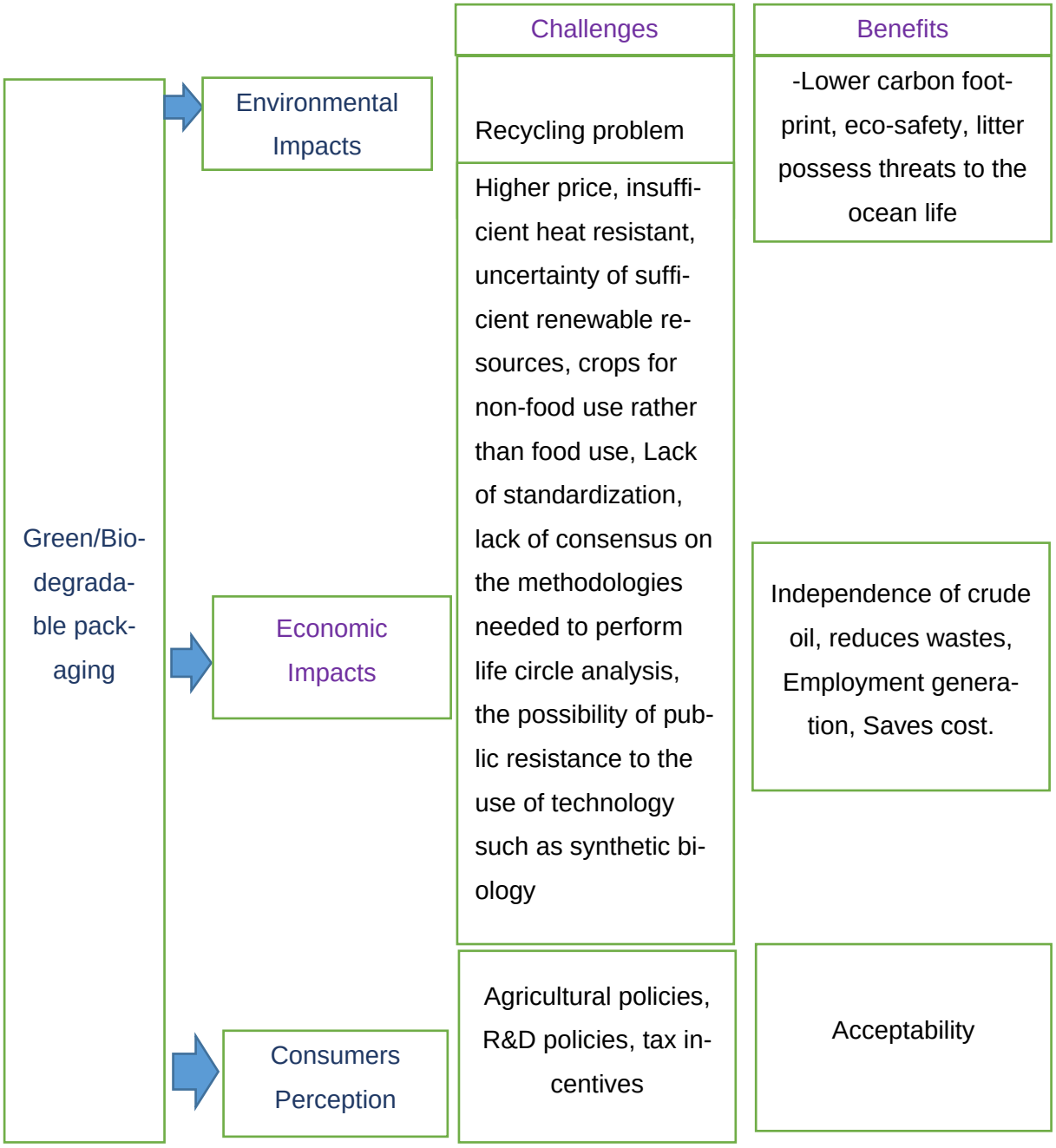

Figure 5. Theoretical Framework

In Figure 5, it can be seen that there are challenges currently facing biodegradable packages. Bio-based materials can affect recycling processes if it is not separated from the conventional materials of non-bio-based. For example, according to Arikan & Ozsoy (2015, 188-192), that while working in infrared rays in waste separation system, bioplastics cannot be separated and also the separating plastic materials might be contaminated with bioplastics. (Arikan & Ozsoy 2015, 188-192.)
Arikan & Ozsoy (2015, 188-192) also noted that the price of bio-based plastics is more expensive than the conventional plastics. But on a brighter side, large scale production of bio-based materials with the implementation of cost reduction will be expected in the future. There are fears that there might be insufficient raw materials for bio-based plastics because of the competition with agricultural resources available for food. (Arikan & Ozsoy 2015, 188-192.)

As seen in Figure 5 page 13, one of the reasons in favor of bio-based plastic materials is the independence of crude oil. The production of conventional plastics currently needs around 5% of the global crude oil production and this will increase to around 20 to 25% by the end of the century. Since the growing demand for crude oil will not only come from the plastic industry and the exploitation of crude oil is characterized by fluctuating oil prices, it is feasible to search for alternative resources. The perception of the consumer towards green products is another reason for the growing interest in bio-based plastic materials. (Peelma & et al 2015)

According to flash barometer (2013), 84% of the European consumers find the environmental impact of a product important and 77% is willing to pay more for products with a reduced environmental impact. Furthermore, other factors, like compost ability as an alternative end-of-life option, legislative drivers (e.g. ban on non-compostable bags) and specific functionality of certain bioplastics (e.g. biocompatibility) contribute to the increasing interest in bioplastics. (Flash barometer, 2013.) In addition, the transition from a fossil-based economy to a bio-based economy is an important EU 2020 Strategy target (Eurostat 2013.)

2.1 Biodegradable package

According to Scarfato & et al (2015), biodegradable materials can be grouped according to their source of origin. That is renewable or petrochemical, or according to the method of their production, with the following main categories:

> Polymers produced by conventional chemical synthesis from renewable or nonrenewable monomer feedstock, for example, poly (lactic acid) (PLA), poly (ε-caprolactone), poly (butylene succinate), and poly (vinyl alcohol).
> Polymers produced by direct extraction from biomass, for example, polysaccharides, such as starch, chitosan, cellulose, and pectin, and proteins, such as zein, gelatin, casein, soy protein, and wheat gluten.
> Polymers obtained from microorganisms or genetically modified bacteria, for example, polyhydroxyalkanoates (PHAs), including poly (β-hydroxybutyrate) (PHB), poly (3-hydroxybutyrate-*co*−3-hydroxyvalerate) (PHBV), bacterial cellulose, xanthan, and pullulan (Scarfato 2015).
> Polymers produced by blending, for example, PLA–PHA, starch–PLA, starch–PHB, starch–poly (ε-caprolactone), starch–cellulose derivatives, starch–poly (vinyl alcohol), PHA–keratin, chitosan–PLA, and PHB–chitosan.
>
> (Scafato, Luciano, Loredana 2015).

Among the currently available bioplastics materials, PLA, starch, and PHAs are the most interesting from a commercial point of view. For more on types of packages and their degradation time lapse please see subchapter 2.1.7. This is so because they can be processed with conventional converting equipment, have a satisfactory balance of functional properties, and are produced on a large industrial scale at competitive prices. (Scarfato et al 2015.)

Table 2: List of some published standards for biodegradation of plastics

Standard	Description
AS 4736–2006	Biodegradable plastics—biodegradable plastic suitable for composting and other microbial treatment
ASTM D5209-92	Standard test method for determining the aerobic biodegradation of plastic materials in the presence of municipal sewage sludge
ASTM D5338-98	Standard test method for determining aerobic biodegradation of plastic materials under controlled composting conditions
DIN V 54900-2	Testing of compostability of plastics- testing of the complete biodegradability of plastics in laboratory tests
EN 13432:2000	Requirements for packaging recoverable through composting and biodegradation—test scheme and evaluation criteria for the final acceptance of packaging
ISO 14851:1999	Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium—method by measuring the oxygen demand in a closed respirometer
ISO 15314:2004	Methods for marine exposure ISO 16221:2001 water quality—guidance for the determination of biodegradability in the marine environment
CEN/TR 15822	Plastics: biodegradable plastics in or on soil—recovery, disposal and (under approval) related environmental issues
AFNOR NF U52-001	Biodegradable materials for use in agriculture and horticulture-mulching products—requirements and test methods

Source: Journal of Civil Engineering and Architecture, investigation of Bioplast (Arikan 2015).

