AN INTEGRATED FARM MANAGEMENT INFORMATION SYSTEM FOR THE SOUTH AFRICAN HYDROPONIC INDUSTRY

By

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DECLARATION BY CANDIDATE

I, Justin Cork, hereby declare that:

- This work has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

- This dissertation is being submitted in partial fulfilment of the requirements for the degree of Masters in Business Administration.

- This dissertation is the result of my independent work and investigation, except where otherwise stated. Other sources are acknowledged by complete referencing. A reference list is attached.

- I hereby give consent for my dissertation, if accepted, to be available for photocopying and for interlibrary loan, and for the title and summary to be made available to outside organisations.

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ABSTRACT

The world's population is growing at an average of 1.2% per annum and forecasts see the global population reaching 9.6 billion by 2050. This places great demands on the sustained production capacity of agricultural organisations to meet the desperate need for nutrition. This problem will continue to persist if production methods do not evolve to improve production and quality.

Hydroponics and Controlled Environment Agriculture (CEA) was first seen in Rome during the 1st Century. Then sixteen Centuries later Greenhouses were developed in France and England as experimental hydroponics for basic laboratory research. Rapid expansion took place from about the 1950's in areas where traditional open-environment agriculture was difficult or impossible such as the deserts of Iran, Abu Dhabi and California.

Sixty-five years later in 2015 hydroponics and CEA are well established around the world with thousands of hectares under propagation. Hydroponics is a method of agricultural production that has been refined over the years to become an exact science. Through the application of technology and know-how the physiological processes within plants can be manipulated and controlled to produce superior results. These results require less land area and less water to accomplish.

It can be seen, based on this development, that hydroponics is such an evolution that has the capacity to meet the needs of a growing global population and its nutritional needs. The challenge lies, though, in the scientific understanding and application of knowledge in growing and managing a hydroponics farm.

This study seeks to determine the internal data and external information needs of farmers in the hydroponics industry. This data and information will be integrated into a Farm Management Information System (FMIS) model that will be used for decision making, report generation and documentation. The problem leading to this study is the dissemination of data and information sources that are currently underutilised and difficult to access.

In determining the internal data and external information needs, an empirical study was conducted using structured interview. Thirty farm managers were interviewed to assess what their current information system consisted of, whether they had a need for an FMIS and what internal data and external information was needed which related to four functional components of hydroponic farming. The results of this study indicate that there is a need for an FMIS for the hydroponic industry in South Africa. The results also indicate that managers are not fully satisfied with the performance of their current information system and would be interested in considering alternative information systems. Data points relating to the four functional components were assessed and integrated into an FMIS model for the hydroponic industry. This model sets out to integrate internal data and external information for purposes of decision making, report generation and documentation.

KEY WORDS: Farm Management Information Systems, FMIS, Information Systems, Hydroponics, Closed Environment Agriculture, CEA, South African Hydroponics Industry.

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LIST OF ABBREVIATIONS

BI	Business Intelligence
CEA	Closed Environment Agriculture
CGCSA	Consumer Good Council of South Africa
CIS	Current Information System
DoA	Depart of Labour
ETL	Extract Transform Load
FIM	Financial Information Management
FMIS	Farm Management Information System
FMIS	Farm Management Information System
FOM	Field and Operations Management
GDP	Gross Domestic Product
GMO	Genetically Modified Organism
HRM	Human Resource Management
ICT	Information and Communication Technology
MIS	Management Information System

1. SCOPE OF THE STUDY

1.1. INTRODUCTION

Chapter 1 introduces the study by giving background context and continues by identifying the problem statement, research questions and objectives. It establishes the significance of the research and breaks down the study into a framework on which this report will be based. Limitations to this research will be clarified, research ethics detailed and methodology mapped out.

Agriculture has been evolving rapidly, as have other industries and has incorporated more and more the elements of sustainability (Sørensen, *et al*., 2010). This evolution and progress has placed upon farm managers increasing demands with regard to operational requirements and efficiency in order to survive (Carli and Canavari, 2013). Amongst these requirements are those stipulated by government, retailers and financial institutions in the form of certifications, risk assessments, financing, health and safety records, environmental stewardship, etc. All of which amount to a large quantity of documentation and practices to ensure that businesses operate sustainably at company, national and global level (Sørensen, *et al*., 2011).

In addition to this, has been the development in farming since 1870, where agricultural production per unit of area has increased dramatically. During the 30 years preceding the year 2000 there have been phenomenal increases in production as a result of the development and utilisation of chemical and biological inputs, machinery and other mechanical technologies (Kaloxylos, *et al*., 2012). The last 15 years however, have seen the adoption, integration and usage of computer technology to further increase the efficiency and productivity of agricultural enterprises (Kaloxylos, *et al.*, 2012).

The Agricultural industry has therefore become extremely data intensive and the challenge created is that farmers are now faced with vast amounts of data. Data comes from different sources, in different forms, making it difficult to collate and use (Kaloxylos, *et al.*, 2012). As a result, information available to farmers is often inaccessible, unless copious amounts of time are put into collating and analysing all the information (Fountas, *et al.*, 2006).

The challenges require that farm managers utilise available technology to meet the various demands placed upon them. As a result of these developments, there is a growing interest in Farm Management Information Systems (FMIS). FMIS can provide benefits from increased connectivity, processing power and automation (Carli and Canavari, 2013).

Hydroponic production is a production technique, also known as closed environment or protected agriculture. It is a method of growing crops by using nutrient-enriched water in a plastic or glass greenhouse. The hydroponics industry is characterised by large establishment costs, high production per unit area and increased efficiency of water use. Coupled with these is intensive management of plant-growing conditions, labour, inputs and production. Key knowledge and skill are required by growers to incorporate the production factors to ensure successful production (Pandey, *et al.*, 2009).

Because of the characteristics of the hydroponics industry and the developments of information technology, a problem experienced by farmers is often, not the availability of information, but its organisation and collation. This collation allows ease of access and usability by farmers to meet the demands placed upon them. These demands require easy and efficient access to information that can be used for decision making, report generation and documentation.

A study done by Fountas, *et al.,* (2015) identified 11 generic function from 141 different FMIS software solutions. Software solutions that were all developed to meet the needs of farmers. Three of these components were identified to be the most important, listed below, with the inclusion of a function specific to the hydroponic industry. The four function are Human Resource Management, Financial Information Management, Field and Operations Management and Green-House Climate Control.

This study therefore seeks to establish the requirements of FMIS for the Hydroponics Industry by identifying the extent of the need for an FMIS, what the current information management practices are and what internal data and external information are important. The focus of the study in determining the requirements of the FMIS will be on the 4 functional areas identified above. These functions are:

1. **Field Operations Management:** This involves all the activities related to the growth and maintenance of crops in the greenhouses. Production planning, labour scheduling and monitoring, pest and disease management, etc.,
2. **Human Resources Management:** This involves the management of employees; their information, activities, performance, education, etc.,
3. **Financial Management:** This involves the financial aspect of the farm; costs, revenue, valuation of activities, input-output calculations, etc. and,
4. **Greenhouse Climate Control:** This involves the management of greenhouse environmental conditions; temperature, humidity and nutrition through the irrigations.

These 4 functions will form the base of the conceptual model. Due to them being the most important functions of a hydroponic farm enterprise.

1.2. PROBLEM STATEMENT

The problem being addressed, based on the above discussion, is that of dissemination of internal data and the dissemination of external information. There is also the problem of limited value of information and knowledge creation, information and knowledge that are vital for decision making, report generation and documentation.

> **Problem Statement:** *Information is not available for decision making, report generation and documentation as part of an integrated farm management system for the South African Hydroponic industry*.

In addressing this problem, the main research objective [Section 1.3] was formulated with the intention of building a conceptual model to overcome this problem. This model seeks to facilitate the flow of information, thus making it more accessible and easy to use with regard to decision making, planning and report generation.

1.3. RESEARCH OBJECTIVES

The primary objective of this research study is:

RO_m: *To develop a conceptual model for an FMIS for the South African Hydroponic Industry that will help to transform data into information and knowledge.*

Secondary objectives of this research study are:

RO_1: *Determine the significance of the South African Hydroponics Industry.*

RO_2: *Describe the environment in which farm managers operate.*

RO_3: *Determine the purpose to be fulfilled by an FMIS.*

RO_4: *Describe the current management of information.*

RO_5: *Determine what internal data and external information are required.*

RO_6: *Develop a conceptual model of an FMIS.*

1.4. RESEARCH QUESTIONS

The main research question is:

RQm – *What components are required in an FMIS in the South African Hydroponics Industry?*

In answering the main research question there are six following secondary questions:

RQ_1: What is the significance of the hydroponics industry in SA?

RQ_2: What factors are placing demands on farmers?

RQ_3: To what extent is there a need for FMIS?

RQ_4: What is the current status of information management in the hydroponics industry in S.A?

RQ$_5$: What components need to be included in the FMIS?

RQ$_6$: How can all the data and information be integrated into a conceptual model of an FMIS?

1.5. DELIMITATIONS OF RESEARCH

The research of this study will be limited to the hydroponic, closed environment or protected agricultural industry of South Africa. Further limitations will be that commercial establishments are both private and corporately owned.

1.6. SIGNIFICANCE OF THE RESEARCH

The significance of this research lies in the contribution that the management of information can make to the sustained development and survival of the hydroponics industry. It is an industry that has significant prospects because of its contribution to alleviating global challenges such as food insecurity, urbanisation, climate change, population growth and water scarcity.

In a 20 year longitudinal study carried out by Harris, *et al.* (2008) it was evident that a quality, management-information system (MIS) played an important role in the long-term survival of a business. With quality information available for managers, decisions being made every day had a long-term effect on the organisation's health (Harris, *et al.,* 2008). It can thus be seen that information within an organisation can be leveraged to assist with survival.

The cost of time involved in managing data outweighs the benefits of using it. This is specifically true when much of that management is tedious and manual repetitions of searching through various sources of information (Sørensen, *et al*., 2010). Consequently farmers and farm managers are not able to waste valuable time in their offices entering data and analysing information. Lawson, *et al*., (2011) pose the question whether an FMIS will reduce office time. By using available and advancing technology this is the aim exactly, to provide managers with accurate and timeous information when and where it is needed (Lawson, *et al*., 2011).

The importance of good information with regard to good management is identified in [Section 3.4.]. The technology available to facilitating information creation is available and constantly under development. From these two perspectives it can therefore be observed that information is important in managing technology and for creating information or accessing the information that is available. The following section describes how the research will be conducted to meet the research objectives.

1.7. RESEARCH METHODOLOGY

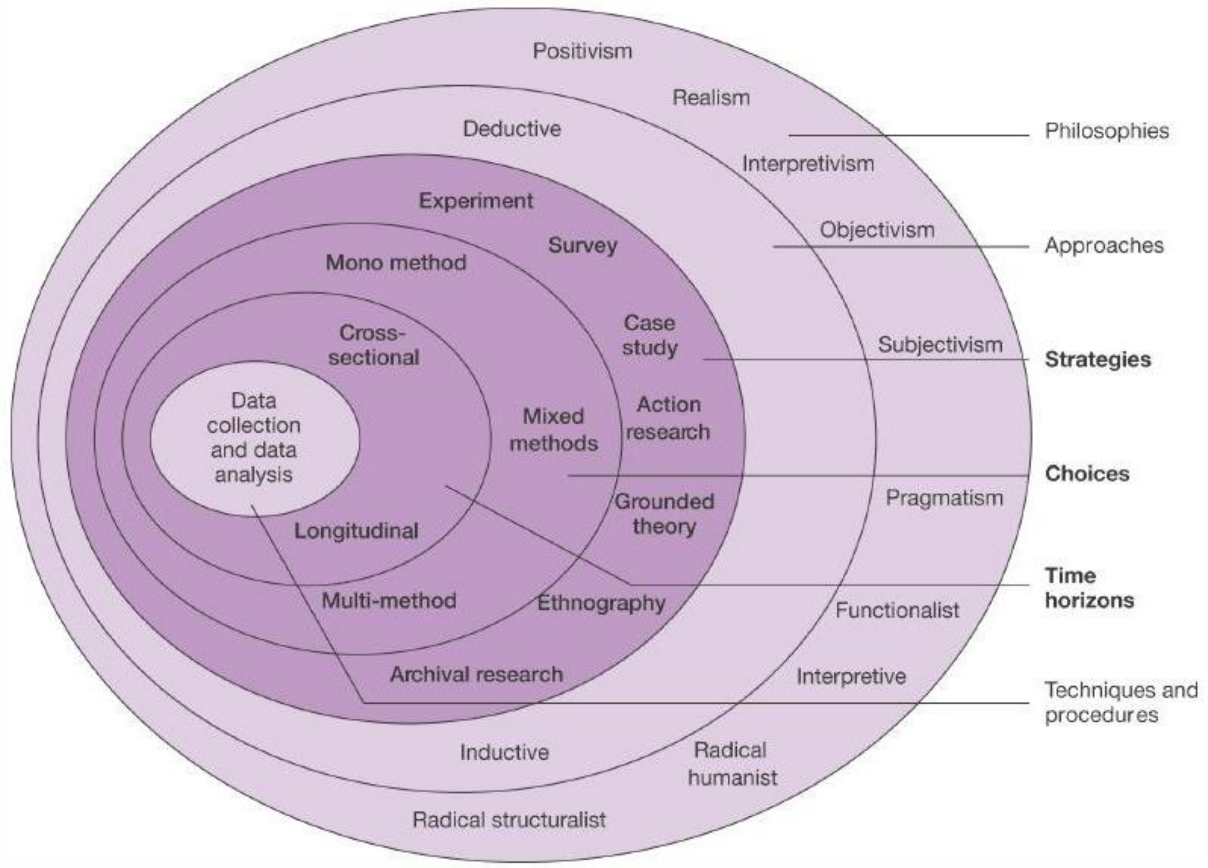
By using the 'research' onion approach proposed by Saunders and Tosey (2012) the research methodology will be determined. The 'research onion' approach is a model structure (Figure 1-1: Research Onion) incorporating research philosophies, approaches, strategies, time horizons and techniques and procedures.

