# An Evaluation of Environmental Costs of Agricultural Inputs: A survey on Selected Farms, South Africa

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## CERTIFICATE

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***"AN EVALUATION OF ENVIRONMENTAL COSTS OF AGRICULTURAL INPUTS: A SURVEY ON SELECTED FARMS, SOUTH AFRICA"***

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**DECLARATION**

I, Nkosana Samuel Mlangeni, hereby declare that the mini-Dissertation “An Evaluation of Environmental Costs of Agricultural Inputs: A survey of Selected Farms, South Africa” submitted to the University of Limpopo for fulfilment of the degree of Master of Business Administration has not been previously submitted for any degree by me and that it is my own work in design and in execution and all material contained herein have been duly acknowledged by means of complete references.

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Signature Date

## DEDICATION

I dedicate this work to my cousin Nhlabathi, L.J. who is pursuing his farming dream and to my Grandmother (Mrs. M.S. Mlangeni) and my late Grandfather (Mr. N.T. Mlangeni) who also loved farming and has been my inspiration in studying.

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**ABSTRACT**

The objective of this study was to determine the environmental impact of agricultural inputs, to know if the environmental impacts of agricultural inputs have environmental costs, and to know who bears the environmental costs of agricultural inputs. Using a purposive sampling method, the researcher studied six farms from Chief Albert Luthuli Municipal area, Mpumalanga. The research design for the study was a mix of qualitative and quantitative research approaches. Data collection was from primary and secondary sources. Data was collected from the six farmers in Albert Lithulu, in addition secondary data was collected from the archives of Index Mundi, the University of Pretoria, the US EPA and the World Bank. Using a mix of correlation and regression analysis, findings from the study provided an answer to the three research objectives. Findings from the analysis of correlation and regression indicated that agricultural input (fertilizer, used in this study) does affect the environment; it causes an agricultural induced emission of greenhouse gases (nitrous oxide and methane). Furthermore, findings from analysis of potential environmental costs of environmental impacts (methane and nitrous oxide) showed that agricultural inputs have social costs for South Africa. Furthermore, the final findings in this study showed that the environmental costs from agricultural inputs are born by the victims. Consequently the study recommends additional environmental regulation to enable farmers internalise some of the environmental costs of agricultural inputs that are born by victims. Further research is suggested to determine the model that may be used to internalise environmental costs of agricultural inputs back to the farms.

Key Words: farms, environmental costs, agricultural inputs, externalities

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# Chapter 1
# Introduction and Background

## 1.1 Introduction

The Agriculture sector occupies a key place in fulfilling food requirements of a growing population, meeting raw material requirements of agro-based industries and providing employment to the majority of the rural population (Gundimeda, 2007:56). In South Africa, farmers are provided with packs containing essential agricultural inputs (Gift of the Givers Foundation, 2009). An estimated 70 percent of the world's poor rely on agriculture for all or some of their household income and 'healthy living' consumption. Farmers face a number of risks to their livelihoods and farms.

This work evaluated the environmental costs of agricultural inputs on the environment, basing the study on selected farms in Mpumalanga Province, South Africa. This study was conducted on 10 farms situated in the Albert Luthuli Municipality in Mpumalanga. The use of agricultural products on farms, e.g. pesticides and fertilizers, do not only affect the health of the people and animals, but it also affects the environment (land, plants, water and air). Plants, after applying the pesticides, can be ready for human consumption after some time and if it is consumed immediately after applying the pesticide a particular living being might suffer serious illnesses.

## 1.2 Problem Statement

Only less than 1% of the pesticides applied would directly work on the pests, whereas the majority would be diffused into the environment (Chen, Zhan and Hou, 2006:490). Information gathered from farms when visiting them earlier on is that, they are using the agricultural inputs especially fertilizers and pesticides that are harmful to the environment. The quality of the soil they are planting on leaves them with no choice but to continuously use fertilizers since the soil cannot produce on its own anymore.

In most cases farmers destroy their farms unintentionally through the use of the agricultural inputs; they waste too much on buying these inputs in order to use them to increase their production, whereas on the other side they are negatively affecting their resources and the economy, since they have to incur expenses on the land every time they need to use it. Land that is always subjected to these products lose its value and power for producing plants on its own. The farmers have to always apply these products in order to get the required production. At the same time, the consumers end up eating food with the understanding that it is healthy whereas they are eating food intoxicated with chemicals.

A study conducted by Pimentel (2005) on *Environmental and Economic Costs of the Application of Pesticides Primarily in the United States* has shown that in the US there were huge environmental losses on natural resources through pesticides' application in terms of crops, birds and ground water contamination; the government spent funds in reduction of environmental and social costs due to the application of the pesticides.

The depletion and degradation of the environment is treated as an increase in income, while these can in fact have a negative impact on the economy of the future (Gundimeda, 2007:6). This can actually be true, since this destruction of the environment also affects the value of the land, in a way that we will end up not having quality land for planting, but the land in turn needs to be sustained by the fertilizers/chemicals. Livestock will also lose its value since it will also be grazing on the same land products. A decrease in land production will negatively affect the economy of the country. The Oecd Proceedings (1999:15) indicated that the basic long-term challenge facing agriculture is to produce sufficient food and industrial crops efficiently, without degrading natural resources and the environment.

## 1.3 Motivation of the Study

Current ecological problems have been traced to business, of which farming business is part of, because the farms use pesticides and fertilizers which are harmful to the eco-system, it is therefore important to pay significant attention and to account for the costs incurred here.

## 1.4 Significance of the Study

This research is not only important to the farmers, but also to the people and livestock and their health. It can also be relevant in other geographical areas beyond the research area which are also affected by the use of the agricultural inputs. It will also assist farmers in managing and reducing environmental costs.

## 1.5 Aim of the Study

The aim of this study is to evaluate the impact and burden of agricultural inputs on the environment.

## 1.6 Objectives

- To ascertain if agricultural inputs have environmental impacts on the environment.
- To find if the environmental impact carry environmental costs.
- To evaluate if these environmental costs are internal or external and who bears these costs.
- To make recommendations on the high usage of agricultural inputs

## 1.7 Research Questions

Research Questions:

- Do agricultural inputs have environmental impacts?
- Do the environmental impacts carry environmental costs?
- Are these costs internal or external and who bears these costs?

## 1.8 Definition of Concepts

*Agricultural inputs*: are all substances or materials used in the production of agricultural products, e.g. manure, pesticides, etc. (USDA Organic, 2014).

*Environmental costs*: are expenditures incurred to prevent, contain or remove environmental contamination (Answers, 2014).

*Agricultural products*: are fruits and vegetables produced from the soil, e.g. cane oranges, lemons, etc. (Department of Agriculture, 2005:9-10).

*Community*: a group of people who live in the same area (such as a city, town or neighborhood) (Merriam-Webster, 2014).

## 1.9 Chapter Outline

Chapter 1: INTRODUCTION AND BACKGROUND

This chapter explains the statement of the problem, purpose and objectives of the study and justification of the study. In addition, limitations of the study forms part of this chapter.

Chapter 2: LITERATURE REVIEW

This chapter focuses on the review of related information. What is reviewed in this chapter is good or poor succession planning, the barriers to succession planning, the importance of succession planning in family businesses, the advantages of succession planning, the disadvantages of succession planning, succession planning process, models of succession planning and the factors required for effective succession planning.

Chapter 3: RESEARCH METHODOLOGY

The chapter includes the research design and the methodology that is used to collect the data. The research methodology is explained according to the subheadings which are as follows: research design; population and sampling; data collection and lastly, data analysis.

Chapter 4: INTREPRETATION OF THE RESEARCH FINDINGS

This chapter presents the information collected from the respondents. The interpretation of data is based on the subsections of data gathering instruments. The collected data are analysed and presented in the form of a pie chart and tables.

Chapter 5: CONCLUSION AND RECOMMENDATIONS

This is the chapter where the summary of the whole study is outlined together with the recommendations based on the research findings.

## 1.10 Research Limitations

The recognized limitation of this study is the small sample size of farms. The scope of this study is based on the factors influencing the continuous use of agricultural inputs on farms in Albert Luthuli Municipality. These resources are limited in terms of cost and time available to undertake the research. Another limitation would be the respondents'

lack of interest to participate in the study and unwillingness to provide the right information expected from them.