Table 2 page 16 reveals various standardisation for biodegradation of plastics, which can be considered based on the potential field of application and its end-of-life. For the sake of this thesis, attention is given to the highlighted point.

These standards are vital to the case company during production of biodegradable bags. As a result of the indiscriminate habit of disposing sachet pure water bags on land and water surfaces in Nigeria (Figure 2 page 3), recommendations for the case company would be to apply standards AS 4736-2006, ISO 15314:2004 and CEN/TR 15822 during production. Biodedegradable bags that are exposed to micoorganisms will quciken its breakdown to a posible compostable level of degradation (AS 4736-2006). Because this sachet water bags also find their way into rivers and ocean, ISO 15314:2004 guide will help in the production of biodegradable bag.

2.2 Packaging material and handling system

With reference to Wessel, Pienaar & Vogt (2009, 273), the use of packaging materials has to become more efficient over the last three decades, as rising costs of raw materials and increasing environmental concerns have compelled the packing industry to become more responsible and innovative. Plastic bags are 45% lighter than 20 years ago, which has made a major contribution towards waste minimisation in the packaging industry. (Wessel, Pienaar & John, Vogt 2009).

In the course of this thesis, more attention will be given to low-density polyethylene (LDPE) plastic type of packaging material.

Figure 6: Shows 30pieces of 15cm by 13cm Sachet Water bags arranged inside a plastic bag (Anhui, 2017)

In Figure 6 page 18, one can see how sachet water bags are been handled during production and arranged for further transportation. Wessel & et al (2009, 273), mentioned that plastics are very lightweight, versatile, resin- based, artificial products that easily be manipulated or transformed into different shapes and sizes. (Wessel, Pienaar & John, Vogt 2009).

According to Bloomberg, Lemay & Joe (2002, 186) material handling is the movement of raw materials, work-in-progress (WIP) inventory, and finished products within a facility. Correct packaging can make the material handling more efficient and effective. A properly installed material handling system can reduce costs and labour, increase safety, increase productivity, reduce waste, increase capacity, and improve services. These creates economic value to the case company. (Bloomberg, Lemay & Joe 2002, 186.)
This aspect is important and worth mentioning because the consumer handles and exposes this sachet water quite differently. Beginning from factory through the various forms of transportation to the final destination.
For example, lack of standardisation as a symptom of poor material handling of the sachet water bags could lead to higher inventory costs, customer dissatisfaction and eventual financial loss to the company. Proper standardization and movement of product inside and

outside the facility among other factors helps to improve customer service and costs control. The sachet water must be able to move in the right quantity through production stage to the customer (Appendix 10).

According to Bloomberg & et al (2002, 187), there are three types of material handling systems: manual, mechanised and automated. If the firm plans to build a new structure, the facility should be designed around the material handling system. The type of system also depends on the type and amount of equipment required. The size, shape and material greatly affect productions labour efficiency, transportation in loading, unloading, and transporting a product. Although packaging is not as costly as transportation, 10 percent of integrated logistics costs can be attributed to packaging. The easier it is to handle a product, the lower the transportation rate. (Bloomberg, Lemay & Joe 2002, 194.)

The equipment selection equation is:

What + where + when = equipment specifications

The “what” refers to the type of material been handled in the facility. Material variables include handling characteristics, size, shape and show-ability. The “where” from the equation refers to everything involved in routing the material throughout the facility “When” means that the material must be at the right place at the right time. (Bloomberg, Lemay & Joe 2002, 186.)
It is advice able for a start that “Divine Table Water” company uses the manual material handling system in other to save costs attributed to purchasing a more expensive mechanised or automatic equipment. The disadvantages associated with the manual equipment is that they use cubic space poorly, handling speed is low throughout, and there are excessive employee accidents due to manual handling of materials. However, mechanized material handling is the most common type and it replaces some manual handling with mechanical movement. (Bloomberg, Lemay & Joe 2002, 186.)

In the case of sachet water carriers, because of bulk movement, normally require little package protection (Figure 6 page 18). For Packaging affects not only marketing and production but also many other integrated logistics activities (Bloomberg, Lemay & Joe 2002, 186).

In Figure 3 page 9, the packaging design seems to satisfy size relative to price, shape, and transparency of the product. In addition, the writings are clearly stated in other for customers to have pre-knowledge of the content and registration. However, there are still room for improvement in terms of the quality of the bag. The sachet water mentioned in

Figure 3 does not have expiry date written anywhere. The inclusion would give the customer an idea of when it was produced and how long it will be valid for consumption.

2.3 **Recycling**

The challenges facing the recycling of Sachet water in Nigeria has necessitated the need to introduce a biodegradable packaging. The unrecycled sachet bags will only stay some few months and then decompose out of sight. This will curb litter effects that is associated with non-degradable and unrecycled sachet water.

Table 3: Recovery and recycling rates for packaging wastes

	Recovery rate	Recycling rate
EU-28 (*)	79.2	65.3
Belgium	96.6	78.7
Bulgaria	66.0	65.7
Czech Republic	74.7	69.9
Denmark	85.6	64.8
Germany	97.7	71.8
Estonia	77.7	58.4
Ireland	88.1	70.2
Greece	52.8	52.4
Spain	73.1	66.6
France	75.4	66.4
Italy	58.8	58.8
Croatia	76.5	66.7
Cyprus	56.6	56.6
Latvia	54.5	51.0
Lithuania	53.9	53.5
Luxembourg	91.8	62.8
Hungary	60.3	49.2
Malta	38.2	38.1
Netherlands	93.9	70.5
Austria	96.1	66.6
Poland	50.4	36.1
Portugal	64.8	61.5
Romania (²)	57.4	56.8
Slovenia	92.5	69.0
Slovakia	69.5	65.9
Finland	93.2	58.0
Sweden	87.4	71.9
United Kingdom	72.7	64.6
Iceland (²)	56.5	41.8
Liechtenstein	90.9	50.3
Norway	93.2	54.5

Source: Packaging wastes statistics (Eurostat, 2016)

Table 3 page 20 shows the recovery rates and recycling rates in percentages of which none of the countries stated above has been able to reach a 100% rate of recovery and recycling. The closest been Germany 97.7% and Belgium 96.6% respectively. The unrecycled and unrecovered amounts usually could be seen as litters which are economic wastes and threats to our environment.