The study will be conducted from an Interpretivistic view point. An Interpretivistic view point is characterised by the use of qualitative data. It takes into account the softer aspects of human nature and the mystery of complex social phenomena (Collis and Hussey, 2013). This can be seen from the nature of qualitative data being collected and analysed regarding the management and usage of data and information by farm managers. Research seeking to understand practices and view-points of the farm managers themselves confirms the Interpretivistic approach.

This study seeks to develop a conceptual FMIS model based on the collection and analysis of qualitative data. By working from empirical observation to theory development this study is described as an inductive study. Inductive, by definition, is developing theory from observations, working from broad to specific (Collis and Hussey, 2013).

Strategy used to collect the qualitative data has been done by means of a structured interview. The interview used a set framework of questions informed by literature. The structured interview was the only strategy used, thus making it a mono-method of data collection. The study was cross-sectional concluding that it was done over a fixed period of time as opposed to over a long period of time.

Figure 1-1: Research Onion



Source: (Saunders and Tosey, 2012)

The respondents in this study consisted of farm owners and/or farm managers in the hydroponics industry anywhere in South Africa. Selection and contact of participants was made by using the snowball sampling method, working from one individual to the next. Snowball sampling is described as a method in which the starting point is one farm manager who matches the participant criteria, through whom contact with others was made and so on (Collis and Hussey, 2013). This method was found to be suitable as farming communities in South Africa are well connected.

1.7.1. Literature Study

The literature study [Chapter 2] and [Chapter 3] provides an informed background and in-depth review of hydroponics in South Africa and FMIS. Important concepts and linkages are identified. All sources sought were fully cited and referenced in the final section of this study. The sources consulted were:

- Internet;
- Online databases;
- Books;
- Academic journal articles; and
- Industry Specialists.

1.7.2. Data Collection

Data was collected by means of a structured interview using a questionnaire informed by the literature study. The measurement instrument used had a combination of five-point Likert Scale questions ranging from 1 – 5 (Strongly Disagree – Strongly Agree, Not important – Very important) and open-ended questions. A sample comprising 30 farmers from the South African hydroponics industry represented the population under study.

1.7.3. Data Analysis

The data collected was analysed and statistically assessed to create information upon which the FMIS was based. The type of analysis consisted of predominantly descriptive statistics as is done with qualitative data.

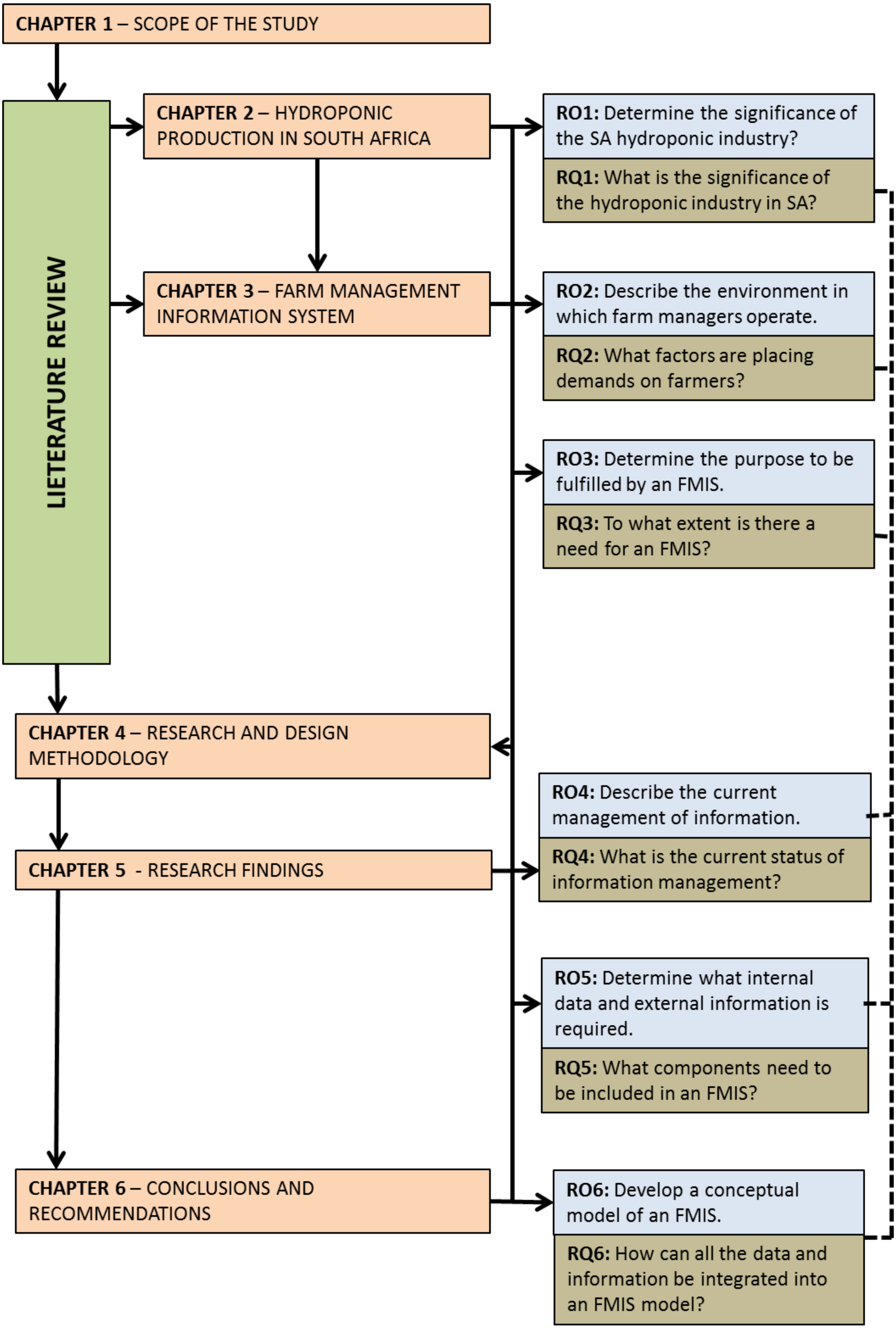
1.8. ETHICS CLEARANCE

The study does not involve any vulnerable population groups requiring full ethics clearance. The ethics clearance form was therefore submitted to the NMMU Business School for ethics clearance [Annexure C].

1.9. CONTENTS OF FINAL REPORT

Figure 1-2 shows the framework of this study. It displays the chapters and where the research objectives and questions will be addressed. Thereafter is an outline of the chapters to be addressed in this study.

Figure 1-2: Study Framework



Chapter 1: Scope of the Study. This section identifies the problem statement, research questions and objectives. It establishes the significance of the research and breaks down the study into a framework.

Chapter 2: Hydroponic Production in South Africa. This chapter will describe the global and national trends affecting the agricultural industry. By building on this it will identify hydroponic production as a viable production method for future growth. This chapter will address research question **RQ_1** and research objective **RO_1**.

Chapter 3: Farm Management Information System. This chapter introduces the key focus of this study including all key concepts as they relate to FMIS. It describes the transformation that the agricultural industry has gone through. It defines FMIS, data, information and knowledge. The chapter then identifies the purpose fulfilled by FMIS and the functional components of an FMIS. This chapter will address research objectives **RO_2, RO_3** and research questions **RQ_2, RQ_3.**

Chapter 4: Research Methodology. This chapter defines the way in which the study will be done in which paradigm it stands, the approaches and strategies it will use to accomplish its results and what tools will be used for analysis and presentation of results.

Chapter 5: Research Findings. This chapter presents the findings from the empirical study and draws conclusions upon which to base the conceptual model of an FMIS based on the four functions. This chapter will address research objectives **RO_4, RO_5** and research question **RQ_4**, **RQ_5.**

Chapter 6: Conclusions and Recommendations. This chapter concludes the research study in presenting a model of an FMIS for South Africa. The model was developed by bringing together both theoretical and empirical research. This chapter addresses **RO_6** and research question **RQ_6**.

1.10. SUMMARY

Chapter 1 introduced the study to the reader by providing background information as context leading up to the identification of the problem statement, research questions and objectives. It established the significance of the research and separated the study into a framework that this report will follow. Limitations of the research have been clarified, research ethical clearance detailed and methodology described.

The following chapter will provide a backdrop to the challenging global and local environment in which farm managers need to operate. It will then narrow down the focus to the hydroponics industry and hydroponic production. In conclusion, it will describe how hydroponics has significant potential for future agricultural production.

2. HYDROPONIC PRODUCTION IN SOUTH AFRICA

2.1. INTRODUCTION

Chapter 1 identified the scope of this study, moving from global challenges to the characteristics of the industry and its research objectives. It set out to establish the research framework and so position the research problem in the context of its surroundings; that is the dissemination of data within the hydroponics industry. This study seeks to identify the internal data and external information to be incorporated into an FMIS as it relates to four functional components in creating information and knowledge for managers in the hydroponics industry.

With reference to Figure 2-1, this chapter will identify key, global challenges [Section 2.2] as they relate to agriculture and their role in playing a significant part in policy creation and strategy development. The chapter will then continue by describing the South African agricultural industry [Section 2.3] to introduce local context and identify opportunities and problems as they relate to agricultural production. Finally, the specifics of hydroponic production [Section 2.4], and how it has the potential to meet the growing problem of food production arising globally and nationally will be described. This will be done by means of defining hydroponics and identifying the advantages and disadvantages as it relates to field production, and the problems associated with it. In concluding the chapter a description of future prospects [Section 2.5] for this technology and methods of production will be addressed.

The objective of the research is to determine the potential problems in food production which the hydroponics industry has in South Africa. Another objective is how to overcome global and local challenges and gaining from the opportunities. In doing so, the addressed objective $\mathbf{RO_1}$ is:

$\mathbf{RO_1}$ – Determine the significance of the hydroponics industry in South Africa.

In addressing $\mathbf{RO_1}$ the following question will be answered:

$\mathbf{RQ_1}$ – *What is the significance of the hydroponics industry in South Africa?*

The deliverable of this chapter is to link the hydroponics industry with global challenges within the local context of South Africa as an important industry for future growth. The purpose is to highlight the importance of hydroponic production.

Figure 2-1 Chapter 2 Outline

1. SCOPE OF THE STUDY

2. HYDROPONIC PRODUCTION IN SOUTH AFRICA
   - 2.1. INTRODUCTION
   - 2.2. GLOBAL CHALLENGES
     - 2.2.1. Climate Change
     - 2.2.2. Population Growth
     - 2.2.3. Urbanisation
     - 2.2.4. Food Security
     - 2.2.5. Water Scarcity
   - 2.3. SOUTH AFRICA SITUATION
     - 2.3.1. Agricultural GDP
     - 2.3.2. Decrease in Number of Farmers
     - 2.3.3. Productivity
     - 2.3.4. National Consumption
     - 2.3.5. Agriculture Industry Break-Down
     - 2.3.6. Horticulture
     - 2.3.7. Hydroponics
   - 2.4. HYDROPONIC PRODUCTION
     - 2.4.1. Definition
     - 2.4.2. Advantages
     - 2.4.3. Disadvantages
   - 2.5. FUTURE PROSPECTS
     - 2.5.1. Bright Farms
     - 2.5.2. Sky Greens
   - 2.6. SUMMARY

3. FARM MANAGEMENT INFORMATION SYSTEMS

4. RESEARCH DESIGN AND METHODOLOGY

5. RESEARCH FINDINGS

6. CONCLUSIONS AND RECOMMENDATIONS

2.2. GLOBAL CHALLENGES

The following section seeks to highlight the key global challenges that have an impact on agricultural production world-wide. These challenges have an influence on production techniques and highlight the need for additional production. Global challenges, from a strategic perspective, shape and mould policy practices and decisions continually.