## 1.11 Summary of Chapter 1

Chapter 1 has provided a general introduction to this research. The background highlighted briefly on the need to consider the environmental cost of agricultural inputs. Furthermore, this chapter presented the research problem which highlights the gap and hence the need for the study; this chapter also presented the research questions, research objectives, the significance, definition of terms and the arrangement of this research.

# Chapter 2
# Literature Review

## 2.1 Introduction

This chapter focuses on the review of related information. The literature in this research is divided according to the research questions and objectives of the research as follows:

- Environmental costs
- Environmental Impacts of Agricultural Inputs
- Environmental Costs of Agricultural Inputs (chemicals and fertilizers)
- Responsibility for Environmental Costs of Agricultural Inputs (internal or external)

## 2.2 Environmental Cost

Environmental costs are expenditures incurred to prevent, contain or remove environmental contamination. There are products that, when they are used, cause contamination on the environment (soil, air, water). They sometimes cause negative impacts on the ecosystem (environment). Graff *et al.* (1998:2) in the *Snapshots of Environmental Cost Accounting,* state that the impacts caused by society, organizations or individuals resulting from activities that affect environmental quality define environmental costs and these impacts can be expressed in the form of monetary or non-monetary terms. It is very important that environmental impacts of any activity undertaken be looked at and be accounted for.

In another research by Shields*,* Beloff and Heller (1995:6), environmental costs are defined as costs which have been incurred in order to reduce or eliminate releases of hazardous substances, all other costs associated with corporate practices aimed at reducing environmental impacts. Farmers use some agricultural inputs (herbicides, fertilizers) to control their farms and the use of these products calls for proper monitoring on their application on the fields and that costs them time and money.

The constant increase and heavy use of Nitrogen (N) containing fertilizers in agriculture attracts more environmental costs and it is a global concern, therefore, sustainability considerations require that there should be alternatives in order to reduce this (Bohlool *et al.,* 1992). The higher percentage of chemical N fertilizers in the ground is dangerous to the environment/ecosystem, since they are diffused into the underground water in times of rain (Chen *et al.,* 2006:490). Farms these days depend on the use of the fertilizers in order to yield more production from their farms and to meet the demand of the market. The impact caused by the fertilizers may not be seen in the beginning, although if attention is paid on the farm it can be noted that the use of the fertilizers is increasing every year.

A study conducted by Pimentel (2005) on *Environmental and Economic Costs of the Application of Pesticides Primarily in the United States* has shown that in the USA there were huge environmental losses on natural resources through pesticides' application in terms of crops, birds and ground water contamination. The government spent funds in reduction of environmental and social costs due to the application of the pesticides. Today's crops/plants cannot live longer than they used to previously and the taste has changed. Municipalities have to spend more funds in treating raw water into usable/potable water that meet their required standards.

Gale and Peter (2001) state that it is know that environmental costs can be substantial from five to twenty percent of the total costs of business activities, meaning that almost one fifth of production costs in a farm are environmental costs. According to Sustainability Concepts (2014), Environmental Accounting is an important process that provides organisations with a means to integrate information with business decision making and business operations. When operating a farm, the farmer must know about environmental issues affecting the farm. When taking decisions the information is to be considered, since it might either be dangerous to the farm or residents around the farm or its customers.

The costs of environmental protection for firms in the US have been increasing since the 1970's and are expected to increase further in the future (Christmann, 2000). It can be seen also in several farms that the production have deteriorated and needs to be sustained by the use of the agricultural inputs that in turn is harmful to the environment.

## 2.3 Environmental Management Accounting

According to Burritt (2005), Environmental Management Accounting (EMA) is concerned about accounting needs of managers in relation to activities that affect the environment and environmental related impacts on the organisation. Management for farms must account for the environmental impact caused by their farms.

Environmental Management Accounting was developed to recognize someboundaries of conservative management accounting approaches to environmental costs, consequences and impacts (Accounting Web, 2014). Management Accounting involves identifying, collecting, estimating, analysing and using of cost or other information used for decision-making in organisations. Therefore, Environmental Management Accounting can be described as Management Accounting with a close attention to resources and energy flow information together with environmental cost information.

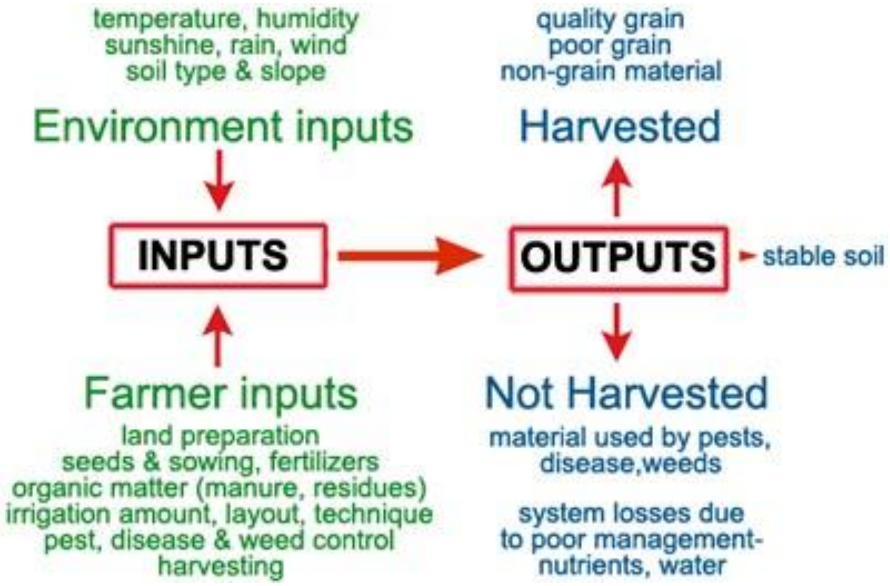
Smukler et al. (2012) indicate that farmers are not only expected to produce food, but they are also expected to think about ecosystem processes that ensure long-term production. They are also expected to be stewards of the environment by ensuring that all goods and services are provided without or with less negative environmental impacts.

According to the Oracle (2014), Environmental Accounting and Reporting make it possible for organizations to track their greenhouse gas (GHG) emissions and other environmental information against reduction targets and facilitates green reporting for both voluntary and regulated emissions' reporting systems.

## 2.4 Environmental impact of agricultural inputs

Agricultural inputs can be divided into two parts, namely Physical (natural) and Human inputs. Physical inputs don't need any expenditure to be incurred to make use of them, while Human inputs need expenditure to be incurred for them to be accessed and utilized (Farming, 2012:1). The inputs include:

- Seeds,
- Seedlings,
- Irrigation water,
- Fertilizers and pesticides,
- Land,
- Capital,
- Agricultural equipment (The Daily Star, 2012).




(FAO Corporate Document Respiratory, 2014)

It can be noted that the environment has its own input, which is nature, while farmers also have their own inputs which include fertilizers and pesticides. Agricultural inputs are applied in an effort to maximize production and profits, while their negative effects on the land are neglected (Bünemann, Schwenke and Van Zwieten, 2006). Devaney (2014), states that the fertilizers used by farmers have the following effects on the environment: infertile soil, acidic soil, increased micro-organisms and groundwater

pollution and those are some of the reasons why many environmentalists are against the use of chemical fertilizers.

Tillman (1999:5995) states that agricultural expansion will have a significant impact on natural ecosystems, especially due to the high usage of nitrogen and phosphorus fertilizers. The impact will also be in the marine and freshwater ecosystems; the existing nonagricultural ecosystems provide pure, drinkable water is affected by the high concentrations of pesticides, which in turn becomes unfit for human consumption. Research has shown that nitrogen-rich compounds found in fertilizer runoff are the primary cause of serious oxygen depletion in many parts of the ocean, especially in coastal zones and fertilizers containing nitrogen cause soil acidification which may lead to a decrease in nutrient availability.