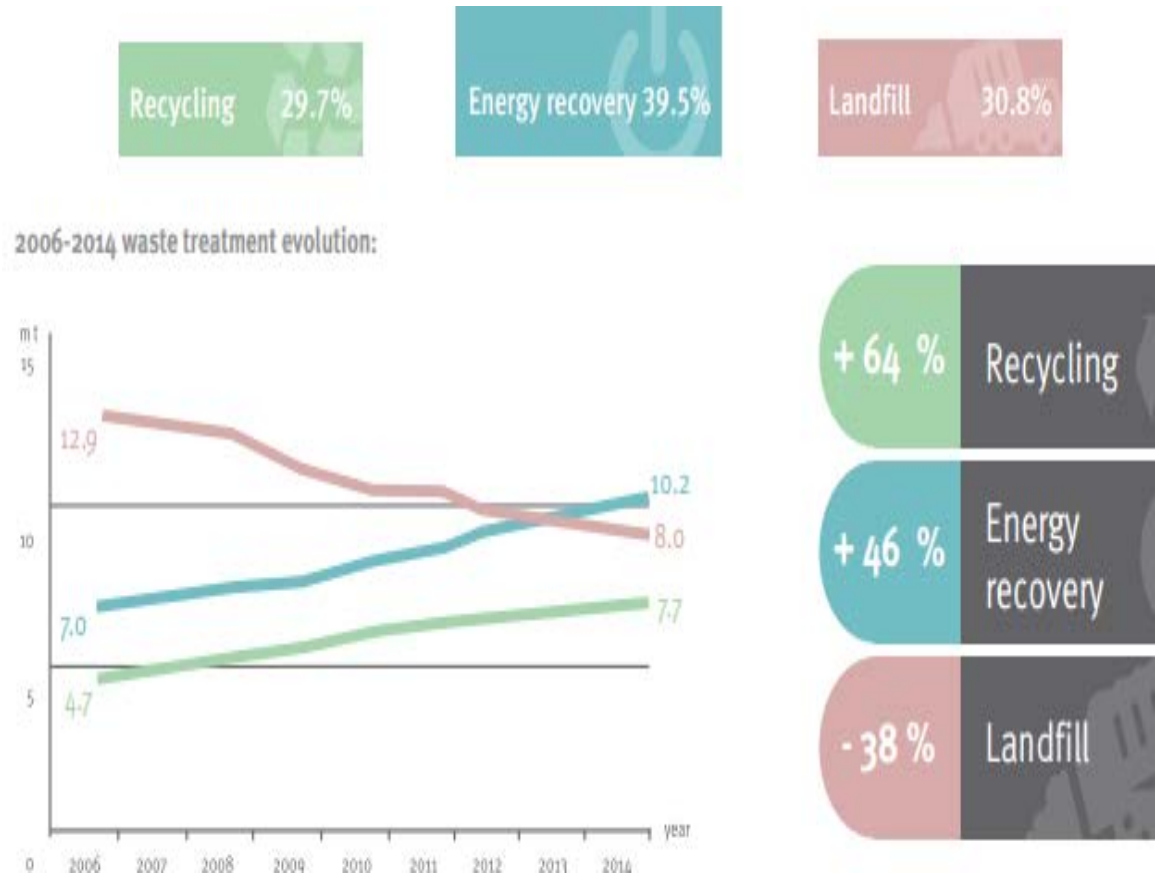

Figure 7: Plastics Waste Treatment in EU28+2 member States (Plastic Europe, 2016)

Figure 7 provided us with a statistic report in 2014, that out of 25.8 million tones that ended up in the official waste stream of post-consumer plastics waste 29.7% was recovered through recycling and 39.5% energy recovery while 30.8% still went to landfill (Plastic Europe, 2016). This further shows that the recycling of plastic wastes even in a more civilized place like in Europe still face challenges of 100% recycling.

2.4 Health Consequences of Polyethylene bag

Polyethylene consumption could cause toxicology implications if left untreated or unnoticed. The initial phase of ethylene glycol poisoning is characterized by inebriation caused by unmetabolized ethylene glycol. In situation of an acute poisoning cases, the following symptoms are common: ataxia, slurred speech, drowsiness, irritation, restlessness, disorientation. (Dianyi 2007.)

In addition, polyethylene bags act as a good breeding ground for mosquito parasites which causes sickness and death (Figure 2 &10 pages 3 and 30 respectively).

The re-packaging of sachet pure water bags, using biodegradable materials will help in reducing possible health hazards and therefore reduce threat to human lives. This is because the materials mainly used in making the biodegradable package are generally from natural sources like: paper, woods, corn etc. which are less harmful to plants, animals and the environment at large (Marsh & Bugusu 2007, 39-55.)

2.5 Current disposal statistics and analysis

According to March & Bugusu (2007, 39-55), waste generation statistics indicate that 245.7 million tons of Municipal solid waste were generated in 2005, which is an increase of approximately 37% over the 179.6 million tons generated in 1988 and a decrease of 1.6 million tons from 2004. The decrease in waste generation is attributed in some extent to the decrease in individual waste generation rate. In product categories, containers and packaging represent mainly wastes from food packaging such as soft drink cans, milk cartons, and cardboard boxes. Among materials, plastics contributed 11.8% (28.9 million tons). In product categories, containers and packaging formed the highest portion of the total product waste generated at 31.2% (76.7 million tons). For more on wastes generated statistics refer to appendix 6. (March & Bugusu 2007, 39-55.)

2.6 Argument between biodegradable vs non-biodegradable

Sachet bags are difficult to identify which makes them constitute large amount of wastes. Beverage containers made from metal, glass, and plastics have been the most notable recycling successes because they are easily identifiable and made of single materials that are recyclable. Alternatively, biodegradable packaging could slowly help remove unsightliness and the hazards to animal and marine life caused by litter. However, it is possible that the existence of biodegradable containers may cause people to be less careful with

their discards, which could hamper recycling efforts. Even though the biodegradable packaging may not be used on a wider basis, yet the advantages are very significance in certain type of applications. The litter argument for biodegradable plastics has merit to the extent that biodegradable plastics will tend to break down and become less obtrusive after being littered. (March & Bugusu 2007, 39-55.)
Biodegradable packages are important to be used in the marine life, because the presence of litter possess threats to the ocean life.

2.7 Plastic Bag Life Span

There are various types of plastic bags used for different packages. Below is a table that shows types of packaging bags and their estimated breakdown time when exposed to natural landfill. The rates also depend on the thickness and other environmental factors like level of exposure to ultraviolet rays, moisture content of landfill, product configuration.

Table 4: Estimated Packaging Bags Life span

Types of Plastic Bags	**Estimated breakdown Time**
PET- Polyethylene Terephthalate	5 to 10 years
HDPE – High-density Polyethylene	Under 100 years
PVC - Polyvinyl Chloride	Not readily degradable
LDPE Low-density Polyethylene	Average time of 1000 years, not less than 500years
PP – Polypropylene	Will not decay for millennia
PS – Polystyrene	under 50 years
Others	Most plastics in this categories are considered chemically and permanently bonded.
Biodegradables	3 months

Source: How quickly does plastics breakdown (Sleight, 2011)

2.8 Market Trends

The Global Biodegradable Mulch Films Market size to grow from USD 35.76 Million in 2016 to USD 52.43 Million by 2021, at a CAGR of 7.95% from 2016 to 2021. The growth of the biodegradable mulch films market can be attributed to the rising demand of biodegradable mulch films in greenhouse, increased applications in agriculture, and rising environmental concerns. (MarketsandMarkets.com, 2016.)

Bio-based production is now seen to capture companies where it can be seen that new bio-refineries are springing up on a regular basis. “A lot of attention focuses on integrated bio-refineries, in which the higher margins and lower production volumes of bio-based chemicals are envisaged alongside bulk biomass fuels with their lower margin” (Jim 2014, 19-21).

3 Qualitative as Research Method

Qualitative investigators think they can get closer to the actor's perspective through detailed interviewing and observation (Silverman 2005, 10). Qualitative research method is chosen for this thesis also because according to Renata (1990), information a researcher gathers that is not expressed in numbers is grouped under qualitative method (Renata 1990).
The semi-structured interview method was used to create the flexibility needed in order that participants are not restricted by standardized questions and closed-ended structured answering formats. The type of questions is mostly open-ended, yet directed at obtaining a particular information. (McLaughlin 2003.)

In this research, data collection includes interviews and observations. The interviews conducted is concentrated mainly on the management level of the case company and 2 environmental field workers. This is so because the decision for the product change is entirely within the management level. The management decision is however influenced by the current practice of packaging as already mentioned. End users interview has little or no influence because they do not have much impact over what kind of package they get, provided the product is affordable and approved by environmental agencies. However, 10 anonymous consumer's responses were recorded on different occasions, in other to give a signal of consumer's knowledge and perception of current polyethylene package in Nigeria and how it affects them.
A welcoming insight was generated through a one-on-one interview with the general manager of processing and distribution Igbuja Solomon (2 February 2016).

3.1 Research Design

In other to have an in-depth understanding of this research, qualitative research method is used. The research design is then formulated in other to have a clearer picture of the situation. Respondents ranges from management staff to field workers and end-users. The collection of data involved interviews, observation and desktop research.