2.2.1. Climate change

Climate change, as defined by the Intergovernmental Panel for Climate Change (IPCC), is the long term persistence of changes in climate that can be seen by changes in variances in mean temperature, precipitation, wind and other properties, whether by natural occurrence or by human influence (IPCC, 2007). The significance of these changes in light of agricultural production around the world impacts the following:

- **Growing seasons**: Growing seasons have been extended in some regions such as Asia and Africa (Ye, *et al*., 2015; Mueller, *et al*., 2015);
- **Production areas:** Worldwide, there have been geographical shifts and boundary changes of areas suitable for growing crops (Ye, *et al*., 2015; Machovina and Feeley, 2013);
- **Pest and disease zones**: Changes in climate will cause geographic shifts in pest and disease occurrences (Machovina and Feeley, 2013),
- **Water availability:** Shifts in precipitation, as a result of climate change and coupled with increased water consumption, have resulted in several regions around the world struggling with water insecurity (Schwank, *et al.*, 2014), and
- **Plant behaviour**: Sub-Saharan Africa produces 90% of its food from rain-fed agriculture. Climate change, in the form of heat waves, temperature fluctuations and changes in precipitation threaten the yield potential of these crops (Traore, *et al*., 2013).

2.2.2. Population growth

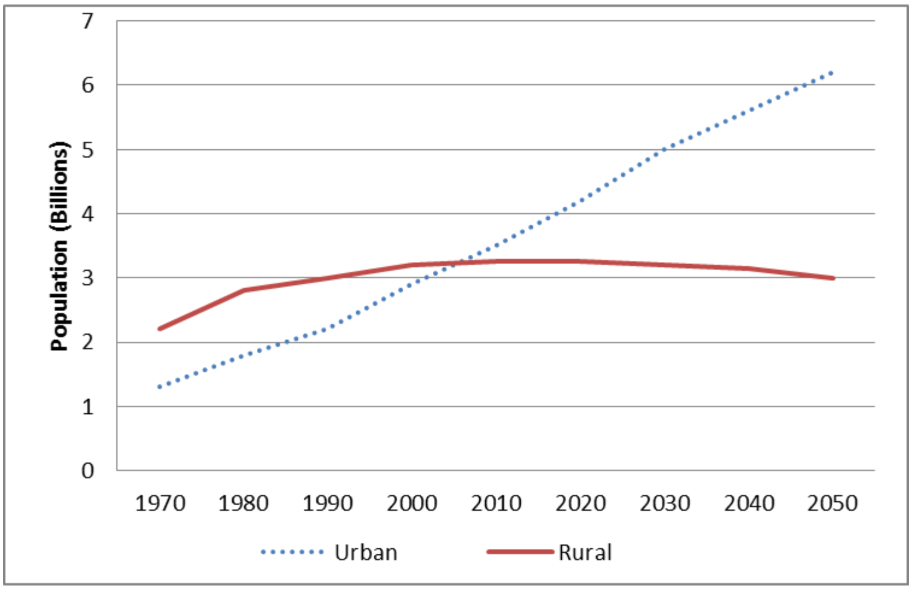
The world's population was estimated at the beginning of 2014 to be around 7.2 billion people with an average growth rate of 1.2% per annum. An additional 82 million people are added to the world every year. Forecasts see the global population reaching 8.1 billion by 2025 and by 2050 a world population of 9.6 billion (United Nations, 2014). The impact of this on agriculture is a continual rise in food demand which presents opportunities and also pressure for additional supply (Bureau for Food and Agricultural Policy, 2008).

2.2.3. Urbanisation

Urbanisation and its current growth is one of the greatest challenges of the twenty-first century. It presents significant opportunities for improved access to housing, education, health care and economic productivity. While these urban areas continue to attract a growing number of people, energy requirements increase significantly (Nahman, 2015). This energy strain requires good governance and sustainable urban planning (United Nations, 2014).

With regard to agriculture, there are two concerns: decreasing agricultural land because it is becoming urbanised and built up, rendering it useless for production, and large quantities of food that need to be transported into these urban areas (Nahman, 2015). Figure 2-2 illustrates how more than half the world's population resides within urban areas.

Figure 2-2: Urban and Rural Population



Source: (United Nations, 2014)

2.2.4. Food security

Food security is defined as all people having access to food at all times in order to live a healthy life (Department of Agriculture Forestry and Fisheries, 2014c). Food insecurity is a pressing issue that does provide an opportunity for agriculture. Between 2012-2014 there were 805.3million undernourished people around the world (FAO, 2014). In South Africa the number of individuals who struggle to obtain adequate food is 13.8 million people (Department of Agriculture Forestry and Fisheries, 2014c). Agriculture is the means of providing food security. It is claimed that unsustainable agricultural production, using methods that over-exploit natural resources like water and soil, negatively affect food security because of the decreased production capacity (Nahman, 2015). On the other hand, sustainable production techniques have the capacity to overcome food insecurity by increasing production.

2.2.5. Water Scarcity

Water is essential to agricultural production, to mankind and it also affects all living creatures in the world population (Hanjra and Qureshi, 2010). Shortages of water can severely cut production and negatively impact food security. It seems that these challenges create opposing problems. Food security is improved with the increased use of irrigation as described by Molden, *et al*. (2010), in describing how 40% of global food is produced from 19% of agricultural land because of irrigation. But Hanjra and Qureshi (2010) highlight the dilemma; that increased use of water elsewhere, for urban and industrial uses, has put pressure on water usage for agriculture. This, therefore, presents the need to improve water use with the end goal being increased food production, healthy ecosystems and improved income with less water use (Molden, *et al*., 2010).

2.3. SOUTH AFRICAN SITUATION

Section 2.3 will introduce the South African agricultural industry, showing first its contribution to Gross Domestic Product (GDP). It will go on to identify the trend of the decreasing numbers of commercial farmers and what role thia is playing. National consumption, the break-down of the industry and an introduction to hydroponics as a sub-industry of horticulture will be investigated.

2.3.1. Agricultures Gross Domestic Product

Agriculture's contribution towards South Africa's GDP in 2014 was R218 billion, up from R190 billion in 2013, although agriculture's contribution as a percentage to South Africa's GDP has declined. It has declined from 6% in the 1970's to 1.9% in 2013 (Department of Agriculture Forestry and Fisheries, 2014b). Although it is proportionately a small contributor to GDP, agriculture is a vital sector within the economy by providing job employment and foreign exchange earnings (Department of Agriculture Forestry and Fisheries, 2014b).

2.3.2. Decrease in Number of Farmers

Between 1993 and 2007 the number of commercial farms has decreased by 31% with a small decrease in the number of hectares farmed. These figures indicate a decrease in the number of farms but increase in farm size (Department of Agriculture Forestry and Fisheries, 2014a). This is due to the increasing difficulty to stay in the industry as a result of decreasing profit margins (Koos, 2015). Profit margins require stringent efforts with regard to productivity improvement and this is a factor which farmers are overlooking (Koos, 2015). The pressure is therefore clear on farmers to increase their productivity and improve their profit margins to stay in the industry.

2.3.3. Productivity

Continuous improvement in productivity is fundamental to long-term survival of farmers within South Africa due to rising costs and decreasing profit margins (Koos, 2015; Bureau for Food and Agricultural Policy, 2008). Farmers will have to make use of the following in order to improve their production efficiencies: (CGCSA, 2014)

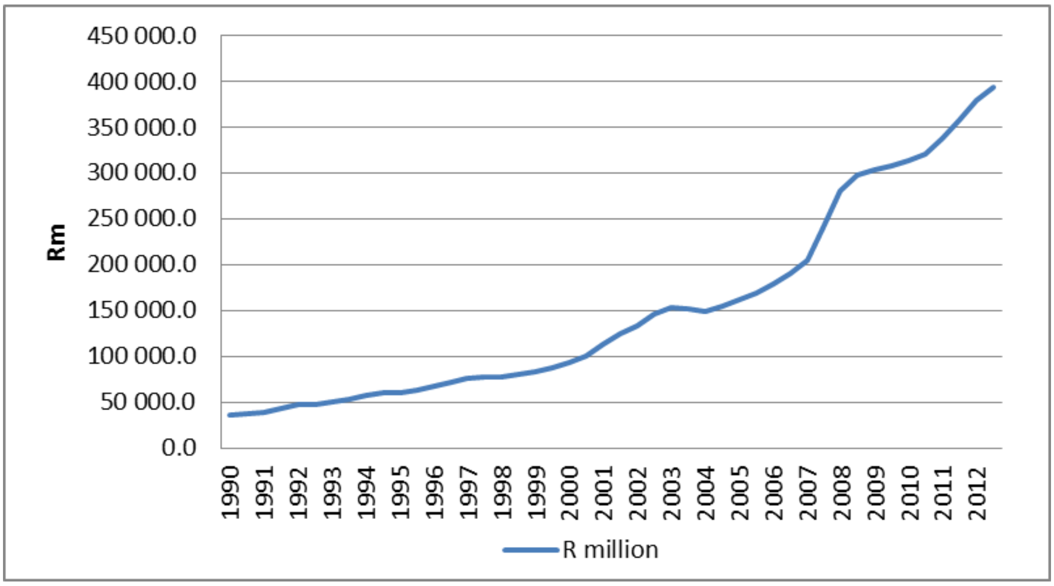
- Biological methods of production;
- GMO (Genetically Modified Organism) technology;
- Storages technology;
- Economies of scale; and
- Information technology.

2.3.4. National Consumption

South Africa's national private consumption is depicted in Figure 2-3. It shows how over the last 23 years, private expenditure on food has risen significantly. Since 1990 private consumption has increased 1 000%. This is due to:

- Inflation,
- Increased population, and
- Increased number of economically active people.

Figure 2-3: Private Consumption (Rm)

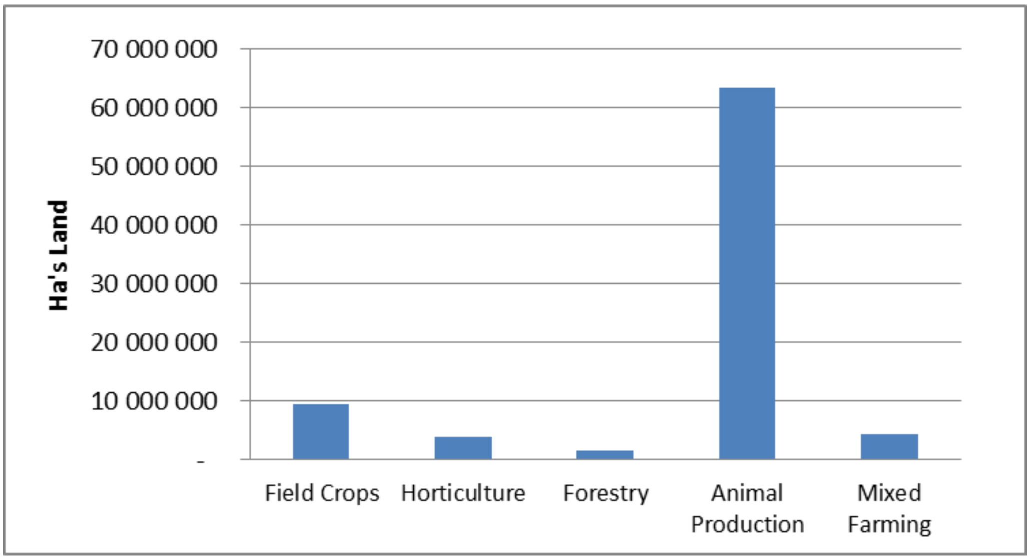


Source: (Department of Agriculture Forestry and Fisheries, 2014a)

2.3.5. Agriculture Industry Break-Down

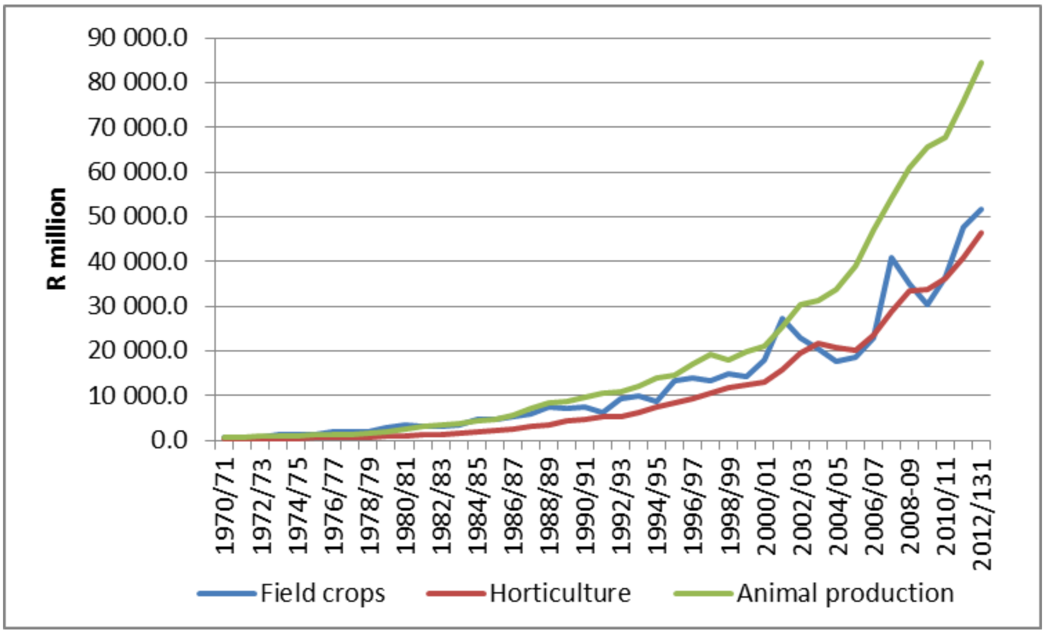
The South African agricultural industry is divided into five categories as can be seen in Figure 2-4. From the figure it can be seen that horticulture is relatively small in comparison to animal production and field crops in terms of hectares. With regard to gross value of the different industries Figure 2-5 shows the trend over the last 43 years of the different industries.