Shrestha, Koilara and Tamrakar (2010:95) in the topic *knowledge, Practice and Use of Pesticides among Commercial Vegetable growers of Dhading District, Nepal,* indicate that pesticides used by the farmers were extremely hazardous and have a waiting period which is normally more than four days after application, meaning crop must not be consumed within this period. Some of the farmers experienced symptoms of health hazards due to the use of the pesticides (inputs).

Carrie (2014) states that the use of chemical sprays, powders and gases can bring about unintended harm to those people exposed both directly and indirectly and to the environment nearby the crops. Chemicals are used indiscriminately to grow more crops which may cause an environmental disaster in coastal zones (Andaman Chronicle, 2013).

While there is steady increase in the consumption of food produced by agriculture, there is also a steady decline in the quality and productivity of soil around the world, due to the increase of demand for agricultural products (Clay, 2004:vii). According to Census (2011), the population of the country has grown from the previous years. This means the need for agricultural products is rising as well, as farmers are now forced to ensure

that they meet the needs of the residents by producing enough food from agriculture, since most nutrients are found in plants. During the production, pests also find a way of living and feeding on the plants, in order to control them farmers use pesticides. A study by Atreya, Johnsen and Sitaula (2012) has shown that the pesticides carry health risks to humans and environmental costs.

The world's agricultural production does not only provide marketable products (which are fruit and vegetables), it also provides non-marketable products (which are emanating from the use of agricultural products). Meaning that while the use of the inputs provides farmers with effective outputs, the risk of environmental degradation is experienced (Ball *et al.*, 2002). Farmers are at times forced to maximize production due to the previous use of the agricultural inputs which caused degradation of the natural environmental resources and the increase in need for agricultural products in the market. This puts future farmers at risk, as they might not be able to farm properly, if not at all, due to the degraded environment.

Metcalfe, Sunding and Zilberman (2002) state that there is a high awareness of environmental side effects caused by agriculture and the other problems associated with environmental pollution, depletion of (effects on) natural resources and the effects on human and animal health caused by the farming activities on farms. This shows that the agricultural activities are negatively affecting the environment, especially where there is a high dependency on the agricultural inputs. The effects are extended to human and livestock as well, which might cause high expenditure on medical costs, to the governments, especially where people use government facilities (hospitals, clinics, veterinary clinics).

Only less than 1% of the pesticides applied would directly work on the pests, whereas the majority would be diffused into the environment (Chen, Zhan and Hou, 2006:490). This shows that in order to get rid of pests, a farmer has to use high volumes of chemicals and this negatively affects the environment.

The Oecd Proceedings (1999:15) indicated that the basic long-term challenge facing agriculture is to produce sufficient food and industrial crops efficiently, without degrading natural resources and the environment. Approximately a billion people are chronically malnourished while our agricultural systems are concurrently degrading land, water, biodiversity and climate on a global scale (Foley *et al.*, 2011).

Modern agriculture has led to a serious decline in soil and water quality as a result of practices which are not sustainable in the long-term (Sumner & McLaughlin, 1996). Agricultural activities can have significant effects kilometres away from where the activities take place and the agricultural pollution may as well have economic effects in the form of remedial water treatment and clean-up costs (Skinner *et al.,* 1997). It is therefore important to develop and implement systems that would reduce harmful impacts on the environment by agricultural activities.

The use of agricultural chemicals does not only deplete the quality of the soil, but it also alters water bodies, affects human health and causes climate changes across the globe.

The Rand Water Board has pointed out a number of things that cause pollution in the water, of which agriculture was one through the use of fertilizers and pesticides. Arrival of these substances in the rivers/dams may cause eutrophication.

### 2.4.1 Fertilizers

South Boulder Mines Limited describe fertilizers as nutrients that are added to plants in order to ensure that crops yields are maximized and plant health is preserved as much as possible. Fertilizers can further be classified in terms of organic and inorganic fertilizers, of which organic fertilizers are derived from animal wastes, crop residues, compost and other by-products of living organisms, while inorganic fertilises are derived from non-living sources which are manmade (manufactured) commercial fertilizers which include:

- Nitrogen (N) - helps plants grow quickly, while also increasing the production of seed and fruit and bettering the quality of leaf and forage crops and also gives plants their green colour and also aids in photosynthesis (FEECO International, 2014)
- Phosphorus (P) - stimulates root growth, helps the plant set buds and flowers, improves vitality and increases seed size. It does this by helping with the transfer of energy from one part of the plant to another (Gardeners Supply Company, 2014)
- Potassium (K) - promotes flower and fruit production and is vital for maintaining growth and helping plants resist disease (Allotment & Gardens, 2014)

Synthetic fertilizers can kill the useful organisms in the soil, sterilizing the soil and creating dependence, which is like an addiction (like someone taking drugs), to the synthetic replacements. These fertilizers are known to be made from fuel/gasoline. Many fertilizers have the peat substance in them which normally contributes to global warming. In addition, synthetic fertilizers, have oil in them that get washed to the rivers, contributing to algae blooms that deprive waterways of oxygen and kill off aquatic life (National Geographic, 2014). This shows that fertilizers have both positive and negative impacts on the environment.

There are risks that are carried by the contaminations accumulating in soils and crops due to the agricultural fertilizers, these include exposure to arsenic (As), cadmium (Cd), fluorine (F), lead (Pb) and mercury (Hg). Cadmium and Fluorine accumulate in fertilised soil at a faster rate than the others. Cadmium transfers from soil to edible portions of agricultural food crops at a significantly higher rate than the other elements (McLaughlin *et al.*, 1996). The environment (soil) is exposed to different kinds of chemicals through the application of fertilizers.

Impacts that are caused by fertilizers in the environment include depletion of the quality of the soil, altering the biology of water bodies, affecting human health and causing climate changes across the globe. The use of fertilizers for growth and cultivation is

food security requirements for now, but then if things keep on progressing the way they are, it won't take long to see the times where there is a lack of food, water and health (Environment, 2013).

The effects of chemical fertilizers are not widely spoken about. One popular fertilizer, urea, produces ammonia emanation, contributes to acid rain, groundwater contamination and ozone depletion due to the release of nitrous oxide by a denitrification process. The groundwater contamination has been linked to gastric cancer, goitre, birth malformations and hypertension, testicular cancer and stomach cancer (Sustainable Baby Steps, 2014).

The excess nutrients from all fertilizers used run off into waterways and blocks them, also to the rivers and cause oxygen to be depleted, thus causing fish or any living organism in the river to die or move to purer parts of the river (Scientific American, 2014). This would also cause the government to spend much in purifying the contaminated water, since they will have to use more purification chemicals and processes.

Haller *et al. (2014),* state another result of the use of fertilizers containing Nitrogen, as the nitrate. It is mostly found in ground water during the spring season, since it is the season when farmers are using the fertilizers most. As mentioned above, farmers use these fertilizers in order to increase their production to meet the demand for food in the world, they therefore are forced to use more and more of these products (while destroying the soil). They further state that the cleaning-up of nitrate from contaminated water is not an easy job.

### 2.4.2 Pesticides

A pesticide is any substance/mixture used to kill, repel or control certain forms of plant or animal life that are considered to be pests (National Institute of Environmental Health Sciences, 2014). Pesticides include:

- Herbicides – destroy weeds and other unwanted vegetation, leaving desired crops relatively unharmed. They are alleged to cause a number of health consequences ranging from skin rashes to death (Science Daily, 2014);
- Insecticides - control a wide variety of insects. The careless or excessive use of insecticides destroys many beneficial insects, birds and small mammals. In addition, some insecticides, tend to persist in soil and water and can eventually accumulate in the body tissue of fish, wildlife and humans (How Stuff Works, 2014)
- Fungicides used to prevent and cure diseases (moulds and mildew), which can have severe adverse effects on crop yields and quality (Syngenta, 2014);
- Disinfectants for preventing the spread of bacteria and compounds used to control mice and rats.

Pesticides can cause harm to humans, animals or the environment because they are designed to kill or otherwise harmfully affect the living unwanted organisms on crops (US Environmental Protection Agency, 2014).

According to GRACE Communication Foundation (2014), the harmful environmental impacts of the use of pesticide include:

- Loss of biodiversity and elimination of key species (e.g., bees)
- Water pollution
- Soil contamination
- Pest resistance, resulting in the need for increased application of pesticides or formulation of alternate pesticides.