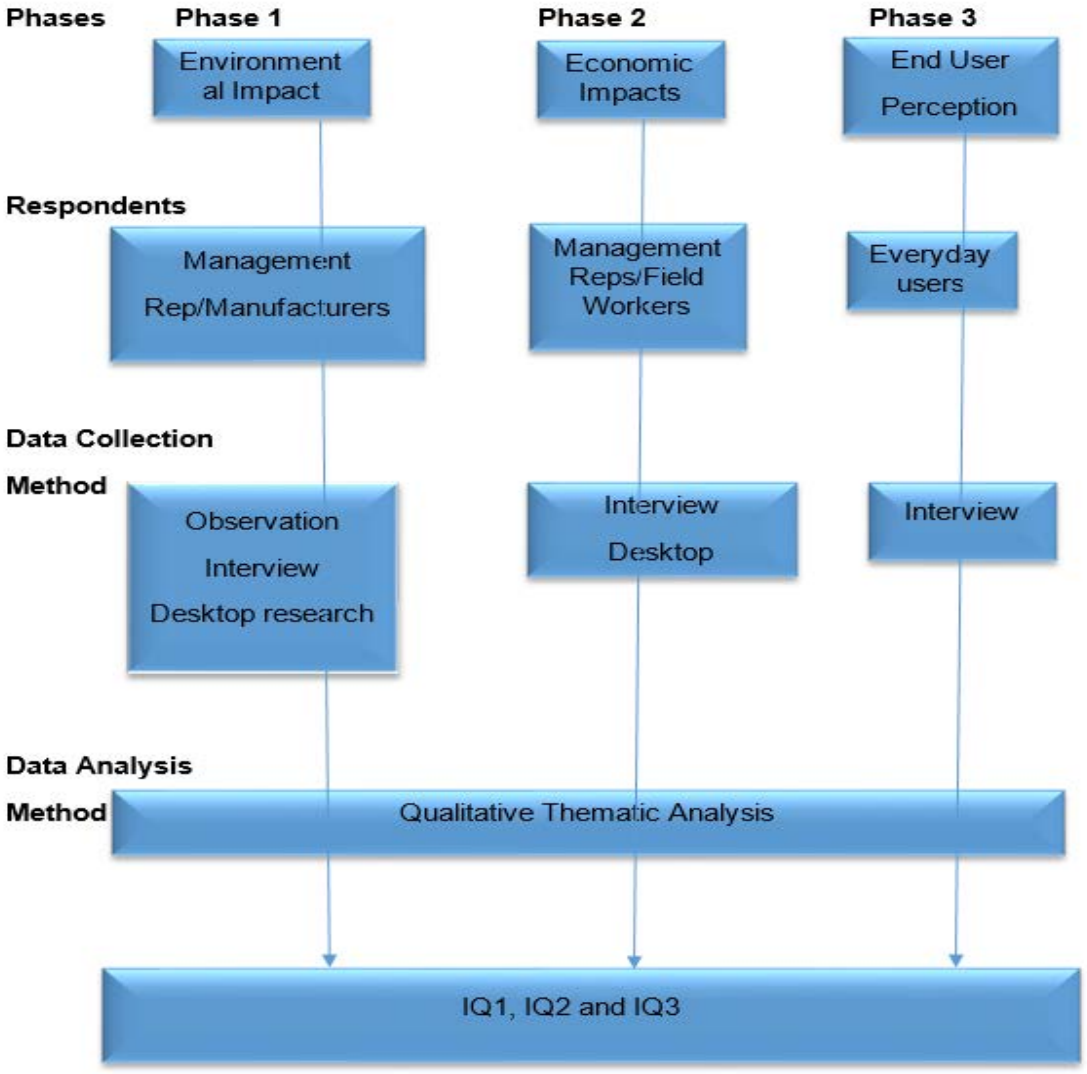

Figure 8. Research Design

In Figure 8, the research design is grouped into three research phases fashioned to answer the investigative questions mentioned in the introductory part of this thesis. Phases 1, 2 and 3 tends to answer investigative questions 1, 2 and 3 respectively. The respondents and data collection methods are carefully chosen in other to achieve the desired results. Furthermore, the results obtained are then analysed and compared. Thematic categorisation of investigative questions was also mention (see appendix 2).

Stakeholders involve in this thesis area are those that manufacture the existing products and are most likely to be manufacturing a new product. This is so because they stand the chance of low patronage by consumers and possibly sanctions from government in terms of higher taxes or complete ban on the polythene bags.

This research also intends to find out how consumers on the street are willing to shift their product use. In addition, to find out how customers use the existing product and the extent of awareness of the economic and environmental consequences therein.

3.2 Data Collection

Data collection involves mainly observations, interview and desktop research work. Observation involves taking of photographs to show and further clarify the need for immediate action. A face-to-face interview as a research method was conducted with the company manager precisely on 2 February 2016 at 14:30pm, in order to find out the company's consciousness on how their product eventually end up and how these bags affect the environment. The interview was also important to find out the readiness for a possible replacement of their sacheted water bag.

The interview with the company manager was the only possible management interview available in the company. However, the questions asked were all answered and the main purpose of the interview was achieved. This was done to ascertain their level of awareness and willingness in changing packaging designs. And also, interview involving 2 environmental field workers to know how possible change of pure water bags will affect them and their work and to also find out the level of awareness on the importance of their jobs. There were also questions directed to 10 anonymous end users to access their level of awareness to the threats resulting from the water bags they consume and dispose indiscriminately. Observation was carried out in terms of pictorial evidence of the menace caused by these bags. This was achieved by taking pictures of drainages and refuse dump sites in Osubi community where some of these bags eventually end up (Figures 2&9, pages 3&29).

3.3 Validity and Reliability

Shank (2006, 111) clarified that validity deals with the notion that what you observed is, in fact, what really happened. Therefore, validity is all about truth according to observational records. (Shank 2006). The validity and reliability of this research was increased by observation through pictures and interview responses. Responses were checked during the interview by making sure that there is a trust between the interviewer and the interviewee. Thereafter, questions directed to the interviewee was as clear as possible. Also, there was clarification on the reason for the interview as a research work for thesis, and information gathered would be available for publication. And of course, the interviewee has the right to mention whatever that he is not comfortable with been seen published.

Reliability according to Shank (2006, 110), is simply about the matter of accuracy. Reliability was strengthened through interviewee consistencies and credibility. Assuring the accuracy and inclusiveness of research data through observation in terms of pictures and findings was important in reliability of this research. (Silverman 2016, 414.)

4 Results

The results of this thesis are summarised according to the investigative questions.

4.1 Environmental Impacts

What are the environmental impacts of biodegradable packaging of sachet water?

For quite a long time, packaging has been seen as a major source of environmental problem along the supply chain. On the other hand, proper packaging design can also act as a catalyst to solving these problems.

The main limitation point according to Scarfalo & et al (2015) that is affecting the mass production of bio-based plastics, has been the process ability and reduced barrier properties to small molecules like water and oxygen. (Scarfalo & et al, 2015.)

Based on Andreas & et al. (2016, 21), that “the property of biodegradability is not dependent on the origin of the raw materials but only on the chemical composition of the polymers” (Andreas & et al 2016).

The result gathered from the interview of the general manager of the case company reveals that, the case company has never used any form of bio-based packaging material for the packaging of their products other than the conventional polyethylene based packaging (Appendix 3). However, the introduction of a biodegradable material for the packaging of sacheted pure water will impact positively to the environment. This can be achieved in terms of reduced greenhouse gases emission, potential to providing a more end-to-life, reduction of on sight waste because of its faster rate of decomposition (chapter 2). The interview with the manager also reveals that the company do not pay particular attention to how the end users use and dispose their products. The company is also aware that there is a high possibility that their products may be seen littered on the streets and drainages. This means there is no action plan in retrieving these sacheted bags back for recycling even though the company feels concerned on how some of their sacheted water bags eventually end up. Below is an evidential figure that illustrates how some of these plastic bags eventually end up.