Figure 2-4: Agricultural Industry Break-Down



Source: (Department of Agriculture Forestry and Fisheries, 2014a)

Figure 2-5: Gross Value by Industry (1970-2013)



Source: (Department of Agriculture Forestry and Fisheries, 2014a)

Figure 2-5 shows that relative to its size, horticulture is an intensive industry and its value is on par with that of field crops even though area is less than half that of field crops. This distinguishes horticulture as a more intensive industry and animal production is a predominantly, but not exclusively, more extensive industry.

2.3.6. Horticulture

Hydroponics falls under the category of horticulture and contributed 27% of agriculture's GDP in 2013 (Department of Agriculture Forestry and Fisheries, 2014b). Horticulture is an intensive form of agricultural plant production. Intensive in terms of labour, investment and other inputs, it is confined to smaller portions of high, good quality land (International Society for Horticultural Science, 2015). Horticulture crops consist of products such as:

- Vegetables;
- Aromatic and medicinal foliage;
- Cut flowers;
- Ornamental grasses; and
- Vine fruits.

Production of South Africa's major vegetables increased by 75% between 1985 and 2013. The average prices of those major vegetables, listed in Table 2-1 as sold on major fresh produce markets has increased 183% in the same period. The gross value of the horticultural industry has increased 195% between 2001 and 2013 to R46 481 million (Department of Agriculture Forestry and Fisheries, 2014a).

Table 2-1: Major South African Vegetables

Potatoes	Gem squashes	Cucumbers
Tomatoes	Sweet potatoes	Lettuce
Cabbages	Cauliflower	Green peas
Onions	Green beans	Green mealies
Pumpkins	Hubbard squashes	Sweet Corn
Carrots	Beetroot	Marrows
Turnips	Butternut squashes	

Source: (Department of Agriculture Forestry and Fisheries, 2014a)

One of the main contributors towards the growth of this industry sector, Horticulture, is because of the growth of South Africa's population and an increase in the number of economically active people (Department of Agriculture Forestry and Fisheries, 2014a). South Africa's population has increased 181% since 1970 from 19 211 million people to 54 million people (Statistics South Africa, 2014).

2.3.7. Hydroponics

SA's hydroponic industry has grown significantly over the last decades. Hydroponics is an intensive form of horticulture. Section 2.4.1 defines what it is and how it is different to regular horticulture.

In SA, the number of greenhouse suppliers and companies selling greenhouse-related equipment has grown significantly. The greenhouse vegetable area, currently about 2 000 hectares, is increasing annually by about 10%. The major crops are tomatoes, peppers and cucumbers with most of the growth taking place in pepper and cucumber production. The average size of a greenhouse establishment is about 5 hectares concluding that there are about 400 greenhouse farmers (Enthoven, 2015).

Other crops grown in greenhouses consist of:

- Strawberries;
- Lettuce;
- Baby marrows; and
- Cherry Tomatoes.

2.4. HYDROPONIC PRODUCTION

Having introduced hydroponics within the context of SA and as a sub-industry of horticulture, this section introduces the details of hydroponic production. It provides a definition and its advantages and disadvantages. It then goes on to clarify how hydroponics is a good fit between the challenges that are being faced, nationally and globally. It will finally establish how this production technique is of significant importance in meeting growing nutritional needs under challenging circumstances.

2.4.1. Definition

Hydroponics is a soilless method of agricultural plant production that utilizes nutrient-enriched water and, but not exclusively, artificial mediums for root growth

(Department of Agriculture Forestry and Fisheries, 2011). Hydroponics is also predominantly practised under cover in greenhouses or tunnels where climatic conditions can be controlled. This production technique is otherwise known as Controlled Environment Agriculture (CEA) (Jensen, 2013). Closed environment means that the greenhouse/tunnel is a closed structure separating the internal environment from the external environment. Figure 2-6 illustrates a plastic covered greenhouse found in East London, South Africa. Figure 2-7 illustrates a plastic covered tunnel. The main difference between the two is the volume of air inside and the number of spans/sections. A Greenhouse is generally larger with multiple spans while a tunnel is smaller made up of single units. This separation from the external environment gives the growers, production managers, control over the growing environment of the plants, through a climate control system, and enables maximum production (Yin, *et al.*, 2014).

Figure 2-6: Greenhouse

Figure 2-7: Tunnel

Source: (Blueberry Hill Farm, 2015)

Climate control systems such as PRIVA and NUTRI-FLEX are popular in the South African market. These systems make it possible to control the greenhouse environment. This is done by establishing strategies or control parameters on a networked computer that controls certain activators within the greenhouse. These activators control greenhouse components such as the following:

- **Vents:** greenhouse windows that can be opened and closed to allow the movement of air. These are used to control temperature and humidity,

- **Wet wall:** a radiator type wall that has running water flowing over it, combined with the movement of air through it. This is used to control air temperature and humidity; and
- **Irrigation:** through a network of pipes, pumps and electric valves, water and nutrition is provided to the plants in the greenhouse.

The above mentioned components are instruments that are used to control the environment within the greenhouse. Depending on available capital there are additional components that incur additional costs.

2.4.2. Advantages

Hydroponic production, because of the closed environment, allows for the following advantages:

- **Speed of Growth**: Less growing time is required for production cycles due to less restriction on root growth as nutrients are readily available. In addition, light, temperature and humidity can all be controlled to a degree (Pandey, *et al.,* 2009). This allows for more production over shorter periods of time and increased turn-around times;
- **Water Use Efficiency:** Hydroponically grown plants use 1/20 the amount of water than conventionally grown outdoor plants. Water is conserved considerably more than by conventional agriculture (Jensen, 2013; Lakkireddy, *et al,.* 2012; Pandey, *et al,.* 2009). In light of water security and climate change this aspect is a great benefit;
- **Increased Yield:** Production per unit of area is significantly higher than conventional agriculture; (Department of Agriculture Forestry and Fisheries, 2011; Pandey, *et al.,* 2009). To satisfy increased nutritional needs is going to require significantly higher yields and hydroponics can produce these increases (Yin, *et al.*, 2014);
- **Possible Production:** As the plants are being grown under-cover in greenhouses, plants can be grown outside of their normal season as well as in areas where normal production would be impossible. Areas such as deserts, outer space and snow (Lakkireddy, *et al.,* 2012; Pandey, *et al.,* 2009)

In light of climate change, hydroponic production would not be limited or affected due to the closed environment; and

- **Less Space Requirements:** In comparison with conventional agriculture less area is required for production requirements. This is due to utilisation of vertical space and higher plant populations (Pandey, *et al.,* 2009). Due to the intensity of hydroponics, vertical space is used to increase production per unit area. It is therefore possible, with the increase in urbanisation, to use smaller spaces to produce larger quantities of food (Jensen, 2013).

2.4.3. Disadvantages

The disadvantages in hydroponic production, are the following:

- **High Establishment Costs:** Equipment, structures and inputs are necessary and expensive (Jensen, 2013; Pandey, *et al.,* 2009; Agricultural Research Council, 2001);
- **Skill and Knowledge:** Optimum production environment needs to be created and maintained by growers (Jensen, 2013). This is done by a clear understanding of the physiological needs of the plants and the tools available to meet those needs (Pandey, *et al.,* 2009; Agricultural Research Council, 2001);
- **High Risk:** Plants depend on the operation of pumps and other systems. If these fail to run for a certain period, production losses would be significant (Lakkireddy, *et al.,* 2012; Pandey, *et al.,* 2009); and
- **Mono-Crop:** Because plants all share the same nutrient solution in an enclosed environment, pests and disease are additional risks capable of significantly affecting production (Pandey, *et al.,* 2009).

Machovina and Feeley (2013) mention that it is theoretically possible to grow any crop anywhere. But there will have to be the input of light, temperature and water to make up for what the natural environment does not offer, and the greater the demand for inputs, the greater the economic cost (Machovina and Feeley, 2013).

2.5. FUTURE PROSPECTS

Having identified global and local challenges and defined how hydroponic production works, this section will identify, based on the above discussion, the prospective future of hydroponic production. It describes some trends that are gaining momentum in two established economies, namely Singapore and America.

2.5.1. Bright Farms

Bright Farms is an American-based company that finances, establishes and operates greenhouses for fresh produce retailers (BrightFarms, 2015). The company establishes long-term purchase agreements with the retailer and sells all the freshly grown produce to the retailer. The greenhouses are established in close proximity, some cases on the roof of the store, and thereby decrease the need for transport to move produce to the store (BrightFarms, 2015). This ensures a shorter supply chain and decreased fuel consumption which result in lower carbon emissions (Beier, 2015; Moss, 2014). The produce is said to be fresh from farm to table and supplied all year round to the satisfaction of the consumer (Crowley, 2015).

2.5.2. Sky Greens

Sky Greens is a Singapore-based farm that boasts of being the first low carbon, hydraulic driven farm (Sky Greens, 2014). Sky Greens has patented a vertical 'A' frame system up to 9 metres tall that has made significant improvements on per area production. By operating in a closed environment that circulates and recycles water efficiently, and it has achieved exceptional production in small spaces (Sky Greens, 2014). The company has also been given global awards for innovations in sustainability (Sky Greens, 2014).

Due to significant growth, yield and quality improvements, as stipulated above, in greenhouse farming, South Africa and the world, have seen the hydroponics industry grow significantly (Maboko, *et al.*, 2011; Department of Agriculture Forestry and Fisheries, 2013). With trends such as those in Singapore and America gaining momentum in the developing world growth, the industry is set to continue.

2.6. SUMMARY

Chapter 2 identified the background literature of the study. It introduced the management problem and outlined the research questions and objectives. Building from Chapter 1, this chapter identified key, global challenges that are influencing the agricultural industry world-wide.

To bring this into the context of SA, the local industry was described and further challenges were identified that are relevant to the players within the SA Hydroponics Industry. The hydroponic industry was then identified and described with reference to its advantages and disadvantages. Future prospects of hydroponic production were identified and linked with global and local challenges.

The objective of this chapter was to:

RO_1 – Determine the significance of the hydroponics industry in South Africa.

By addressing the research objective, the following question was answered:

RQ_1 – *What is the significance of the hydroponics industry in South Africa?*

The significance of the hydroponics industry in SA is that it is a growing industry with the potential to meet growing food security concerns more effectively, especially since yields are phenomenal. It is a labour-intensive method of production that has the potential to create jobs. It does not require large areas of land and can be done within or in close proximity to urban areas. With that comes the advantage of lower transport costs and better savings on costs.

The objective of the study was to determine how much potential hydroponics has for future production to meet the needs of a growing population despite varying challenges. The outcome of this chapter was to draw a link between global and local challenges and opportunities in the hydroponic industry, a production technique that is water efficient, does not need large areas, has significantly higher yields and a quicker growth cycles.