Pesticides have been linked to a large number of health problems in the world which include the following:

- Endocrine and neurologic system disorders,
- Cancer,
- Birth defects and other diseases.

People working on farms where pesticides are used are exposed to the above mentioned health risks and as well as people working with harvesting pesticide-sprayed products. The Toxics Action Center (2014) points out that the endocrine disruption can produce infertility in humans and a variety of birth defects and developmental defects in children, as well as hormonal imbalance and incomplete sexual development, impaired brain development, behavioural disorders and many others.

The application of pesticides leads to loss of biodiversity and degradation of environment. Each pesticide comes with unintended side effects. They can be either washed away by rain or blown away by wind into undesired areas. Animals are most vulnerable to the side effects and those may also affect humans that may consume that particular animal, mainly those who practice hunting.

Previous researchers have shown that the problem is at input level, where the inputs are used and the effects thereof manifested. This also raises a risk for the health of the intended consumers (human or animals) of the agricultural products.

## 2.5 Environmental Costs of Agricultural inputs (chemicals and fertilizers)

Emana, Gebremedhin and Regassa (2010:8) in the topic *Impacts of Improved Seeds and Agrochemicals on Food Security and Environment in the Rift Valley of Ethiopia: Implications for the Application of an African Green Revolution,* talks about side effects arising from the application of large quantities of more expensive and more toxic chemicals in order to sustain agriculture. In another research, Altieri (2012) brings to attention that the use of pesticides and chemical fertilizers have a negative impact on the environment, which results in soil erosion, loss of soil fertility, depletion of nutrient reserves in the soil, etc. The economic and environmental costs of the heavy use of chemical N fertilizers in agriculture are a global concern (Bohlool, Ladha, Garrity and George, 1992).

The high usage of agricultural inputs (fertilizers) in the environment, alters the fertility of the soil by increasing acid levels in the soil (Buzzle, 2014). Although the

chemicals/minerals are used to boost the growth of plants and productivity, they have side effects in the long run.

Chen *et al.* (2006:494) in the *Estimation of Environmental Cost Incurred by Pesticide Application in Coastal Agric Region and Management Measures,* state that the increase on environmental costs is caused by the application of pesticides. The most obvious phenomenon of pesticides affecting human health is the acute toxicosis of pesticides. Environmental impacts of pesticides depend mostly on the type of chemical used and the amount applied, it is most likely for water to be contaminated by these chemicals (Skinner *et al*., 1997:112). The pollution of the environment and other impacts of production cause the changes in the quality of the environment (Gundamenda, 2007:12).

The depletion and degradation of the environment is treated as increase in income, while these can in fact have a negative impact on the economy of the future (Gundimeda, 2007:6). The effects of the environmental degradation may not be noted now, but may be seen in the future.

Chemical fertilizers are more expensive than the natural fertilizers and there are safety precautions that one needs to take while using the chemical fertilizers, such as wearing a face mask and putting on gloves. Failure to follow these precautions might result in serious health impacts (risks), hence the increase in environmental costs from agriculture. Excessive use of fertilizers may also have a negative impact of the crops/plants it is used on.

As there is a high crop yield from the use of the fertilizers, the greenhouse gases emissions are also increased. According to the Organic Plant Foods (2014), the use of fertilizers may introduce several diseases in water due to the contamination of the water, the use of fertilizers have negative impacts on the health of people and also on the environment. Several kinds of chemical compounds that are found in contaminated water resulting from the chemical fertilizers are:

- Aluminium
- Lead
- Chromium
- Zinc
- Copper
- Cobalt
- Cadmium

Continuous use of water contaminated by fertilizers may cause various types of hazardous diseases which are:

- Kidney failure
- Improper mental and physical growth
- Hypertension
- Haemoglobin deficiency
- Hair loss
- Skin diseases

Synthetic fertilizers can seriously exhaust the nutritional content of foods and direct contact or exposure to synthetic chemical fertilizers can affect infants and cause health inconveniences in many adults (Turf Pro USA, 2014). The diseases may be imparted to people through skin contact with the fertilizers, inhalation or through eye contact.

Omega-3 oil is a very important nutrient in a person's body which needs it to prevent heart diseases and cancer; this nutrient is also declining in our agricultural produced foods, due to the synthetic fertilizers (The Health Wyze Report, 2014). Laboratory tests have proven that the vegetables, fruit, grains eggs and even the milk and the meat of these days are not the way it used to be a few generations ago. Most nutrients are no longer found in them due to the way they are produced. A person can no longer sustain himself on these foods.

The following GHGs have been discovered as the major environmental costs of fertilizer input – methane and nitrous oxide.

### 2.5.1 Methane Emission from the Application of Fertilizer

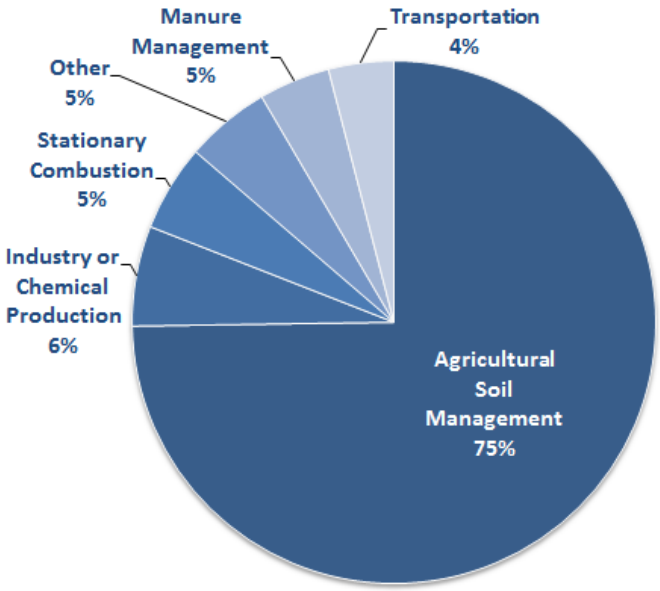
Methane ($CH_4$) emissions are increased by the increase in the application of ammonium-based fertilizers. Its emissions contribute much on the global climate change. This means agriculture is also deemed to be the contributor to global climate change.

Methane emissions result mainly from rice cultivation, due to the high usage of the Nitrogen (N) containing fertilizers (Kamaljit, Manqin and Chaoqun, 2012). The modern agricultural methods and technologies do not only bring an increase in food production but it also brings an increase in environmental costs. By this, agriculture can be regarded as the major contributor to greenhouse gases (GHGs). Rice production contribute about 11% of global methane emissions, of which the global methane emission amounted to about 540 million tonnes pa. (Nono, Deratista and Monica, 2012).

### 2.5.2 Nitrous Oxide Emission from the Application of Fertilizer

Agricultural nitrous oxide ($N_20$) emissions are emissions produced through fertilizer use (The World Bank, 2014). Agricultural lands are the major contributors to the production of nitrous oxide due to the high usage of synthetic fertilizers. These nitrogen containing fertilizers are used in order to ensure a large crop production. Large amounts of these gases are emitted into the atmosphere (GHG Online, 2014).

After application of fertilizers, the nitrogen get washed by heavy rains into rivers, dams, drains, etc. and when they are exposed to air they emit the gas into the atmosphere. The increase in the application of nitrogen containing fertilizers is a result of the increase in the need for food in the world, hence crop production needs to be enhanced. According to Signor, Cerri and Conant (2013), nitrous oxide has a high potential for global warming in the world.




**Note: All emission estimates from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012.**

The above shows the US Nitrous Emission by source, it clearly shows that the main contributor for Nitrous Oxide Emissions is the agriculture sector (US Environmental Protection Agency, 2014).

Nitrous oxide emissions in tropical agriculture are particularly high due to the warm and wet climatic conditions and often high fertilizer N (nitrogen) application rates (Wang *et al.,* 2014).