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Figure 9: 40% presence of Pure Water bags in a 100m*50m plot of land in Osubi Town (Ekrake, 2015)

Figure 9 shows a location in Osubi town that reveals the level of indiscriminate disposal of polythene bags and the serious challenges the present-day government is facing. This also reveals that abandon landed properties can easily be converted into a waste bin. Desktop research was conducted before the face-to-face interview in order to confirm to the case company that there are biodegradable types of materials or additives that can be considered during production and or purchasing of their packaging bags.

Figure 10: Film with d2w vs Control Film after 480hrs (Higgs 2011)

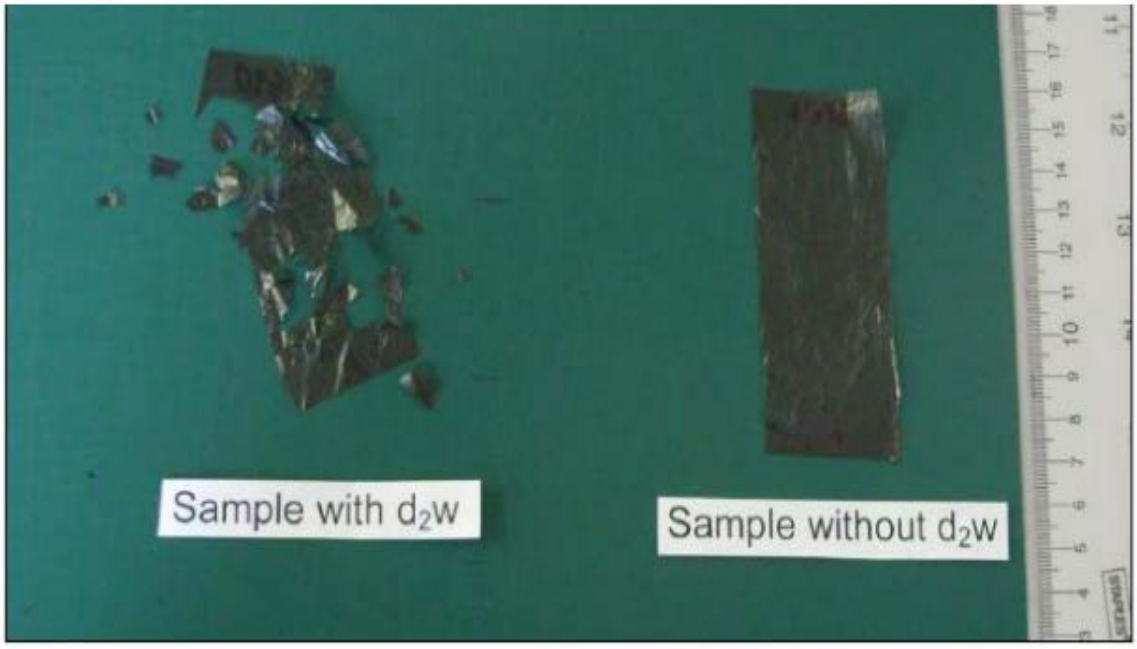

Figure 11: Sample with d2w vs Sample without d2w after 528hours of accelerated UV ageing (Higgs 2011

In other to further provide an awareness to the case company of the use of biodegradable bags, test results of Higgs (2011), were presented to the case company (Figures 10 &11)

to show that samples containing d2w additives can degrade greatly in 20 and 22 days respectively. This test also shows that the ability of d2w product to comply with the biodegradation test of ASTM 6954-04 requirement has been proven. D2w additive is safe enough for direct food contact according to the European Union requirements for direct food contact, United States FFDC Act and Keller and Heckman certificate (Higgs 2011.) From the technical specification, d2w additive fulfilled the standard practice for heat aging in landfill and composting environment (ASTM 5510).
Also, as mentioned earlier, one of the purpose of this thesis is to address the concerns associated with the final product after degradation. Consequently, from the result of this test, the ultimate biodegradation process resulted to no harmful residues. (Higgs 2011.)
The summary on Higgs (2011) report, on the verification of the technical specification and performance of d2w is mentioned in (Appendix 10).

In summary, test result by Higgs (2011), basically tells us that when d2w additives (refer to key concept in page 8) is added to plastics bag (polyethylene bag LDPE), it becomes degradable plastic bag. The rate of degradation compared to the usual plastic bags becomes faster when subjected to accelerated UV and Thermal ageing. Basically, product containing d2w additives are tested in other to monitor degradation through changes in the aesthetics, chemical and mechanical properties of the product as described in ASTM Standards. (Higgs 2011.)

4.2 Economic Impacts

What are the economic impacts of bio-degradable packaging of sachet water?

In other to find out what economic impact therein for the company in changing to a biodegradable package, an interview was conducted with the company manager (Appendix 3). The fact that the case company have never used an alternative packaging materials for their product according to the company manager, therefore, an opportunity to try to invest in a different product could be established. As mentioned earlier, the cost of making a standard biodegradable bag is much higher than the non-biodegradable plastic bag. According to the general manager of the case company, it presently cost 12naira (0.0381cent) to produce one bag of sachet water which is sold for 20naira (0.0634naira). The cost of making a biodegradable bag for easy comparison cannot be attained because production of biodegradable bags are not locally available at the moment. However, according to California grocers association, a standard plastic bag cost 2 cents or less and a biodegradable bag cost about 15 cents (Lerner 2008). This is one of the basic problem

still facing the commercialisation of biodegradable package. But if higher cost has been pointed out as a problem, then the solution can be found using a lower cost option to produce biodegradable bags.

In terms of cost savings, there are cost associated with manufacturing. Factors like energy consumption needs to be considered. Biodegradable plastics need lesser energy to produce them because they are made from plant base sources like corn and starch and other eco-friendly materials. This means that using the same source of energy, manufacturers can produce more biodegradable bags than non-biodegradable bags. Also, it must be pointed out that costs involved in research and development also contribute to the final price of the product. When comparing the cost of making biodegradable and non-biodegradable bags, it must be pointed out that there are hidden cost associated with them. According to the market trends as discussed in sub-chapter 2.8, that an increase in the demand of biodegradable products will result to increase in jobs and employment creation. However, there are also panics of possible job cuts. In addition, based on death statistics (Figure 12 page 33) caused by malaria parasites and as a long-term investment, the company will save cost when government authorities key into the implementation of green packaging and restricting polyethylene bags. Government authorities through plastic bag manufacturers, could promote biodegradable bags through increased taxation instead of outright ban on non-biodegradable bags.

The economic effect of using biodegradable package is of long term, in that; cost of production will decrease gradually because the concept is new at the moment and needs time to develop and adjust to. “However, prices have continuously been decreasing over the last decade. With rising demand, increasing volumes of bioplastics on the market and rising oil-prices, the costs for bioplastics will be comparable with those for conventional plastic prices” (European bioplastics 2016). The true cost of non-biodegradable plastic bags is not reflected if one considers their environmental impacts. If this kind of associated costs are added, the conventional plastic bags would cost even more. The successful packaging of sacheted pure water bag using biodegradable materials, will yield economic results including reduction of death rate caused by malaria parasites. This will indirectly save cost spent on hospital bills and economic time lost as a result of waiting for recovery.