3. FARM MANAGEMENT INFORMATION SYSTEMS

3.1. INTRODUCTION

Chapter 2 identified the significance of hydroponic production in South Africa and how much potential it has for meeting local and global challenges. These global and local challenges, in many ways, present opportunities for the hydroponics industry to grow, due to increased efficiency in water use, high yields, space saving and climate-controlled environments. But like any business environment, there are challenges that require good management and decision making. In the context of this study, that challenge is the dissemination of internal data and external information. This study has set out to determine what components are required for a conceptual model of an FMIS for the South African hydroponics industry.

Chapter 3 builds on Chapter 2 by identifying how the agricultural industry has transformed over the last two decades in becoming data intensive [Section 3.2]. It provides a comprehensive definition of an FMIS [Section 3.3] and identifies some of the goals which it aims to attain [Section 3.4]. The chapter then identifies 4 generic functions [Section 3.5.], 3 that were selected from a list of 11 and 1 from exploring the hydroponics industry specifically. These components form part of an FMIS and will be described in detail as to what they're about and how they can benefit the manager. Lastly, Business Intelligence (BI) will be looked into as a basis upon which to possibly build a FMIS model.

Figure 3-1 shows the chapter outline and how these components fit in.

The objectives of this chapter are the following;

RO_2 – *Describe the environment in which farm managers operate.*

RO_3 – *Determine the purpose to be fulfilled by an FMIS.*

In fulfilling these objectives the following research questions will be answered:

RQ_2 – *What factors are placing demands on farm managers?*

RQ_3 – *To what extent is there a need for FMIS?*

The deliverable of this chapter is to identify the different factors that will contribute towards developing a conceptual model of a FMIS. The conceptual model of an FMIS will constitute an understanding of the research problem and how it can be solved through the design and application of an FMIS.

The chapter follows the course of a literature review, the findings of which will contribute towards establishing the questionnaire. A combination of structured interviews and questionnaires will be used in an empirical study [Chapter 4] using a survey.

3.2. TRANSFORMATION OF THE AGRICULTURAL INDUSTRY

A description of how the agricultural industry has been transformed to become data- and information-intensive as a result of various influences and economic pressures is detailed below. The transformation of this industry has made FMIS an important topic of research to assist in alleviating the heavy demands and challenges being placed on farm managers.

Agriculture, according to Rivera-Ferre and Ortega-Cerdà (2011), is a global activity and a complex system that has a significant impact on the lives of the world's population. This complexity consists of numerous variables as illustrated in Figure 3-2. This gives an idea of the many influences that farm managers have to take into account when making decisions and planning. It includes ensuring that all the interconnections are satisfied. Production methods have an impact on food safety and quality, research has an impact on new production techniques, and labour legislation is always changing. All these influences need to be monitored while carrying out daily activities. With this in mind, agriculture itself has the capacity to significantly influence people's livelihoods, water availability, the environment, economics and political decisions which make it an industry of great concern for all stakeholders, both producers and consumers (Rivera-Ferre and Ortega-Cerdà, 2011).

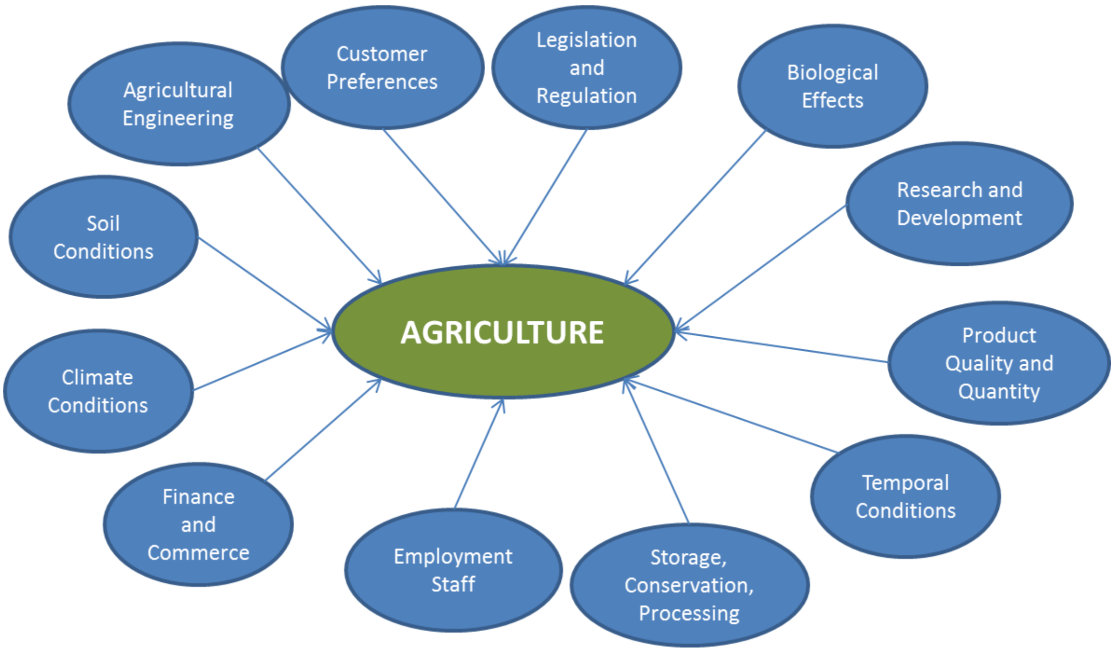
Figure 3-1: Chapter 3 Outline

1. SCOPE OF THE STUDY
2. SOUTH AFRICAN HYDROPONICS INDUSTRY
3. FARM MANAGEMENT INFORMATION SYSTEMS
   - 3.1. INTRODUCTION
   - 3.2. TRANSFORMATION OF THE AGRICULTURAL INDUSTRY
   - 3.3. DEFINITION OF AN FMIS
   - 3.4. PURPOSE OF AN FMIS
     - 3.4.1. Improve Farm Activities
     - 3.4.2. Reduce Uncertainty in Decision Making
     - 3.4.3. Facilitate Compliance
     - 3.4.4. Manage Overload of Information
     - 3.4.5. Reduce Office Time
     - 3.4.6. Create Operational Plans
     - 3.4.7. Generate Reports
   - 3.5. FUNCTIONS OF AN FMIS
     - 3.5.1. Field Operations Management
     - 3.5.2. Human Resource Management
     - 3.5.3. Financial Management
     - 3.5.4. Climate Control
   - 3.6. BUSINESS INTELLIGENC
     - 3.6.1. Data Sources
     - 3.6.2. Data Movement
     - 3.6.3. Data Mining
     - 3.6.4. Data Presentation
   - 3.6. SUMMARY
4. RESEARCH DESIGN AND METHODOLOGY
5. RESEARCH FINDINGS
6. CONCLUSIONS AND RECOMENDATIONS

Agriculture therefore, has an important role in society and there has been an increased focus on production methods and techniques from a policy and efficiency perspective (Sørensen, *et al*., 2011; Sørensen, *et al*., 2010; Fountas, *et al.*, 2006). The focus has moved from quantity to quality and sustainability. It incorporates the elements of ecological footprints, labour welfare, nutritional responsibility, plant and animal health and welfare, information transparency and economic responsibility as identified by Kaloxylos, *et al.*, (2012). While trying to meet these growing concerns of changing focus, pressure mounts from rising costs that challenge efficiencies and require costs to decrease while volumes still need to increase without compromising quality (Sørensen, *et al.*, 2011).

Because of the increased demands and responsibility placed on farm managers, coupled with developments in information and communication technology (ICT) Nikkila, *et al.*, (2010) state that ICT is vital in bringing together all the necessary components. These components are necessary to reduce uncertainty and ensure that good decisions are made by managers (Verdouw, *et al.*, 2015; Fountas, *et al.*, 2006). Real-time information would further increase the efficiency of decision making, and developments in ICT, according to Azvine *et. al.*, (n.d.) are making the modernisation of agriculture ever more possible.

Figure 3-2: Agricultural Influences



Source: Adapted from Munack and Speckmann, 2001, p. 3.

Farmers in recent years have started to collect copious amounts of data and information, relating to the components mentioned in Figure 3-2. There components are some of those factors placing demands on farm managers. Data collection, historically, was predominantly carried out manually and was paper based (Kaloxylos, *et al.*, 2012). Though there has been a shift and a large adoption of ICT, manual methods are still being used in some cases. Continued development in remote controlled and automated, sensory technology is set to increase even more (Kaloxylos, *et al*., 2012). Automated, sensory technology is the capturing, transforming and reporting of data by sensors such as a camera or temperature probes (Mahmoud, *et al.*, 2004).

Where previously farm managers may have made use of manual methods of information management, FMIS is allowing them to become more efficient as they have been given some relief from heavy tasks (Sørensen, *et al.*, 2010). There are still challenges, however, in utilising available information in such a way as to achieve defined objectives [Section 3.4] and help farmers to adopt new technologies (Fountas, *et al.*, 2006; Kuhlmann and Brodersen, 2001).

3.3. DEFINITION OF AN FMIS

The transformation of the agricultural industry has been described as a data-intensive industry. The following section will define FMIS and key terms relating to what it is and how it works. Data, information, knowledge and FMIS are key terms that will be defined.

FMIS as described by Fountas, *et al.*, (2015), Kaloxylos, *et al*. (2012) and Sørensen, *et al.* (2010) is the collection, processing, storage and dissemination of raw data into usable information. Sørensen, *et al.* (2010) specify further that information generated is used for the operational functions of the farm. This is confirmed by Fountas, *et al.*, (2015) who highlight the value obtained from an FMIS in its functional use for decision making.

For the purposes of this study, data refers to facts, figures, measures and statistical results referring to nameable entities (Beránková and Houška, 2011). Information on the other hand refers to data that has been organised, transformed or processed and made sense of in context (Beránková and Houška, 2011). Data is the atoms that make up the information (Logan, 2012). Knowledge refers to an ordered set of information in space and time regarding a certain field of expertise with the potential to be strategically used (Beránková and Houška, 2011; Logan, 2012).

From these definitions, an FMIS is an important component of an organisation contributing to supporting managerial decisions (Sørensen, *et al.*, 2010). It forms part of an organisation's toolset when it comes to data and information management. Unlike Enterprise Resource Planning (ERP) that has a broader set of management activities that seek to meet all the essential information needs of business processes, an FMIS focuses on managerial decision making (Sørensen, *et al.*, 2010).

3.4. PURPOSE OF AN FMIS

Building on the above argument it is clear that agriculture has become data intensive as a result of external and internal forces. It is also clear that FMIS is an available tool to be used in managing that data. This section introduces the purpose of an FMIS and identifies the need of managing information in such a way that allows its effective use for improved decision making. It is a process of decision making for farmers that involves a complex and integrated relationship of biological processes, perfect competition, meteorological occurrences, fixed supply of land and human resources.

3.4.1. Improve Farm Activities

This refers to a broad grouping of all the activities that take place on a farm and how they can become more efficient, cost less and produce more. It is through efficient management and use of this information that decision making and planning are based. By doing so, areas can be identified where yields can be maximised and costs can be minimised (Sørensen, *et al*., 2011). It is also stipulated that an FMIS can facilitate the improvement of economic returns and decrease the negative impact on the environment (Fountas, *et al.,* 2006). There is a growing source of literature describing the positive correlation between information in decision making and organisational/business performance (Brynjolfsson, *et al.*, 2011).

3.4.2. Facilitate Compliance

As a result of consumer awareness and agricultural development today, farmers are required to comply with quality, environmental, health, safety, labour and production standards (Verdouw, *et al.*, 2015). These standards are met through national and international compliance with certifications and audits. These often require reports, documentation and production data to be made available for certification audits. Some of these certifications, described below in Table 3-1, are GlobalGAP, HACCP and DAFF *(Sørensen, et al*., 2011).

Table 3-1: Certification Agencies

HACCP Hazard Analysis Critical Control Point	Global G.A.P. Global Good Agricultural Practice	DAFF Department of Agriculture, Forestry and Fisheries
Source: Google Images	Source: (GlobalG.A.P., 2015)	Source: (Department of Agriculture Forestry and Fisheries, 2014d)
Description:		
HACCP is a science-based system of hazard identification. It is a tool that examines hazards and determines methods of control with a strong emphasis on prevention. It is a set of international principles used by local companies to ensure safety.	GlobalG.A.P. applies research and industry collaboration to develop sustainable agricultural production standards. Standards that benefit the consumer, the retailer and the farmer. It is an international body with a strong global presence.	One of the functions of the department of agriculture under compliance auditing is to assess compliance. Compliance with applicable policies, regulations, procedures and laws.