## 2.6 Responsibility for environmental costs agricultural inputs (internal and external)

The UNCTAD (1995:12) in the topic *Sustainable development and the possibilities for the reflection of environmental costs in prices* indicate that internalization comes with reflecting environmental costs in prices since it constitutes a rise in the cost of production; these are therefore passed to the consumer. Environmental costs are normally hidden/included as production costs, especially in agriculture, the costs for application of pesticides and fertilizers can be called production costs, otherwise there would be no/very little costs of production. Grossman (2007:4) in the paper Agriculture and the Polluter Pays Principle, states that the Polluter Pays Principle made it a

requirement that a polluter should bear expenses that come after pollution and the main goals of the principle are the allocation and internalization of the costs.

Nabileyo (2009:9) indicates that the costs incurred in addressing the environmental degradation and consequent health effects of the pollution are to be borne by those responsible for harming the environment. In a similar research by De Sadeleer (2012:405) in the topic *The Polluter-pays Principle in EU Law – Bold Case Law and Poor Harmonization* state that the principle is seen as accepting environmental degradation as foreseeable, provided that the polluter pays for the damage/pollution. This might cause farmers to deliberately pollute the environment with the expectation that they will pay for the damage since this seem to license them to do so, especially when the penalties don't are very less in a way that profits are not affected.

Ball *et al.* (2002) state that most of the social costs that emanate from agricultural inputs (chemical) usage are not translated into private costs borne by farmers. Social costs are costs on human health, it can be workers or community members residing around the farm. It is disadvantageous that these costs be borne by the people instead of the farmers because it should be farmers' duty to ensure that the used products do not trigger health risk to other people. There should be a way of holding the farmer responsible for the medical expenses if found that the illness is caused by a certain agricultural product used.

Due to increased external pressure from stakeholders, the local companies were forced to draw their attention to environmental accounting (Lee, Jung and Kim, 2005), such should also be done with farmers. They must show an active interest. The government should also play a part on this, because in some areas the farmers are supplied with these agricultural inputs. There should be programmes and policies developed in the country to ensure that the farmers reduce the use of agricultural inputs.

Ottinger (1991) states that if environmental costs imposed on the society/community by polluters can be internalized, then the issue of environmental degradation can be

addressed. This is true in a sense that the farmers/polluters will ensure that they reduce these costs so that in their financial statements, Sustainability reporting, the costs that are reflected are low and do not put their farms (companies) at risk of losing investors. As investors might not be willing to invest in a company that destroys the environment or spends too much on environmental cleanup costs. In another study by Fakoya (2013) it is stated that organizations may be compelled to pay penalties if they exceed set environmental standards.

## 2.7 Summary Chapter 2

This chapter focused on the review of related to the literature on environmental costs, environmental management accounting, environmental impact of agricultural input (fertilizers and pesticides), the costs of these agricultural inputs in terms of methane emissions and nitrous oxide emissions from fertilizer applications as well as a review on the responsibility of the environmental costs.

# Chapter 3
# Research Methodology

## 3.1 Introduction

This chapter includes the research design and the methodology that was used to collect the data. The research methodology is explained according to the subheadings which are as follows: research design; population, sampling, data collection, data analysis, ethical considerations, validity and reliability and lastly the summary/conclusion.

## 3.2 Research Design

According to De Vaus (2001), research design is the overall strategy that a researcher chooses to put together the different components of the research in a reasoned and logical way, ensuring effectively addressing of the research problem. Tustin *et al.* (2005:82) define research design as the plan to be followed to comprehend the research objectives and it represents the master plan that specifies the methods and procedures for collecting and analysing the required data.

The variables that were considered in the study are the inputs (chemicals/pesticides/herbicides) used and associated possible environmental impacts and costs. This study is done in order to find out if the use of agricultural inputs have a positive or negative impact on the environment.

Crossman (2014) explains qualitative research as a field research, typically involving fieldwork in which the researcher observes and records behaviour and events in their natural setting. The researcher physically goes to the people, setting or site in order to observe the subject as it normally and naturally occurs or behaves. The method of data collection is in-depth interviews where the researcher interviews participants one-on-one.

Therefore, this study adopted a mix of qualitative and quantitative research design since it involved going to the farms and residents adjacent to farms where the researcher also observed the situation and setting of the farm with the farm owners and some people residing around the selected farms. In addition, the researcher made use of secondary data from online sources such as from the US EPA (2015) and IndexMundi (2015) to determine and calculate the environmental impact and costs of agricultural inputs. The quantitative approach became relevant since the researcher measured the relationship between agricultural input and methane/nitrous oxide emissions and the associated environmental costs.

## 3.3 Research Area and Population

The Albert Luthuli Municipality of the Mpumalanga Province was the area of the study.
A research population is generally a large collection of individuals or objects that are the main focus of a scientific query or are known to have similar characteristics (Explorable, 2014). Welman, Kruger and Mitchell (2005:53) describe population as the full set of cases from which a sample is taken. The Albert Luthuli municipality has 15 functional farms and hence 15 farm owners.

## 3.4 Sampling and Sample Size

Sampling is defined by Leedy and Ormrod (2013:152) as the process of selecting a sample, while sample is a particular entity selected for analysis. The study used a sample of 10 operating commercial farms and at least 15 people residing around the farms were interviewed. The study focussed only on farms that mainly use the agricultural inputs (pesticides and fertilizers). Sampling is done usually because it is impossible to test every single individual in the population. There are two types of sampling namely, Non-probability and Probability Sampling. In probability sampling all participants in the population have an equal chance of being selected while in non-probability they don't have the equal chance (Explorable, 2014).

Quota sampling is the non-probability equivalent of stratified sampling. Like stratified sampling, the researcher first identifies the strata and their proportions as they are represented in the population. Then convenience or judgment sampling is used to select the required number of subjects from each stratum. This differs from stratified sampling, where the strata are filled by random sampling (StatPac, 2014). Therefore this study used a convenience or judgment to select required farmers based on convenience and easiness of reaching the farmers.

**Sample Size**

As indicated above, the researcher made use of a convenient sample approach, hence due to farmers availability and time of the researcher, 6 famers were interviewed from the 15 farms in Albert Luthuli Municipality.

## 3.5 Data collection

Data collection for this study was from two sources – primary and secondary sources. The primary source of data was from questionnaires administered to farmers. The secondary source of data was from online sources such as from the US EPA (2015), IndexMundi (2015) and University of Pretoria (2014)

A questionnaire is a set of questions for gathering information from individuals (ETA Evaluation, 2008:1). An interview is a direct face-to-face attempt to obtain reliable and valid measures in the form of verbal responses from one or more respondents. It is a conversation in which the roles of the interviewer and the respondent change continually (Key, 1997). In this research, the farmers were given the questionnaires to complete during the interview process. The questionnaire is attached as Annexure A of this work. It was developed based on the research objectives.

## 3.6 Data analysis

The purpose of data analysis is to interpret and draw conclusions from the mass of collected data (Tustin *et al.,* 2005:102). The analysis is a combination of qualitative and quantitative. The qualitative analysis involved the arrangement of questionnaire responses and translation into tables. The quantitative analysis involved the use of descriptive statistics to calculate the mean and mode of responses; the SPSS software was used for the descriptive statistics. Furthermore the simple regression analysis was also used to calculate the relationship between agricultural inputs (fertilizer and pesticide) on carbon emission (methane and nitrous oxide).

## 3.7 Ethical Considerations

There are four ethical considerations to which the researcher should pay attention: Informed consent, right of privacy of respondents, protection from harm and involvement of the researcher (Welman *et al*., 2005:201). Moreover, identities of the study participants was not disclosed as questionnaires did not require them to disclose their identities. The researcher ensured that all participants participate in the study voluntarily as they were not be forced to participate.

## 3.8 Limitations of the study

The recognised limitation of this study is the small sample size of farms. The scope of this study is based on the factors influencing the continuous use of agricultural inputs on farms in Albert Luthuli Municipality. Another limitation could be in terms of cost and time available to undertake the research. Another limitation would be the respondents' lack of interest to participate in the study and unwillingness to provide the right information expected from them.

## 3.9 Summary of Chapter 3

This chapter's purpose was to clarify the followed research methodology in this study. It covered the research instruments used in data collection, analysis and interpretation. The details on the research methodology were given according to the subheadings which are as follows: research design, population, sampling, data collection, analysis and interpretation. The next chapter (Chapter 4) will present the results obtained from the analysis of the data.