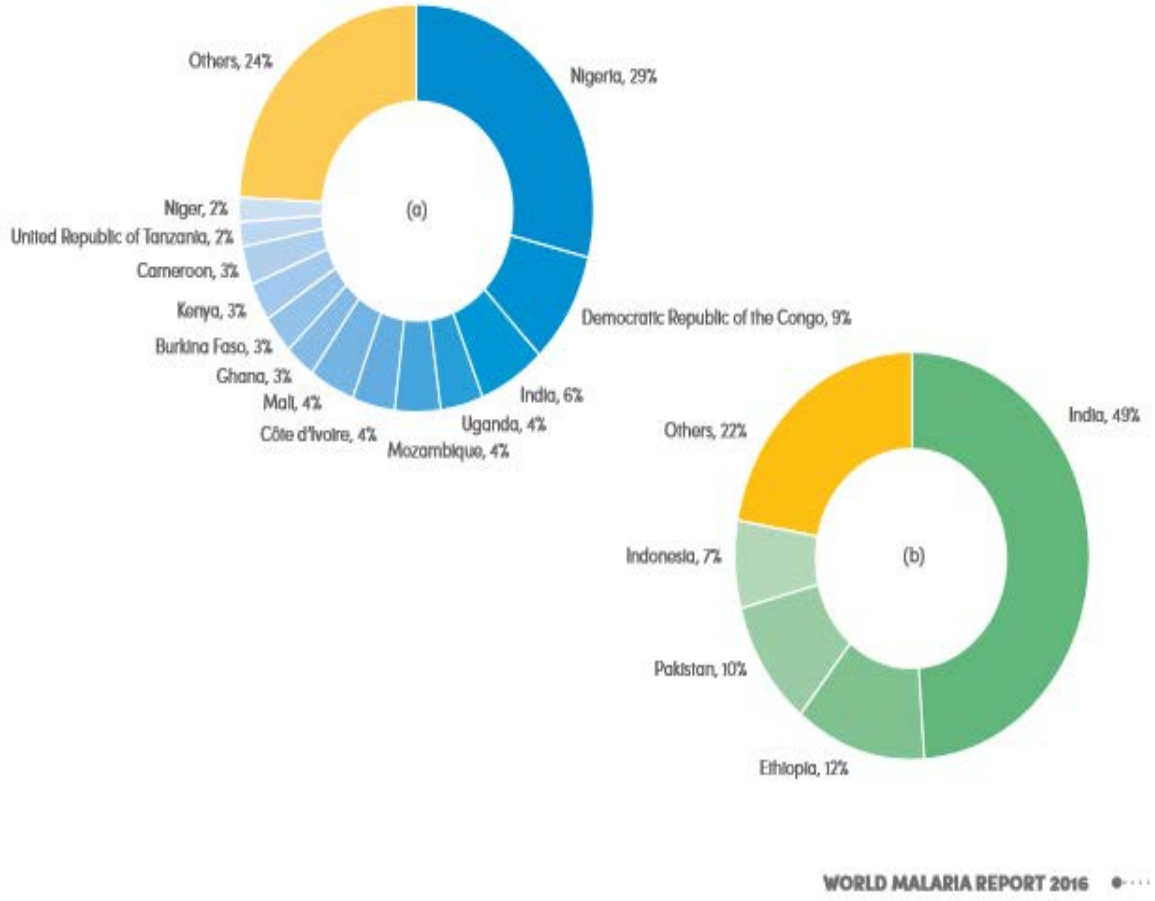

Figure 12. Estimated Country Share of (a) total Malaria deaths and (b) P. Vivax Malaria deaths, (World Malaria Report 2016)

Figure 12, illustrates the percentage estimates of deaths cases according to World Health Organisation. From the pie chart, one can easily see that Nigeria accounted for 29% of world total estimated malaria deaths, followed closely by Democratic Republic of Congo with 9%.

The amount of money spent on the treatment of malaria can be saved and used for other positive development. This percentage loss of lives can be reduced subsequently with the introduction of biodegradable packaging which provides a quicker rate of decomposition (Figure 10, 11 page 30) and to a more environmentally friendly end product. The absence of breeding place for mosquitoes will reduce the increasing death rates of humans caused by these mosquitoe parasites.

4.3 Results of end users perception

How would end users perceive and accommodate biodegradable and polyethylene packages?

In other to provide an insight to the case company on showing the attitude of how end users use and dispose their product, a collection of 10 different reactions of people were gathered from 10 different persons. Ten number of people were chosen to represent a larger group with similar background. The target groups were those whose nature of work were seen to be more directly exposed to sunlight and heat because of the nature of their jobs. They included traders that have their shops by the side of the street, passer-by, and hawkers of food items, drivers of public transport, and passer-by who can also be grouped under this criterion. The average weather temperature in most part of Nigeria is recorded at 26 degree Celsius. These set of people are prone to be thirstier and therefore tend to consume water more often. They included traders that have their shops by the side of the street, passer-by, and hawkers of food items and drivers of public transport.

1. Do you drink sachet pure water?

YES	*	*	*	*	*	*	*	*	*	*
NO										

2. How do you dispose the bag after consuming the water?
   Waste bin?

YES	*	*	*	*	*	*	*	*	*	*
NO										

3. Do you think it is wrong to thing to throw the bag on the ground?

YES	*	*	*	*	*	*	*	*	*	*
NO										

4. Do you know throwing of this sachet bags on the ground causes environmental problems, which also affects our health?

YES	*	*	*	*	*	*	*	*	*	*
NO										

5. Why do you throw them on the ground?
   Waste bin?

YES							*	*	*	*
NO	*	*	*	*	*	*				

6. Do you feel responsible to the environmental problems caused by these bags?

YES	*	*	*	*	*	*	*	*		
NO							*		*	*

7 What will be your reaction if you see a bag that is more environmentally friendly?

GOOD									*	*
VERY GOOD	*	*	*	*	*	*	*	*		
UNCERTAIN										

Figure 13: End users perceception (Ekrake O, 2016)

The type of questions and answers from Figure 13, was formulated directly to end users in other to generate a quick response not to waste the interviewee valuable time and to cover majority of the questions. This was so because the situation was that, most of the end users where in a hurry because of the nature of their work added to the hot temperature which they are constantly exposed to.
The main findings derived from the interview conducted on random end users shows that 100% of them consume sacheted pure water. However, all of them answered they do not use waste bins to dispose this sachet water. At the same time, 100% of them think is wrong to dispose these bags indiscriminately which also causes serious health and environmental hazard. Further questioning reveals that 60% of them feels that the waste bin location is far away from them. 80% of them feels responsible for their actions and would be very happy to see a bag that would be more environmentally friendlier.
However, as mentioned earlier on page 24, that end-user's perception has little or no influence on the provision of an alternative packaging material.

4.4 Results of environmental field workers

Interviews were also conducted on 2 environmental field workers on 6th February 2016. The interview conducted was done on the field and both workers were on their place of work and were not pre-informed of my arrival. The aim is to access the level of awareness, dedication to the environment and the importance of clean environment. This insight was made available by 2 environmental field workers. The choice of 2 workers tends to demonstrate the available number of work force that covers Osubi area. It also provides an insight on how the environment is been cared for and how often they work. The result revealed that they basically dispose trash bins that are placed outside of houses. Customers under this scheme pay a token monthly to have their trash bins disposed for them. However, is not enough to keep sachet bags off the streets and gutters. This scheme is not mandatory for houses to key into, it is rather a voluntary one. There is an occasional environmental sanitation that exist once a month, where everyone participates in cleaning of their closest environment. According to both workers, in commercial places like markets and various public places, it is the responsibility of the government to make sure that those places are clean. From the information gathered, they work according to the area of their concentration even though they will like to have more responsibilities that will attract better payment. Refer to appendix 5 for more details.

5 Challenges and Opportunities

Biodegradables bag as replacement for polyethylene bags partially depends on the fulfilment of economic and environmental requirements. Biodegradable bags as a fairly new concept is prone to several restrictions which will limit their full take off. One reason for such limitation is the fact that biodegradable industry is still on the infancy stage when compared with a more matured polyethylene industry. However, there are windows of opportunity for improvement. These challenges can trigger the need for R&D development which will further open up the industry.

According to Peelman & et al (2015), there are three main challenges associated with biodegradables which are: higher costs of production, processing and performance. From economics of scale, it is quite logical for conventional plastics to be cheaper because their production technology has been long in existence. On the contrary, bio-based products are in the infancy state of technological development. Many chemical companies at the moment are not yet familiar with biodegradable products using bio-based materials. Furthermore, there are barrier properties associated with bio-based materials especially when a very high water barrier like sachet water is needed also barriers like heat resistance and moisture sensitivity. However, increased research and development will further enhance the development of biodegradable bags, which will open up a competitive market to allow a fair price market. In addition, there are uncertainties surrounding biodegradable bags in terms of sufficient availability of bio-based resources for a sustainable development (Peelman & et al. 2015.)