Source: (GlobalG.A.P., 2015; Department of Agriculture Forestry and Fisheries, 2014; FAO, 1997)

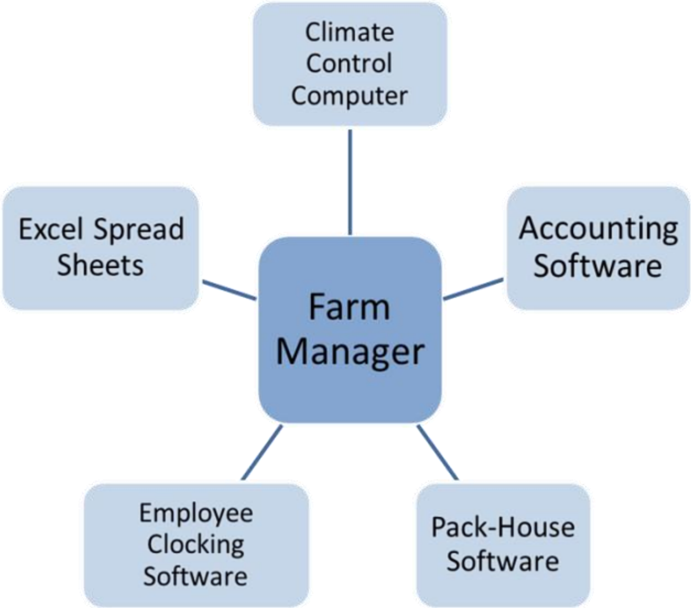
3.4.3. Reduce Uncertainty in Decision Making

Chapter 2 described global and national challenges facing agriculture today. These challenges influence the demands on farm managers to make more effective decisions. An FMIS, by the provision of readily available and relevant information, seeks to give support to more informed decisions (Kaloxylos, *et al.*, 2012). It is also by bringing all the relevant information together that informed decisions can be made (Nikkila, *et al.,* 2010). Data-driven decision making or decisions based on comprehensive information does, according to Brynjolfsson, *et al.,* (2011), decrease uncertainty and contributes positively towards influencing productivity and efficiency. Brynjolfsson, *et al.,* (2011) found in his study that there was a 5-6% increase in financial performance, productivity and market value as a result of data-driven decision making.

3.4.4. Manage Overload of Information

Section 3.4.4 discusses having excessive amounts of information derived from varying sources, such as proprietary software packages, all serving varying needs (Kaloxylos, *et al.*, 2012). This excess of information creates the challenges of making sense from all the available information. Fountas, *et al.* (2006) mention on this point, that progress will not be hindered by the availability of data or information but rather by the capability of identifying its relevance, usefulness and importance. Kaloxylos, *et al*., (2012) emphasise on the need to have data available to identifying what data is needed for business intelligence (BI) to draw the appropriate connections between decision making and data in creating valuable information for decision making. This is one of the goals of an FMIS, to efficiently bring together all the relevant data and information to be used in the management of a farm and its daily functioning. Figure 3-3 depicts some of the proprietary software challenges of data being disseminated and in over supply in the hydroponic industry.

Figure 3-3: On farm proprietary software



Source: (Kaloxylos, *et al.*, 2012)

3.4.5. Reduce Office Time

Due to the significant amount of data and information available, farmers often lack the necessary time to manage that data or information, or, are reluctant to invest the time required to manage the data and information (Fountas, *et al.*, 2006). Sørensen, *et al*. (2010) go further and introduce the concern of how much it costs to manage all the data, the economic benefit of which is outweighed if it takes too long. But with the additional processing capacity and semi-autonomous capabilities of FMIS, data and information management can be streamlined thus decreasing office time (Sørensen, *et al.*, 2010). Semi-autonomous capability is the automation of manual functions done by a computer system (Sørensen, *et al.*, 2010). Such capabilities would be the integration of information from different sources as opposed to manually bringing it together by means of re-capturing or having to manually move it from one application to another using by copy and paste.

3.4.6. Create Operational Plans

The objective of farm management, according to Kaloxylos, *et al*. (2012), is to make a living by operating and organising a farm whilst complying with traceability, global trade, consumer requirements, politics and environmental concerns. As defined earlier, an FMIS collects, processes, stores and disseminates data and one of the outputs of an FMIS is strategic and operational planning (Kaloxylos, *et al*., 2012; Sørensen, *et al.*, 2010). An FMIS provides information on what is taking place within an organisation and it is from the basis of this information that strategic and operational plans can be monitored and controlled (Kruize, *et al.*, 2013).

3.4.7. Generate Reports

Reporting was identified by Fountas, *et al.* (2015) to be the second most important role of an FMIS. Providing managers with current information in a presentable and summarised form is vital to the usefulness of an FMIS (Carli and Canavari, 2013). Through the processing capabilities of an FMIS, large data sets can be reported on and, at times, allow for customisation of reports. Customisation allows the user to make specified queries of the data sets (Carli and Canavari, 2013). Report generation is the output of the FMIS and will be further addressed in Section 3.5.

3.5. FUNCTIONS OF AN FMIS

This section identifies the functions that an FMIS should include to provide information to the farmer. Functions used in this context refer to data and information regarding a specific, functional area of the farm. For example, those listed in Table 3-2. Of the functions listed, four functions are further discussed with relevance to this study with a view of developing a conceptual model of an FMIS for the SA hydroponics industry.

Specific data, generated from within a company and relating to these functions will be identified. Specific information, obtained from external entities, will also be identified. These, internal data and external information sources, will be portrayed in a table accompanying each function. It is from these specific components that information, meaningful to decision makers, is synthesised.

Fountas, *et al.,* (2015) compiled a study on commercial FMIS and found 141 software solutions from 75 different software vendors across Europe, the United Kingdom and Australia. From these he identified 11 generic functions, listed in Table 3-2, that summarise the different services offered to the farm manager.

Table 3-2: Generic Functions of FMIS

FUNCTION	DESCRIPTION
Field Operations Management	Farm activity record keeping; assisting with crop planning for future activities; comparing actual and planned execution of activities; preparation for deviances.
Best Practice	Production methods and activities based on agricultural standards.
Finance	Cost estimations of farm activities; input-output calculations and labour projections. Evaluations of a farm's economic activity.
Inventory	Management and monitoring of all equipment; chemicals; seeding materials; production materials and planting materials; Incorporated into farm plan and adjusted accordingly.
Traceability	Crop recall; tracing product to source field and crop. Traceability to chemical application; fertiliser usage; labour activities; etc.
Reporting	Farm report creation; management plans; progress sheets; purchasing orders and plant information.
Site Specific	Mapping features for field data; guided application of inputs with variable rate technology. Objective of this function is optimising input and output relationship.
Sales	Includes customer order management; packing and accounting systems; inter-enterprise transfers; service charges; labour costing; suppliers and equipment costs.
Machinery Management	Equipment usage; downtimes; cost per week/unit. Fleet management and logistics.
Human Resource Management	Employee management; employee availability assessment; structured issue handling; work time checks; payment management; qualification; training; work performance and knowledge or expertise status.
Quality Assurance	Production evaluation and process monitoring based on legislative frameworks.

Adapted from: (Fountas, *et al.*, 2015)

The eleven generic functions of FMIS listed in Table 3-2: Generic Functions of FMIS all have relevance in varying degrees. Three of the most important have been selected plus an additional one specific to hydroponics production have been selected for this study. The 3 components selected from the list have been chosen for a specific reason. Hydroponics is management intensive therefore field and operations management have been selected. Financial performance of any organisation is vital for business survival and, as mentioned in Section 2.3.2, the number of farmers is decreasing due to business failure resulting from increasing costs and decreasing prices. Human resource management has also been selected as hydroponics being labour intensive. The last function, not included in the list of generic functions, is greenhouse-climate control which is another very important aspect of hydroponics. It is upon these 4 functions that further research will be done. The 4 selected functional areas are namely: Field Operations Management, Human Resource Management, Finance and Climate Control. These 4 selected functions will be further discussed and the data components identified for purposes of information generation. These data components will be detailed in Tables 3-3, 3-4, 3-5 and 3-6.

Each table lists the internal data that is internally generated, and external information that is externally sourced. The lists of data in Tables 3-3, 3-4, 3-5 and 3-6 have been gathered by means of enquiring from managers what data is possible, and needs to be gathered.

3.5.1. Field Operations Management (FOM)

Field operations management entails the every-day operational aspects of the farm. It involves the allocation of resources, such as labour, machinery and equipment. It involves planning and implementation of strategies and ensuring that regulatory requirements are met with regard to policies and procedures.

Table 3-3 shows some of the data requirements for this function that require recording and analysis. Recording and analysis are necessary for regulatory requirements, for example chemical application data for traceability. Traceability is the mechanism whereby, upon request, all activities relating to a particular product at a particular time can be recalled. Traceability is a growing concern in identifying quality and quantity deviations and accountability reporting (Mcbratney, *et al.,* 2005).

Table 3-3: Components of FOM

INTERNAL DATA	EXTERNAL INFORMATION
Labour Allocation.	Technical Assistance: Agronomists, consultants, etc.
Work Plans.	Training: External Training and Development.
Production Volumes.	Suppliers: Production Information, medium, seed, plastic, etc.
Chemical Application Records.	Accreditation institutions: GlobalGAP, HASSP, Faire Trade, etc.
Fertilizer Application Records.	Study Groups
Harvesting Data.	
Pest and Disease Levels.	
Plant Growth.	
Variety Performance.	
Fuel Usage.	
Machinery Maintenance.	
Harvest Quality: 1st, 2nd, 3rd and waste.	
Electricity Consumption.	
Crop Performance: Lettuce, Tomatoes, Peppers, etc.	
Production Plan: Production forecast or production budgets.	

3.5.2. Human Resource Management (HRM)

Human resource management in traditional, individually run, privately owned farms is generally manual. But the labour market is rapidly changing with new demographics and tighter constraints, unionisation, national wage hikes etc. It is becoming a great risk for farm managers to avoid organising their human resource. It is necessary from a strategic perspective, to increase the value of the employee's contribution to the farm through different management and compensations practices (Grobler, *et al*., 2013). This is done to ensure, as much as is possible from an HR perspective, long-term sustainability and to make sure the organisation remains within the legal bounds of operation and performance.

Table 3-4 identifies some of the data and information requirements of the HRM function (Department of Labour, 2008; Department of Agriculture Forestry and Fisheries, 2006). Data that is required by the Department of Labour (DoL) needs to be held on the premises for reporting and documentation for at least 3 years (Department of Labour, 2008). It is also to the benefit of the company to hold the following employee records for purposes of evaluations. These evaluations can contribute to better performance.

Table 3-4: Components of HRM

INTERNAL DATA	EXTERNAL INFORMATION
Employee Personal Details	Department of Labour
Employee Performance	Employment Equity
Employee Disciplinary Record	Trade Unions
Employee Attendance Record	Government Incentives
Job Descriptions	
Employee Contracts	
Hours Worked	
Employee Employment History	
Details of Terms and Conditions	
Pension records	
Record of Training and Development	
Record of Trade Union/Employee Representative Meetings	
Contract Termination Records	
Employee Rates	
Skill Levels	
BEE Status	
Health and Safety Records	

3.5.3. Financial Information Management (FIM)

Financial management, according to Barry, *et al.*, (1983) is the attainment and utilisation of resources by a farm or business and the safe keeping of its equity capital from financial and business risk. Management accounting as defined by Seal *et al.*, (2012) is the recording, estimating, organising and summarising of financial data for the purpose of managerial use in decision making. Management accounting, therefore, in its application here strives to meet the objectives of financial management described above. Seal *et al.*, (2012) further emphasise the need for managers to have access to data that is flexible for analysis and relevant. Timeliness and detail according to activity, department, product, employees or customers are also requirements for good management accounting (Seal, *et al.*, 2012).

Table 3-5 show some of the data requirements of the FIM function.

Table 3-5: Components of FIM

INTERNAL DATA	EXTERNAL INFORMATION
Capital Expenses: Buildings, Machinery, equipment.	Foreign Exchange Rates
Cost of Sales: Fertilizer, medium, chemical.	Bank Interest Rates
Labour Costs	Suppliers: Price changes
Sales Prices	Bank
Sales Volumes	Government: Minimum Wage Determination.
Marketing Costs	SARS: New tax legislation
Administrative Costs	Political Environment
Over-Head Costs	Social Environment: Strikes, attacks, etc.
Machinery Performance: Repairs and Maintenance.	Economic Indicators: Rand value, trends, etc.
Cash Flow	
Budgets	

When it comes to direct and activity-based costing Carli and Canavari (2013) reported that traditional systems are insufficient to meet the growing needs of farmers to efficiently manage and reduce their costs. Direct costing refers to costs that can directly be allocated to a particular product. It is the practice of assigning variable costs to a product. Activity-based costing assigns costs to activities and resources based on the measurement of performance. It then assigns the costs to a product (Carli and Canavari, 2013). The logic of this approach, as motivated by Carli and Canavari (2013), is to give managers a firmer level of control on how resources are consumed/used and how they generate costs.