# Chapter 4
# Data Analysis and Findings

## 4.1 Introduction

This chapter presents the data, the data analysis and findings from the analysis. The data analysis is organised to provide answers to the three major questions of the study. Therefore the first section presents the analysis of data on the impact of agricultural inputs on nitrous oxide and methane emissions, hence this analysis answers question 1 of the research on whether agricultural inputs have environmental impact. The section second section of the analysis presents the analysis of data on the environmental cost of nitrous oxide and methane emissions, hence this analysis answers research question 2 of the research on whether environmental impacts have environmental costs. The final section of the analysis presents the analysis of data on who bears the cost of environmental impacts of agricultural inputs.

## 4.2 Data Analysis

The following research questions are analysed:

- Do agricultural inputs have environmental impacts?
- Do the environmental impacts carry environmental costs?
- Who bears the environmental costs of agricultural inputs?

***Analysis Tool:***

The analytical tool employed in the analysis of first two questions is the correlation statistics and simple regression. The Pearson correlation model used is represented by:

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$$ or $$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{\left(\sum X^2 - \frac{\left(\sum X\right)^2}{N}\right)}\sqrt{\left(\sum Y^2 - \frac{\left(\sum Y\right)^2}{N}\right)}}$$

The simple regression model used is represented by:

$Y = \beta o + \beta_1 \chi_1 + \varepsilon$

### 4.2.1 Analysis of Research Question 1

- Do agricultural inputs have environmental impacts?

In answering this question, the secondary data in Appendix 2 was used. The agricultural fertilizer carbon emission impact was used as represented by agricultural nitrous oxide emission and agricultural methane emission for South Africa. The correlation and regression analysis and result appears below in Table 4.1 and 4.2:

## Table 4.1 Correlation Analysis:

***Relationship between Fertilizer input and Agricultural Nitrous Oxide and Methane Emissions***

***Fertilizer input and Agricultural Nitrous Oxide Emission***

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| AgricNitOxide | 13.7143 | .48795 | 7 |
| FertUsage | 55.2857 | 4.82059 | 7 |

**Correlations**

| | | AgricNitOxide | FertUsage |
|---|---|---|---|
| AgricNitOxide | Pearson Correlation | 1 | -.810* |
| | Sig. (2-tailed) | | .027 |
| | N | 7 | 7 |
| FertUsage | Pearson Correlation | -.810* | 1 |
| | Sig. (2-tailed) | .027 | |
| | N | 7 | 7 |

*. Correlation is significant at the 0.05 level (2-tailed).

The above shows the relation of Fertisizer inputs to the Nitrous Oxide Emission from Agricultural activities.

==========

***Fertilizer input and Agricultural Methane Emission***

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| FertUsage | 55.2857 | 4.82059 | 7 |
| Methane | 19.5714 | .78680 | 7 |

**Correlations**

| | | FertUsage | Methane |
|---|---|---|---|
| FertUsage | Pearson Correlation | 1 | -.753 |
| | Sig. (2-tailed) | | .051 |
| | N | 7 | 7 |
| Methane | Pearson Correlation | -.753 | 1 |
| | Sig. (2-tailed) | .051 | |
| | N | 7 | 7 |

The above shows the relation of Fertisizer inputs to the Methane Emission from Agricultural activities.

## Table 4.2 Simple Regression Analysis:

***Relationship between Fertilizer input and Agricultural Nitrous Oxide and Methane Emissions***

***Fertilizer input and Agricultural Nitrous Oxide Emission***

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.822767045 |
| R Square | 0.676945611 |
| Adjusted R Square | 0.612334733 |
| Standard Error | 0.303811215 |
| Observations | 7 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 0.967065 | 0.967065 | 10.47727 | 0.0230294 |
| Residual | 5 | 0.461506 | 0.092301 | | |
| Total | 6 | 1.428571 | | | |

| | *Coefficients* | *andard Erı* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *ower 95.0%* | *pper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 18.33205763 | 1.431234 | 12.80857 | 5.16E-05 | 14.652953 | 22.01116 | 14.65295 | 22.01116 |
| FertUse | -0.083491072 | 0.025794 | -3.23686 | 0.023029 | -0.1497962 | -0.01719 | -0.1498 | -0.01719 |

==========

***Fertilizer input and Agricultural Methane Emission***

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.769792981 |
| R Square | 0.592581233 |
| Adjusted R Square | 0.51109748 |
| Standard Error | 0.550139929 |
| Observations | 7 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2.201016 | 2.201016 | 7.272385 | 0.04295129 |
| Residual | 5 | 1.51327 | 0.302654 | | |
| Total | 6 | 3.714286 | | | |

| | *Coefficients* | *andard Erı* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *ower 95.0%* | *pper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 26.53795374 | 2.591672 | 10.2397 | 0.000153 | 19.875848 | 33.20006 | 19.87585 | 33.20006 |
| FertUse | -0.125957424 | 0.046707 | -2.69674 | 0.042951 | -0.2460225 | -0.00589 | -0.24602 | -0.00589 |

## Table 4.3 Correlation Analysis:

***Relationship between Glyhosate Agricultural Chemical and Agricultural Nitrous Oxide and Methane Emissions***

***Herbicide input and Agricultural Methane Emission***

**Correlations**

| | | GlyphosateHerbicide | Methane |
|---|---|---|---|
| GlyphosateHerbicide | Pearson Correlation | 1 | .513 |
| | Sig. (2-tailed) | | .239 |
| | N | 7 | 7 |
| Methane | Pearson Correlation | .513 | 1 |
| | Sig. (2-tailed) | .239 | |
| | N | 7 | 7 |

The above shows the relation of Herbicide inputs to the Methane Emissions from Agricultural activities.

***Herbicide input and Agricultural Nitrous Oxide Emission***

**Correlations**

| | | GlyphosateHerbicide | AgricNitOxide |
|---|---|---|---|
| GlyphosateHerbicide | Pearson Correlation | 1 | .552 |
| | Sig. (2-tailed) | | .199 |
| | N | 7 | 7 |
| AgricNitOxide | Pearson Correlation | .552 | 1 |
| | Sig. (2-tailed) | .199 | |
| | N | 7 | 7 |

The above shows the relation of Herbicide inputs to the Nitrous Oxide Emission from Agricultural activities.

### 4.2.2 Analysis of Research Question 2

- Do the environmental impacts carry environmental costs?

**Table 4.4 Environmental Costs of Methane and Glyphosate**

**Social cost of Agricultural Nitrous Oxide and Agricultural Methane for South Africa**

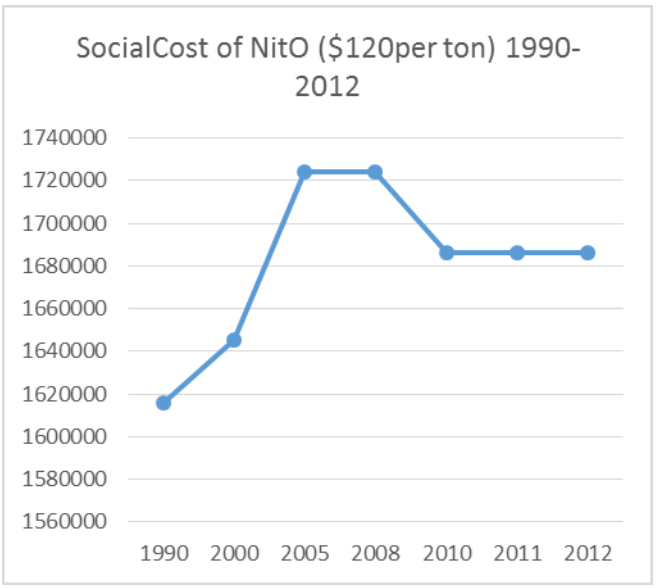
| Year | NitO | SocialCost ($120perton) | Methane | SocialCost ($120perton) |
|---|---|---|---|---|
| 1990 | 13463 | 1615560 | 19108 | 2292960 |
| 2000 | 13710 | 1645200 | 18874 | 2264880 |
| 2005 | 14367 | 1724040 | 20015 | 2401800 |
| 2008 | 14369 | 1724280 | 20338 | 2440560 |
| 2010 | 14052 | 1686240 | 20084 | 2410080 |
| 2011 | 14052 | 1686240 | 20084 | 2410080 |
| 2012 | 14052 | 1686240 | 20084 | 2410080 |