6 Discussion and Conclusion

In spite the rising demands of biodegradable bags, its large-scale implementation to replace the present polyethylene packaging still suffers some setbacks. Limitations like moisture tolerance, heat tolerance, mechanical etc.

The main purpose of embarking on this thesis was to complement the existing packaging of sachet pure water particularly in Nigeria and the West Africa sub-region at large. The alternative is to introduce a biodegradable package that will be economically beneficial to the populace and environmentally sustainable not only for present generation but also to future generations. Therefore, the implementation of this packaging product will go a long way in filling the gaps created by recycling in Nigeria. Also, the attitude of indiscriminate disposal of sachet water bags will be checked through a quicker decomposing biodegradable bag. The fact that this water packaging method is still growing at the moment, there is a market opportunity that is waiting to be exploited in terms of science and technology for gainful employment in the future.
In summary, the importance of using green packaging material as a replacement of non-bio-based packaging of sachet pure water cannot be over emphasised. It provides a significant contribution to the preservation of our mother earth and also added economic value.

6.1 Benefits to the Company

The result of this thesis gave the case company an insight on current packaging trends through the introduction of biodegradable type of package. This also means that there is a positive information made available to the case company for future planning. The research if implemented will give the company a positive economic outlook and a much better environment in the locality. This will boost the company's image and corporate social responsibility.

6.2 Company Feedback

The company was grateful for been singled out for such awareness through improving its packaging of water bags. The case company also feels that the findings can be very helpful in future decisions and would be looking forward to commencing such project later in the future.

6.3 Analysis of Learning

I would like to start by saying this thesis process has equipped me with more knowledge of sustainable logistics in general and in the field of packaging in particular.
This thesis process has made me reflect deeply on my theoretical learning and putting these learnings into practice as a young supply chain professional. It has further enriched me with research knowledge in finding out information and using them rightly. It has thought me how to prepare and execute ideas in a professional manner.
The journey of this thesis started with an idea that was backed with the desire to improve an existing way of packaging. Working with the case company brought me closer to the source of these bags and with the hope of a potential implementation of this idea.
This thesis involved a lot of planning in order to get the right persons to schedule an interview. Therefore, this thesis thought me how to be patient and consistent in dealing with people. This project has exposed me to a new business opportunity that exist in the field of packaging, that one might be tempted to embrace maybe later in the future.

6.4 Suggestions for future research

Biodegradable packaging as a fresh aspect of sustainable supply chain still has lots of challenges that need to be addressed before its full integration and implementation. Therefore, some areas of concerns needed some answers. For example

1. Health impacts of Polyethylene package to biodegradable package
2. Standardization of biodegradable bags
3. Barriers to the growth of biodegradable bags

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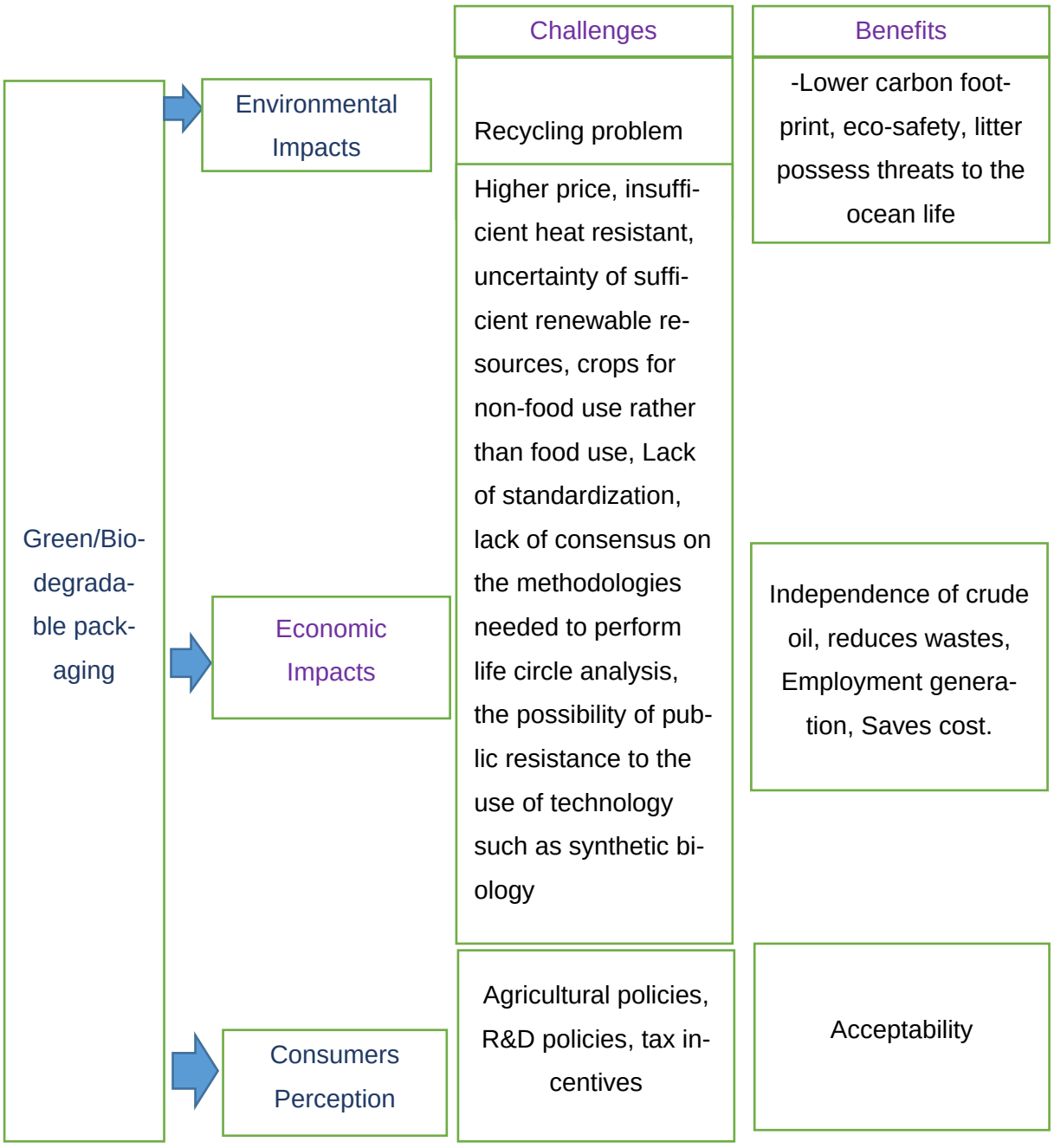
Appendices

Appendix 1 Thematic Categorisation

Thematic Category/Investigative Questions	Main Questions	Additional Question
What are the environmental impacts of biodegradable packaging of sachet water?	Does your company pay attention to how this polyethylene bag finally ends up?	Has your company in any time bought other type of raw material other than polyethylene bags for packaging?
	Do your company have some kind of responsibility to preserving the environment from this bags?	
	How do you dispose the bag after consuming the water content?	Do you think it is a wrong thing to throw it on the ground?
		Do you feel responsible to the environmental problems caused by these bags?
		Do you know throwing of this sachet bags on the ground causes environmental problems, which also affects our health?
What are the economic impacts of biodegradable packaging of sachet water?	As a sales and logistics manager, do you think your company would like to invest in biodegrable packaging?	What is your advice to assist in the success of this biodegradable package?

How would end users perceive and accommodate biodegradable packages?	Do you feel responsible to the environmental problems caused by these bags?	Do you drink sachet pure water?
	Do you know throwing of this sachet bags on the ground causes environmental problems?	How do you dispose the bag after consuming the water content?
	What will be your reaction if you see a bag that is more environmentally friendly?	

Appendix 2. Theoretical framework



Appendix 3. Interview structure with the management

Management interview structure, 14:30pm, 2016.

1) What is your name sir?

2) What is your current position in Divine Table Water?

3). How long have you been working in Divine Table Water?

4) How do you get your raw materials?

5). What do your company do with the raw materials?

6). Has your company in any time bought other type of raw material other than polyethylene bags for packaging?

7). How do you get your packaging materials (Polyethylene) back?