3.5.4. Greenhouse Climate Control (GCC)

Table 3-6: Components of GCC

INTERNAL DATA	EXTERNAL INFORMATION
Greenhouse/tunnel temperature	Professional technical assistance
Greenhouse/tunnel humidity	Training and development
Outside temperature	Weather forecasts
Wind speed	
Wind direction	
Solar radiation	
Quantity of water given	
Quantity of over-drain	
EC and pH of water given	
EC and pH of over drain	
CO^2 levels inside greenhouse	
Light levels inside greenhouse	
Water Quality	
Moisture levels	
Slab/pot weights	
Over drain percentage	
Heating temperature	
Irrigation start and stop times	

Greenhouse climate control entails the monitoring and recording of the greenhouse environment. Thus, recording and monitoring is necessary for strategy, development and implementation. This function of an FMIS is important for greenhouse management. As the growing environment of the crops can be controlled, this aspect has a significant impact on plant growth.

Table 3-6 identifies some of the components required for the GCC function. It lists the two most important aspects of climate, temperature and humidity, both of which have a significant impact on plant performance.

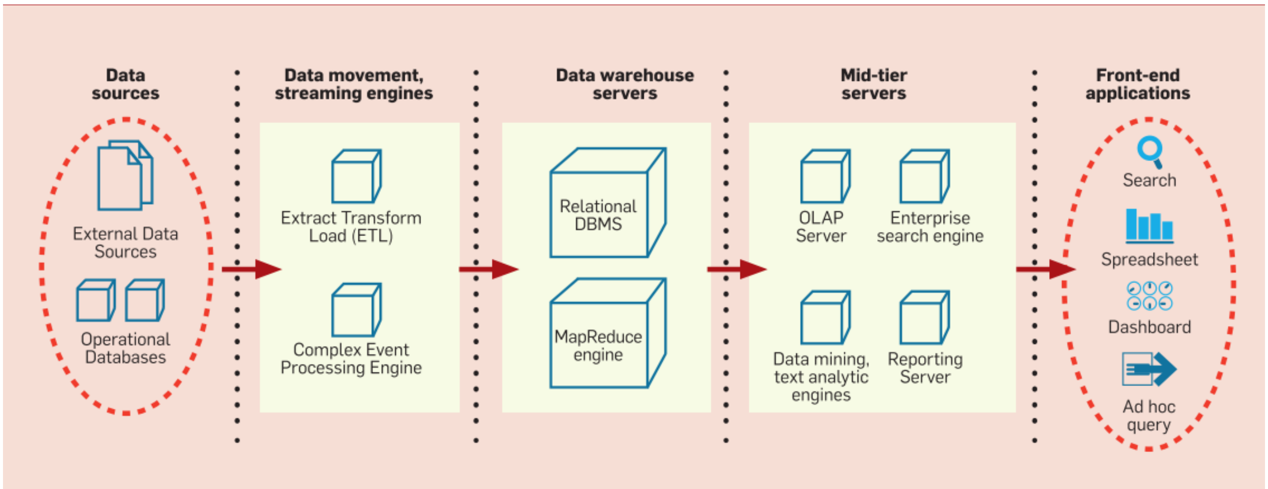
Some of the needs of these functions are currently being performed by proprietary software solutions. These, in other words, are software packages developed by a software company to meet the specific needs of an individual function, such as finance. As mentioned earlier, this is one of the contributing factors that make the dissemination of data and information difficult to use. There is a number of proprietary software packages meeting different needs, but the packages are incompatible with one another. In addition to these proprietary software packages is the use of Microsoft applications such as Excel and Word. These again add to the over-dissemination of data with multiple spread sheets and word documents containing important information being dispersed all over a farm desktop PC.

3.6. BUSINESS INTELLIGENCE

Business Intelligence (BI) as described by Rouhani, *et al.* (2012) is a systemised process whereby information is obtained, analysed and distributed for operational decision making within an organisation. Important components as seen in Figure 3-4: BI Architecture are the data sources which are external and internal (operational). Extract, Transform and Load (ETL) is the movement of data from the sources into a centralised database or server (Chaudhuri, *et al.*, 2011). Data mining which forms the analytical part of transforming data into a presentable and useful format (Talati, *et al.*, 2012). And the front end application which gives the user/manager access to the data/information upon which to make decisions (Hostmann, *et al.*, 2009).

BI has been identified in the business world as a necessary strategic capability the needs to be developed (Raber *et al*., 2012). Especially in the agricultural industry, as the industry continues to be transformed and IT is becoming more integrated, there is a great need to develop BI. Important because BI promises the transformation of data into knowledge (Niu and Zhang, 2008). The hydroponics industry needs to developed BI as a strategic capability for long-term sustainability. Components of a BI model consist of: Data Sources, Data Movement, Data Warehousing, Mid-tier Servers and Front End Applications.

Figure 3-4: BI Architecture



Source: (Chaudhuri, *et al.,* 2011)

3.6.1. Data Sources

As the focus of this study there are various sources of data, both internal and external. External information that has already had some processing and internal data that still requires processing. Fountas, *et al.* (2006), as earlier mentioned, highlights that progress will not be hindered by a lack of information but by the inability to utilise it. The importance of data sources credibility and quality contributes to the success or failure of the system (Dawson and Van Belle, 2013).

3.6.2. Data Movement

An important aspect of a BI models is the centralisation of all the data, and this is accomplished by extracting, transforming and loading (ETL) that data from various sources into one central data base (DB) (Asghar *et al.*, 2009).

3.6.3. Data Mining

Data mining uses various tools to analyse the data stored within the central DB (Raber *et al.*, 2012). This is done to identify hidden trends amongst all the data sources (Asghar *et al.*, 2009). Trends that would add value in creating knowledge that can be applied in the operating environment.

3.6.4. Data Presentation

Analysed data and trends are then presented through tools such as dashboards in a visually appealing format. This allows ease of viewing complex phenomena that managers can then work with (Asghar *et al.*, 2009).

In a cognitive BI model developed by Niu and Zhang (2008) it was mentioned that all the right data and information, clearly and effectively presented, in itself is not sufficient for successful decision making. What is required above all the available data is a clear and consistent view of the over-all situation in identifying critical success factors and how these factors fit into the big picture (Dawson and Van Belle, 2013).

Simmers (2004) takes a different route in developing a model that emphasis stakeholder value as an important point of concern when it comes to steering decision outcomes. Through the amalgamation of various data sources for analysis and knowledge creation Simmers (2004) asks the question of what link is there between BI and value creation for the stakeholders.

From these 2 models, with a basic understanding of BI, it can be identified that application of knowledge is more important than the accumulation of information. And that knowledge has a place in an operating environment that affects a number of key players. To accumulate data for purpose of knowledge and value creation is the objective of a good BI model.

3.7. SUMMARY

Due to the advantages of hydroponic production, amidst global and local challenges, it is possible to achieve higher yields from smaller areas. With increased efficiency of water use, high yields, space saving and climate-controlled environments it is possible to do hydroponic farming anywhere sustainably. But like any business environment, there are challenges that require good management and decision making. In the context of this study, that challenge is the dissemination of internal data and external information. This study has set out to determine what components are required for a conceptual model of an FMIS for the South African hydroponics industry.

This chapter built on Chapter 2 and identified how the agricultural industry has been transformed over the last decades to become data intensive. It provided a comprehensive definition of FMIS and identified the purposes for which it is designed: The chapter identified 3 generic functions, out of a list of 11, plus 1 additional function specific to the hydroponics industry. These generic functions were described and detailed according internal data and external information components. These are the data and information components that will make up the conceptual model of an FMIS.

The objectives of this chapter were the following;

> **RO_2** – *Describe the environment in which farm managers operate.*

> **RO_3** – *Determine the purpose to be fulfilled by a FMIS.*

In meeting these objectives the following research questions were answered:

> **RQ_2** – *What factors are placing demands on farm managers?*

> **RQ_3** – *To what extent is there a need for FMIS?*

The factors placing demands on farm managers are important to understand because of their challenges and/or problems. This then identifies whether an FMIS will be of assistance in overcoming some of those challenges.

The deliverable of this chapter was to identify the different components that would contribute towards developing a conceptual model of an FMIS. The conceptual model of an FMIS would constitute an understanding of the research problem and how it could be solved through the design and application of an FMIS.

The findings in this chapter were determined by a literature review. These finding have contributed towards the compilation of a structured interview by means of which an empirical investigation will be carried out.

4. RESEARCH DESIGN AND METHODOLOGY

4.1. INTRODUCTION

Chapter 1 and Chapter 2 introduced the study and identified key challenges and opportunities that exist in a local and global context:

LOCAL

- Agriculture GDP
- Decrease in Number of Farmers
- Productivity
- National Consumption

GLOBAL

- Climate Change
- Population Growth
- Urbanisation
- Food Security
- Water Scarcity

The challenges and opportunities listed above play an important role because of their influence on policy and decision making, that affect the agricultural industry. Chapter 2 also introduced the horticultural industry and hydroponics. Hydroponics, also known as intensive horticulture, has a significant role to play in addressing challenges and opportunities.

Chapter 3 introduced FMIS and provided comprehensive definitions of key terms. Chapter 3 also described how the agricultural industry has been transformed to become data intensive. It is data intensive as there is an increased need for and use of data and information from varying sources. Thus data and information need to be employed for the benefit of decision making.

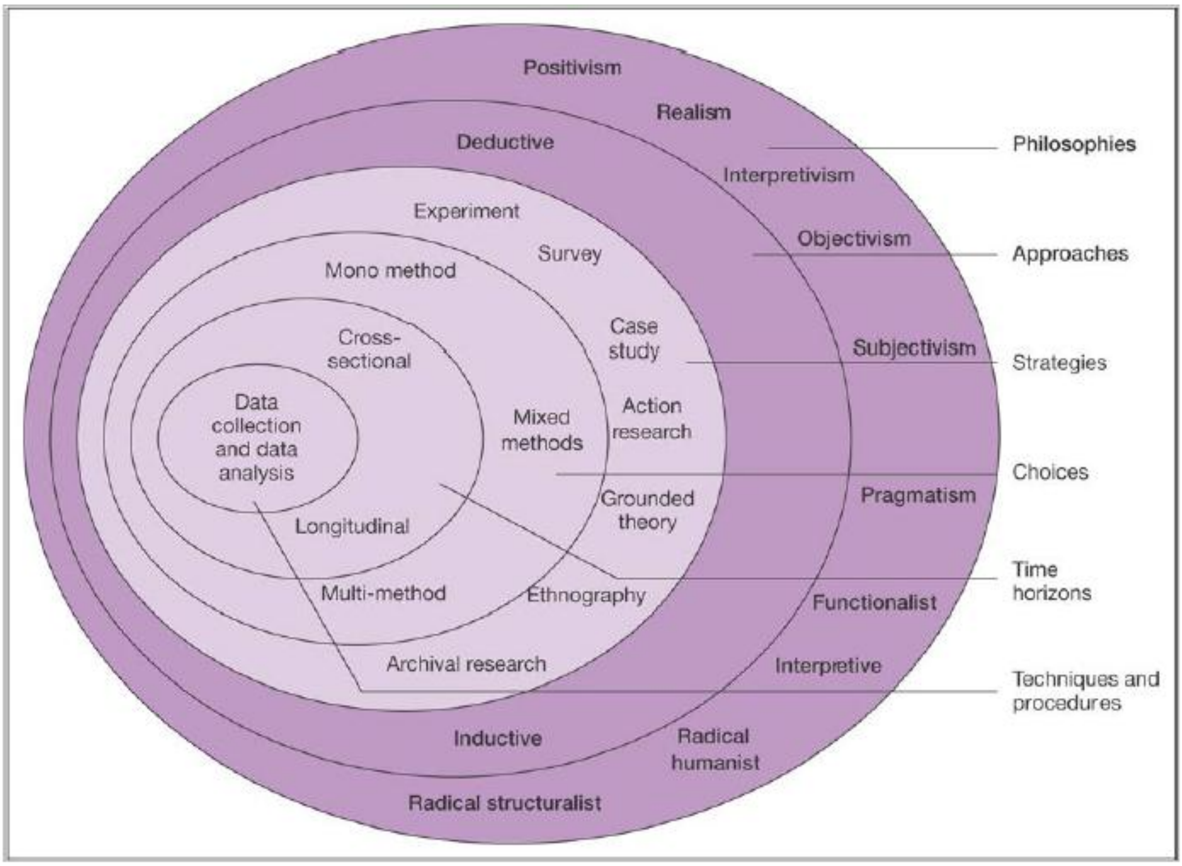
In the context of this study, it is the dissemination of internal data and external information that needs to be addressed. This study has set out to determine what components are required for a conceptual model of an FMIS for the South African hydroponics industry.