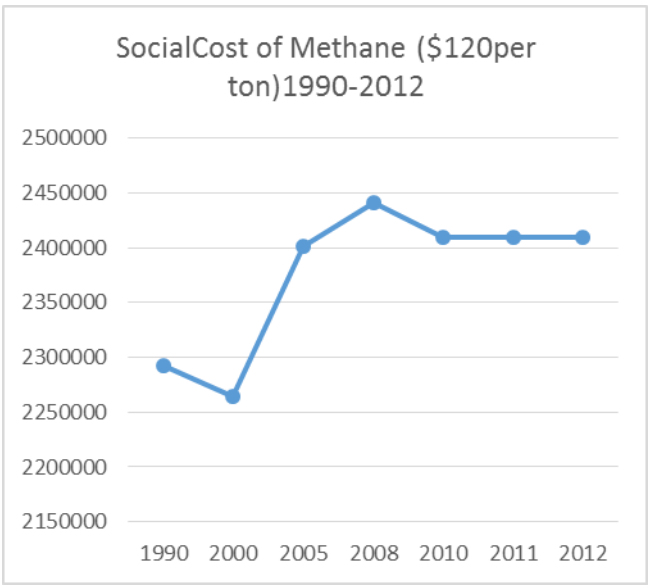
Sources:
Estimated social cost of carbon for South Africa: calculated by author, with social cost of carbon estimate of $120 per metric tons from the US Environmental Protection Agency (EPA) (2015), the social cost of carbon. Available from: http://www3.epa.gov/climatechange/EPAactivities/economics/scc.html
Fertilizer NitO: IndexMundi (2015) South Africa - Nitrous oxide emissions: Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). Available from: http://www.indexmundi.com/facts/south-africa/nitrous-oxide-emissions
Fertilizer Methane: IndexMundi (2015) South Africa - Methane emissions Agricultural methane emissions (thousand metric tons of CO2 equivalent). Available from: http://www.indexmundi.com/facts/south-africa/methane-emissions

The environmental costs of Methane and Nitrous Oxide is calculated above and it can be evident that the costs were rising between 1990 and 2008, but have remained the same between 2010 and 2012 due to that the used amounts of these two items remained the same. The higher the amount used constitutes higher environmental costs. Therefore the less use of the agricultural inputs can save in environmental costs.

The below graph (Figure 4.1) illustrate the above environmental costs in form of a graph.

Figure 4.1 Line Graph of Social cost of Agricultural Nitrous Oxide and Agricultural Methane for South Africa




Source: Authour's graph with data from Table 4.4

### 4.2.3 Analysis of Research Question 3:

- ***Who Bears the Environmental Cost of Agriculture?***

Data from Appendix 1 Questionnaire Responses (Primary Source of Data)

Research objective 3 is analysed in Table 4.5. Table 4.5 presents analysis and tabulated from questionnaire responses and a descriptive statistics from questionnaire responses.

| Question | No of farmers interviewed | | Number of No responses | No of Yes responses |
|---|---|---|---|---|
| Does farming has impact on the environment? | 6 | | 1 | 5 |
| Do you think that agricultural inputs have impact on the environment? | 6 | | 0 | 6 |
| Would you think that these inputs have environmental impacts? | 6 | | 0 | 6 |
| Unintended Impact on farm workers | 6 | | 4 | 2 |
| External Impact on other farms | 6 | | 6 | 0 |
| External Impact on consumers | 6 | | 4 | 2 |
| External impact on the community | 6 | | 5 | 1 |
| Would you think that these external impacts have costs implications | 6 | | 0 | 6 |
| Who bears the external costs - the victims? | 6 | | 0 | 6 |

**Descriptive Statistics**

| | | Noresponses | Yesresponses |
|---|---|---|---|
| N | Valid | 9 | 9 |
| | Missing | 0 | 0 |
| Mean | | 2.2222 | 3.7778 |
| Median | | 1.0000 | 5.0000 |
| Mode | | .00 | 6.00 |

**Table 4.5 Analysis of Questionnaire Responses on Who Bears Environmental Costs of Agricultural Input**

The number of farm owners who responded was six (6), they all responded to the questions in the questionnaire given to them. The majority of the respondents indicated that the use of agricultural inputs in the process of agriculture have an impact on the environment. Despite farmers' acceptance that agricultural inputs have impact on the environment they seem to have no choice because some farmers (respondents) indicated that these agricultural inputs are recommended by the local Department of Agriculture, Rural Development and Land Administration (DARDLA), hence some supplies of the inputs are supplied by the DARDLA since the municipality (Chief Albert Luthuli) was declared a CRDP (Comprehensive Rural Development Programme) municipality by the Mpumalanga Provincial Government. Therefore, more agricultural activities receive the full support from the DARDLA. They have to constantly utilise these agricultural inputs and increase the amount of usage every year in order to yield the required amount of crops.

## 4.3 Findings from the Analysis

The analysis section above used the research data to analysed the research questions, therefore the following sections present the findings in relation to the research questions.

### *Do agricultural inputs have environmental impacts?*

In an attempt to answer the research question on whether agricultural inputs have environmental impacts. Table 4.1 – 4.2 present the data analysis using the correlation analysis and simple regression. Agricultural input is represented by fertilizer usage data for South Africa from 1990 – 2012. Similarly, environmental impact of fertilizer usage is

represented by agricultural nitrous oxide and methane emissions. Tested at 0.05 significant level, Findings from the correlation and regression analysis in Table 4.1 – 4.2 show that fertilizer usage in South Africa is positively related to agricultural nitrous oxide and methane emissions. This therefore indicate that the usage of fertilizer (an agricultural input) has a negative impact on society and the environment by increasing the amount of carbon emission (nitrous oxide and methane emissions) into the environment. This finding confirms previous literature findings by (Bünemann, Schwenke and Van Zwieten, 2006; Devaney (2014) that agricultural inputs have negative effects on the environment. Tillman (1999:5995) states that agricultural expansion will have a significant impact on natural ecosystems, especially due to the high usage of nitrogen and phosphorus fertilization.

***Do the environmental impacts carry environmental costs?***

In analyzing the data on whether environmental impacts of agricultural inputs have environmental costs. The social cost of one ton of carbon as estimated by the US Environmental Protection Agency was used to calculate the social cost agricultural induced nitrous oxide emission and methane emission for South Africa for 1990 – 2012. Findings in Table 4.4 and Figure 4.1 show a rising social cost of agricultural induced methane and nitrous emission since 1990. This finding on the environmental costs of agricultural inputs in South Africa provides confirmation to the US EPA on the potential environmental costs of carbon emission on the environment.

**Who bears the environmental costs of agricultural inputs?**

In order to seek an answer to the question on who bears environmental costs. The primary data retrieved from six farmers interviewed in Albert Luthuli municipality was analysed. In addition to accepting that agricultural input have environmental impact, all the six farmers accepted that the environmental cost of agricultural inputs are born by the victims who are affected by the environmental impact of agricultural inputs.

This finding confirms previous research by Ball *et al.* (2002) that most of the social costs that emanate from agricultural inputs (chemical) usage are not translated into private costs borne by farmers. Social costs are costs on human health; it can be workers or community members residing around the farm. This situation is in contrast with previous

research suggestions that the polluter should internalise such environmental costs into the business operations and be responsible for paying such environmental costs Grossman (2007:4), Nabileyo (2009:9). This therefore suggest that the government of South Africa should introduce environmental laws that may mandate farmers to be responsible for possible environmental costs arising from the use of agricultural inputs such as fertilizer and chemicals, such that humans and animals may remain healthy after consuming crops produces by farmers and that the environment may remain sustainable.

### 4.4 Summary of Chapter 4

This chapter has presented the results of the data analysis and interpretation of research findings. It can be summarized that use of agricultural inputs in farming does have environmental impacts that mainly affect the environment including human beings. The analysis also uncovered that the environmental impacts of agricultural inputs have environmental costs, such as the social cost of methane and nitrous oxide which has been on the rise in South Africa. Given that such costs are born by the victims – the humans, it becomes necessary for government to introduce new environmental regulations that may guide farmers' usage of agricultural inputs and the internalization of the associated environmental costs. The next chapter will present the summary of the study together with the recommendations based on the research findings.