8). Does your company pay attention to how this polyethylene bag finally ends up?

9). Do your company have some kind of responsibility to preserving the environment from this bags?

10). As a sales and logistics manager, do you think your company would like to invest in biodegrable packaging?

11). What is your advice to assist in the success of this biodegradable package?

Appendix 4. Interview Structure with End users

Interview structure on a cross section of consumers, 2016

Consumers decided to remain anonymous

1. Do you drink sachet pure water?

2. How do you dispose the bag after consuming the water content?

3. Do you think it is a wrong thing to throw it on the ground?

4. Do you know throwing of this sachet bags on the ground causes environmental problems, which also affects our health?

5. Then why do you continue to throw them on the ground?

6. Do you feel responsible to the environmental problems caused by these bags?

7. What will be your reaction if you see a bag that is more environmentally friendly?

Appendix 5. Interview Structure for Environmental Field Workers

Interview structure on environmental field workers. January 2016

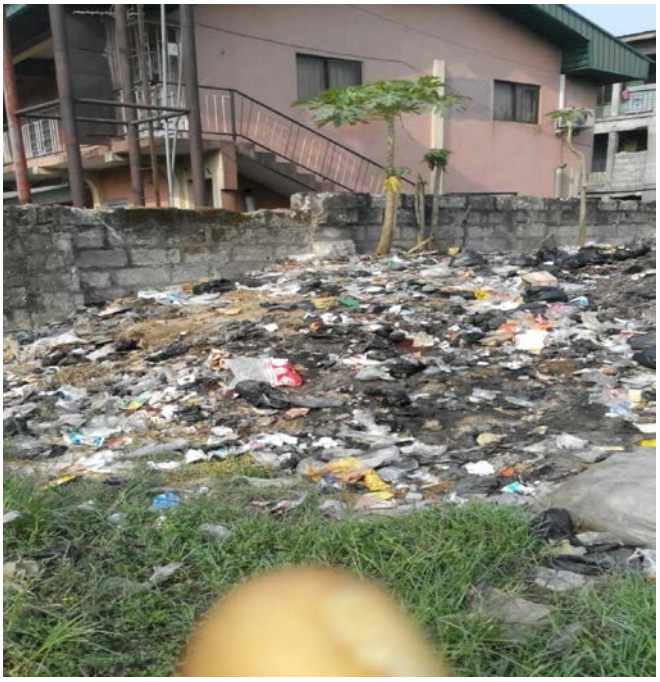
Worker want to be anonymous

1. How often do you come to work?
2. What is your company name?
3. What is the nature of your job?
4. How come there are trash bags everywhere even though sometimes you come to work?
5. Who is in Charge of traches in the streets and drainages in Osubi community?

Appendix 6. Divine Table Water Bag

Appendix 7. Pure Water bags amongst plastic containers blocking drainages in Osubi

Appendix 8. Estimated 40% presence of Pure Water bags in 100m*50m land Osubi



Appendix 9. Material Generated and Discarded in Municipal Waste Stream 2005

Source material	Tons (million)	Percent of MSW by weight	Material discarded as a percentage of total MSW disposal
Materials			
Paper and paperboard	84	34.2	25.2
Glass	12.8	5.2	6
Metals			
Ferrous	13.8	5.6	5.3
Aluminum	3.2	1.3	1.5
Other nonferrous[b]	1.7	0.7	0.3
Total metals	18.7	7.6	7.1
Plastics	28.9	11.8	16.3
Rubber and leather	6.7	2.7	3.4
Textiles	11.1	4.5	5.6
Wood	13.9	5.7	7.6
Other	4.6	1.9	2.1
Total materials in products	180.7	73.5	73.4
Other wastes			
Food scraps	29.2	11.9	17.2
Yard trimmings	32.1	13.1	7.3
Miscellaneous inorganic waste	3.7	1.5	2.2
Total other wastes	65	26.5	26.7

Source material	Tons (million)	Percent of MSW by weight	Material discarded as a percentage of total MSW disposal
Total MSW generated	245.7	100	
Products			
Containers and packaging	76.7	31.2	27.7
Nondurable goods	63.7	25.9	25.9
Durable goods	40.3	16.4	19.6
Total product waste	180.7	73.5	
Other wastes			
Food scraps	29.2	11.9	17.2
Yard trimmings	32.1	13.1	7.3
Miscellaneous inorganic waste	3.7	1.5	2.2
Total other wastes	65	26.5	26.7
Total MSW generated	245.7	100	

Appendix 10: Technical Specification and Performance of d2w

d2w is an additive formulation that renders conventional polyolefin Oxo-biodegradable
“Oxo-biodegradation” is “degradation identified as resulting from oxidative and cellmediated phenomena, either simultaneously or successively” ("Terminology in the field of degradable and biodegradable Polymers and Plastics" CEN TC 249/ WG 9).
Polyolefin products made with d2w additive will abiotically degrade in the presence of oxygen. Degradation has been proved in accordance with the requirements of ASTM 6954- 04 by passing ASTM 5510 (RAPRA Report 46095).
The ability of d2w products to comply with the biotic (biodegradation) tests of ASTM 6954-04 has been demonstrated by the loss of molecular mass achieved after abiotic thermal degradation, resulting in ultimate biodegradation of the material into CO2, water, mineral salts and biomass (RAPRA Report 46303, Pyxis report 30.7.05, and DPPA Chapt. 3, Eco-sigma Report Sept. 2008).
The eco-toxicity sections of EN 13432 and ASTM 6954-04 require that no harmful residues are left – this has been verified for d2w additive. (OWS Report MST-4/1-d2wb&d2wc, EcoSigma Report Sept. 2008).
d2w additive does not contain heavy metals (defined by 92/64/EC Art 11 as lead, mercury, cadmium, or hexavalent chromium).
d2w additive is safe for direct food-contact according to the European Union requirements for Direct Food Contact 2002/72/EC and the US FFDC Act and regulations (RAPRA report 46137, and Keller & Heckman certificate 18.2.2009). It is the responsibility of the manufacturers of products intended for food-contact to ensure that all other materials incorporated by them comply with those requirements.
If polymer products are correctly made with d2w, the additive will have no effect upon the strength and other performance characteristics of the product during its programmed service-life.
Polymer products correctly made with d2w comply with the Essential Requirements of the EU Packaging Waste Directive 92/64/EC Annex II paras. 1, 2 and 3(a) (b) and (d).
d2w Oxo-biodegradable plastics are not currently intended for composting.
If sent to landfill d2w Oxo-biodegradable plastics will degrade in aerobic conditions. In anaerobic conditions they become inert and will not emit methane.

Appendix 11. Symptoms of Poor Material Handling

Aisles are cluttered	Excess scrap
Overhauling of products	Flow inefficiencies
Dock confusion in loading/unloading	Confusing product storage
Too much manual labour	Too much walking
Lack of gravity flow movement	Excessive indirect labour cost
Poor use of skilled labour	Idle cube storage
Stock out on part and supplies	Excessive long hauls
Lack of standardization	Dirty facility
High loss and damage	Excess number of employees

Appendix 12. Survey of end users perceception

1. Do you drink sachet pure water?

YES	*	*	*	*	*	*	*	*	*	*
NO										

2. How do you dispose the bag after consuming the water?
   Waste bin?

YES	*	*	*	*	*	*	*	*	*	*
NO										

3. Do you think it is wrong to thing to throw the bag on the ground?

YES	*	*	*	*	*	*	*	*	*	*
NO										

4. Do you know throwing of this sachet bags on the ground causes environmental problems, which also affects our health?

YES	*	*	*	*	*	*	*	*	*	*
NO										

5. Why do you throw them on the ground?
   Waste bin?

YES							*	*	*	*
NO	*	*	*	*	*	*				

6. Do you feel responsible to the environmental problems caused by these bags?

YES	*	*	*	*	*	*	*	*		
NO							*		*	*

7 What will be your reaction if you see a bag that is more environmentally friendly?

GOOD									*	*
VERY GOOD	*	*	*	*	*	*	*	*		
UNCERTAIN										