# Chapter 5
# Conclusion and Recommendations

## 5.1. Introduction

This chapter summarises the entire research by presenting a brief discussion of how the objectives of the study have be achieved. Hence in the following sections, the three objectives of the study are presented and this is followed by a discussion of how the results of the study supplied an answer to each of the objectives. Therefore, section 5.2 presents a conclusion from the findings that addressed the research objectives raised from the beginning. Section 5.3 makes recommendation.

## 5.2 Summary of Research Findings

***Objective 1: to determine if agricultural inputs have environmental impact:***

Tested at 0.05 significant level, Findings from the correlation and regression analysis in Table 4.1 – 4.2 show that fertilizer usage in South Africa is positively related to agricultural nitrous oxide and methane emissions. This therefore indicate that the usage of fertilizer (an agricultural input) has a negative impact on society and the environment by increasing the amount of carbon emission (nitrous oxide and methane emissions) into the environment. This finding therefore provide an answer to research objective 1. The Fertilizer Association refers to these destructive environmental effects as Adverse Environmental Impacts. The potential consequences of fertilizer application consist of deteriorating soil fertility, weakening production and reduced feed value of grazing land (Fertilizer Association, 2016).

***Objective 2: to determine if the environmental effect of agricultural inputs have environmental costs:***

In order to determine if the environmental effect of agricultural inputs have environmental costs, the researcher made use the US EPA estimated social cost of carbon per ton which, according to US EPA is $120 per ton of carbon. Hence the

researcher calculated the trend in social cost of the two types of agricultural related carbon emissions in South Africa (methane and nitrous oxide) for 1990 -2012. Findings from the documentation by the US EPA and from the analysis of cost by the researcher show a rising trend in the social cost of agricultural induced methane and nitrous oxide emissions in South Africa. Accordingly, objective two of this research was achieved. This finding thus points to the need for the government to provide regulation to assist farmers and the society to internalise environmental costs of agricultural inputs back the farm.

***Objective 3: to determine who bears the environmental cost of agricultural inputs***

Findings from the analysis of research questionnaire show that members of the community affected by the environmental impact of agricultural inputs bear the environmental costs of agricultural inputs. Farmers interviewed accepted that the farms do no bear the costs. This finding supports previous literature that environmental costs from agricultural inputs are born by the victims.

## 5.3 Conclusion and Recommendation

The purpose of the study was to discover if there are impacts on the environment resulting from the use of agricultural inputs and if there are costs attached to the agricultural induced environmental impacts and to determine who bears the associated costs. Hence, the objectives of this study were to determine the environmental impact of agricultural inputs, to know if the environmental impacts have environmental costs, and to know who bears the environmental costs of agricultural inputs.

The study investigated how agricultural inputs impact on the environment. The study included 6 farms from Chief Albert Luthuli Municipal area, Mpumalanga. The research design for the study was a mix of qualitative and quantitative research approaches. This study used a questionnaire to draw data from the six farmers in Albert Lithulu, in addition, secondary data was collected from the archives of Index Mundi, the University of Pretoria, the US EPA and the World Bank. In this study, agricultural input data was represented by fertilizer usage data in South Africa; environmental impact of agricultural

inputs was represented by agricultural induced nitrous oxide emission and methane emissions data for South Africa. Findings from the study provided an answer to the three research objectives. Findings from the analysis of correlation and regression indicated that agricultural input (fertilizer, used in this study) does affect the environment; it causes an agricultural induced emission of greenhouse gases (nitrous oxide and methane). Furthermore, findings from analysis of potential environmental costs of environmental impacts (methane and nitrous oxide) have social costs for South Africa. The last findings in this study showed that the environmental costs from agricultural inputs are born by the victims.

Drawing from the above findings, this study therefore makes the following recommendations. Given that the victims of environmental cost of agricultural inputs bear the environmental costs, this study recommends that the government should devise farm input environmental regulation to enable farmers internalise some of the environmental costs of agricultural inputs that are born by victims. Further research is needed to determine the model that may be used to internalise environmental costs of agricultural inputs back to the farms to reduce farm profit by introducing a new element of cost.

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## Appendix 1

## Questionnaires

# An Evaluation of Environmental Costs of Agricultural Inputs: A survey on Selected Farms, South Africa

The questions are divided into two parts. Part 1 to be completed by Farmers and Part 2 to be completed by community and other stakeholders

Who are you?

- ☐ Farmer
- ☐ Resident
- ☐ Stakeholder

## Part A: Questions for the Farms

1. Do you believe that farming has an impact on the environment?:
   'please tick one'
   a. ☐ Yes
   b. ☐ No

2. What types of agricultural inputs do you use in farming? –
   'please list'
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
   f. _____

3. Would you think that these inputs have environmental impacts?:
   'please tick one'
   a. ☐ Yes
   b. ☐ No

4. Please list the specific impacts of agricultural chemicals and fertilizers under the following sub-headings:

   Unintended impact on your farm (on targeted crops and other crops):

   ---

   ---

   ---

Unintended impact on farm workers

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External impact on other farms

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External impact on the community

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External impact on consumers

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5. Would you then think that these external impacts have cost implications? Please enumerate types of cost:
   a. _____
   b. _____
   c. _____

6. Would you therefore say that these cost implications can be classified as internal costs and external costs?:
   'please tick one'
   a. ☐ Yes
   b. ☐ No

7. Who bears the internal costs?:
   'please tick one'
   a. ☐ Farm Management,
   b. ☐ workers,
   c. ☐ the government

8. Who bears the external costs?:
   'please tick one'
   a. ☐ farm management,
   b. ☐ the community,
   c. ☐ the government

d. ☐ individual victims

## Part 2: Community

9. In which area/community do you live/operate in?

   _____

10. Are there some farms around your community?:
    'please tick one'
    a. ☐ Yes
    b. ☐ No

11. Would you say that the farm operations has any negative impact on the community or individuals?:
    'please tick one'
    a. ☐ Yes
    b. ☐ No

12. Can you please list some of these negative impacts:
    a. _____
    b. _____
    c. _____
    d. _____
    e. _____
    f. _____

13. Do these negative impacts have any monetary cost implication on the community or individuals?:
    'please tick one'
    a. ☐ Yes
    b. ☐ No

14. Who pays for the costs?
    'please tick'
    a. ☐ Individuals
    b. ☐ The community
    c. ☐ The government
    d. ☐ The farm management

15. Are you happy with the farm management?:
    'please tick one'
    a. ☐ Yes
    b. ☐ No

**Appendix 2**

South Africa: Fertilizer consumption; Agricultural Nitrous Oxide Emission; Agricultural Nitrous Methane Emission and Glyphosate Pesticide

| Year | Fert.NitO | FertUse | Methane | Glyphosate Pesticide |
|---|---|---|---|---|
| 1990 | 13463 | 47.124 | 19108 | 9 |
| 2000 | 13710 | 61.20 | 18874 | 9 |
| 2005 | 14367 | 47.33 | 20015 | 9 |
| 2008 | 14369 | 56.29 | 20338 | 10 |
| 2010 | 14052 | 53.78 | 20084 | 17 |
| 2011 | 14052 | 60 | 20084 | 21 |
| 2012 | 14052 | 62 | 20084 | 23 |

Sources:

Fertilizer NitO: IndexMundi (2015) South Africa - Nitrous oxide emissions: Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). Available from: http://www.indexmundi.com/facts/south-africa/nitrous-oxide-emissions

Fertilizer Methane: IndexMundi (2015) South Africa - Methane emissions Agricultural methane emissions (thousand metric tons of CO2 equivalent). Available from: http://www.indexmundi.com/facts/south-africa/methane-emissions

Fertilizer Usage: IndexMundi (2015) South Africa - Fertilizer consumption (kilograms per hectare of arable land). Available from: http://www.indexmundi.com/facts/south-africa/fertilizer-consumption

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Note: missing years were estimated or extrapolated by author