Chapter 4 will describe the research design and methodology followed to conduct this study. It will refer to the 'research onion' depicted in Figure 4-2. Figure 4-1 contains the outline of this chapter and identifies the different sections to be discussed.

Figure 4-1: Chapter 4 Outline

1. SCOPE OF THE STUDY
2. SOUTH AFRICAN HYDROPONICS INDUSTRY
3. FARM MANAGEMENT INFORMATION SYSTEMS
4. RESEARCH DESIGN AND METHODOLOGY
   - 4.1. INTRODUCTION
   - 4.2. RESEARCH PHILOSOPHY
   - 4.3. RESEARCH APPROACH
   - 4.4. RESEARCH DESIGN AND STRATEGY
   - 4.5. TIME HORIZON
   - 4.6. TECHNIQUES AND PROCEEDURES
     - 4.6.1. Empirical Study
       - 4.6.1.1. Sample Design
       - 4.6.1.2. Data Collection
       - 4.6.1.3. Data Analysis
       - 4.6.1.4. Reliability and Validity
         - 4.6.1.4.1. Reliability
         - 4.6.1.4.2. Validity
   - 4.7. SUMMARY
5. RESEARCH FINDINGS
6. CONCLUSIONS AND RECOMMENDATIONS

Figure 4-2: Research Onion



Source: (Saunders and Tosey, 2012)

4.2. RESEARCH PHILOSOPHY

Research philosophy is the personal view held by the researcher of what, in his or her opinion, constitutes the acceptability of knowledge. Inclusive in a researcher's philosophy is the process that is responsible for developing that knowledge (Saunders and Tosey, 2012). Collis and Hussey, (2013) mention a research paradigm that is described as a philosophical framework. This framework guides the process of scientific research and how it should be conducted.

In Figure 4-2 a number of research philosophies are listed:

- Positivism
- Realism
- Interpretivism
- Optimism
- Subjectivism
- Pragmatism
- Functionalist
- Interpretive
- Radical Humanist
- Radical Structuralist

Each philosophy or paradigm, according to Collis and Hussey, (2013) falls on a continuum of paradigms, Figure 4-3, between positivism and interpretivism. Positivism is defined as a more objective paradigm and argues that phenomena are exterior to the research and cannot be influenced by the act of investigation (Collis and Hussey, 2013). Positivism is normally associated with quantitative data. Interpretivism on the other hand is a more subjective paradigm and argues that phenomena are internal to the research and cannot be separated from the researcher (Collis and Hussey, 2013). Interpretivism is normally associated with qualitative data.

Figure 4-3: Continuum of Paradigms

The current study under investigation, developing a conceptual model of an FMIS, falls into the interpretivist paradigm. This paradigm is characterised by the use of qualitative data. It takes into account the softer aspects of human nature and the mystery of complex social phenomena (Collis and Hussey, 2013). This can be seen from the nature of qualitative data being collected and analysed regarding farm management and usage of data and information by farm managers. It can further be determined because farm managers themselves are doing research and seeking to understand practices and view-points. From this understanding the conceptual model will be developed.

4.3. RESEARCH APPROACH

The objective of this study is to develop a model of an FMIS for the hydroponic industry of South Africa. The approach to be taken to accomplish this is by means of developing a model from empirical evidence. By analysing the data, general patterns will be identified and this will guide the development of the model. According to Collis and Hussey (2013) this study is an inductive study whereby a theory or a model is compiled from the observation of particular occurrences. It is a study that moves from the specific occurrences to the identification of a general trend or law.

4.4. RESEARCH DESIGN AND STRATEGY

The research design and strategy addresses the issue of how this study will be conducted to address the research objectives and questions. The research design and strategy will largely be influenced by the research question.

According to Saunders, *et al.*, (2007) three types of research design are found: exploratory, explanatory and descriptive. Collis and Hussey (2013), with the inclusion of analytical and predictive describe these designs as being the research purpose. Since the objective is to develop an FMIS for the South African hydroponics industry, this study described as an exploratory study. It is an exploratory study because it sets out to identify common trends in how farm managers use data and information for report generation, decision making and documentation.

The study, therefore, sets out to perform a literature study that will provide a clear understanding of academic context around the subject. From this study a measuring tool was developed and used in the empirical study that will be discussed in [Section 4.6].

In order to gain a theoretical foundation for the study and problem under investigation a literature study was compiled through reviewing the following sources of information:

- Internet sites;
- Magazines;
- Online databases;
- Books;
- Academic journal articles; and
- Industry Specialists.

The literature studies conducted in Chapter 2 and Chapter 3 investigated the significance of Hydroponic Production in South Africa. Chapter 2 built on some of the global and local challenges in the industry and possible opportunities hydroponics has for the future. Chapter 3 investigated FMIS and the transformation of the agricultural industry to where it is today as a data-intensive industry. It defined and identified the purpose and functions of an FMIS.

4.5. TIME HORIZON

According to Figure 4-2 there are 2 time horizons. The 2 time horizons are cross-sectional time horizon and longitudinal time horizon. A cross-sectional time horizon according to Saunders, *et al.*, (2007) is a study that spans over a short period of time or at a particular point in time. A longitudinal study, on the other hand, spans over a longer period of time (Saunders, *et al.*, 2007). This study falls under a cross-sectional time horizon as it seeks to identify the current state of information management among farm managers.

4.6. TECHNIQUES AND PROCEDURES

Techniques and procedures refer to methodology by which data is collected and analysed in the form of an empirical study. For this study that entails the measuring instrument, sample selection, data collection and data analysis.

4.6.1. Empirical Study

An empirical study is the means by which empirical evidence or data based on observation and experience is collected (Collis and Hussey, 2013). In this study the empirical evidence is the views and opinions or observations of farm managers with regard to the internal data and external information about their farms.

4.6.1.1. Sample Design

The population under investigation in this study consists of hydroponic farm managers and or owners. The sample, which is a small subset of this population, are the participants in this investigation from whom qualitative data was collected. The sample design for determining the respondents was done by means of the snowball method.

Snowball sampling or networking as described by Collis and Hussey (2013) is when each respondent is asked to identify possible participants if they are aware of any others that meet the criteria. Due to the nature of farming communities, they are normally well connected and this method was identified to be the most suitable method of sampling. Contact was also made with greenhouse suppliers to assist in identifying possible participants. In this way contact was made with 30 hydroponic farm owners or managers who participated in the study.

4.6.1.2. Data collection

Based on the literature study, a measurement tool was developed in the form of a questionnaire [ANNEXURE B]. This questionnaire was used in a structured interview with farm managers and/or farm owners involved with hydroponic farming. A structured interview is where a set of questions is used in the interview as opposed to an unstructured interview where there are no set questions (Collis and Hussey, 2013). This method of data collection was more beneficial for this study as farmers are not likely to respond to internet or email surveys. Therefore making contact through farm visits was more likely to result in more effective response rates.

The measurement instrument used had a combination of five-point Likert Scale questions ranging from 1 – 5 (Strongly Disagree – Strongly Agree, Not important – Very important) and open ended questions.

The questionnaire used in the structured interview consists of 7 sections:

1. **Biographic Details**: This section focused on gathering data about the manager and or owner of the farm and the farm itself. It asked questions regarding education level, designation and generation. With regard to the farm, questions were asked regarding the age of the hydroponics, the area under cover, structures, ventilation, crops and number of staff.

2. **Need for FMIS**: This section sought to determine to what extent an information system was needed. It consisted of five-point Likert Scale questions ranging from 1 – 5 (Strongly Disagree – Strongly Agree). These questions were compiled from literature's identification of what purpose an FMIS seeks to accomplish.

3. **Current information system (CIS)**: This section sought to determine what information systems farmers had in place and how satisfied they were with their performance. It consisted of five-point Likert Scale questions ranging from 1 – 5 (Strongly Disagree – Strongly Agree). An important question also asked was whether they would consider an alternative.

4. **Human Resource Management (HRM)**: This section is the first of four functions mentioned in the literature review [Section 3.5.2]. It consisted of five-point Likert Scale questions ranging from 1 – 5 (Not Important – Very Important) and 2 open ended questions. It asked questions regarding data and information about human resources.

5. **Field Operations Management (FOM)**: This section is the second of four functions mentioned in the literature review [Section 3.5.1]. It consisted of five-point Likert Scale questions ranging from 1 – 5 (Not Important – Very Important) and 2 open-ended questions. It asked questions regarding data and information about planning and activities around the farm.

6. **Greenhouse Climate Control (GCC)**: This section is the third of four functions mentioned in the literature review [Section 3.5.2]. It consisted of five-point Likert Scale questions ranging from 1 – 5 (Not Important – Very Important) and 2 open ended-questions. It asked questions regarding data and information about the greenhouse climate control.

7. **Financial Information Management (FIM)**: This section is the last of four functions mentioned in the literature review [Section 3.5.3]. It consisted of five-point Likert Scale questions ranging from 1 – 5 (Not Important – Very Important) and 2 open ended questions. It asked questions regarding data and information about the finances of the farm.

4.6.1.3. Data Analysis

The data collected was analysed and statistically assessed by Dr. Danie Venter from NMMU Statistical Services. This created information upon which the model FMIS was based. The type of analysis was predominantly descriptive statistics as is done with qualitative data.

4.6.1.4. Reliability and Validity

Research is described by Collis and Hussey (2013) as a process that aims to increase knowledge. It is, however, important that the knowledge created by any study be credible. Credibility of research findings, in determining the value of the research, is determined by assessing the reliability and validity of the tool being used to measure (Leedy and Omrod, 2010; Collis and Hussey, 2009). The measuring tool referred to in this study is the questionnaire [ANNEXURE B].

4.6.1.4.1. Reliability

Reliability provides an indication as to whether studies repeated on an unchanged entity will produce similar results (Collis and Hussey, 2009; Kumar, 2012; Maree, et al., 2012). With positivistic studies, reliability is very important but when it comes to interpretivistic studies reliability becomes more lenient (Collis and Hussey, 2013). This is due to the nature of interpretivist studies measuring views and opinions of participants that may be influenced by prejudices, biases and other irrational criteria (Leedy and Omrod, 2010). The following are tests that can be used to determine how reliable a study is:

1. **Split Half Reliability:** This test requires that the measuring tool be split into to two separate parts. The findings from the two parts will then be compared by means of a correlation coefficient to provide an indication of reliability (Collis and Hussey, 2009; Maree, et al., 2012). Coefficients indicating high reliability will be as close to one as possible, on the other hand coefficients indicating a low reliability will be close to zero.
2. **Test – Retest Reliability:** As the name suggests this test involves testing on a group of participants already tested to determine whether the test will provide similar results. The challenge with this test lies with the familiarity the participants have with the measurement tool from the first time they participated (Collis and Hussey, 2009; Maree, et al., 2012).
3. **Equivalent Form Reliability:** is used to eliminate the problem of participants being familiar with a measurement tool, as found in the Test-Retest Reliability.

This test requires the development of two measurement tools that are given to the respondents. The results of these tools are correlated and calculated to determine their coefficient (Maree, et al., 2012).

4. **Internal Reliability:** This test aims to assess the internal consistency of the responses to the measurement tool. When measuring something, all the responses should be similar. Cronbach's alpha coefficient is a tool that measures the internal consistency of the measuring tool. A coefficient, as mentioned earlier, indicates that a high degree of reliability will be close to one, and a low degree of reliability will be close to zero (Collis and Hussey, 2009; Nunnally, 1978; Maree, *et al*., 2012).

Table 4-1 shows the guidelines for reliability ratings. It indicates, based on the results of the Cronbach Alpha test whether a measuring tool is highly reliable or unacceptable as it is not reliable and of no value in creating knowledge. Cronbach Alpha values between 0.50 and 0.69 for new and experimental studies have been indicated as acceptable reliability (Collis and Hussey, 2009; Nunnally, 1978; Maree, *et al*., 2012).

Table 4-1: Reliability Rating Guidelines

Guideline	**Reliability**
Cronbach Alpha ≥ 0.90	High Reliability
Cronbach Alpha ≥ 0.80	Moderate Reliablity
Cronbach Alpha ≥ 0.70	Low Reliability
Cronbach Alpha 0.5-0.69	Acceptable
Cronbach Alpha < 0.50	Unacceptable Reliability

Source: (Collis and Hussey, 2009; Nunnally, 1978; Maree, *et al.*, 2012)

4.6.1.4.2. Validity

Validity according to Collis and Hussey (2013) and Leedy and Omrod (2010) determines to what extent the measuring tool actually measures what the researcher is trying to measure. Tools that can be used to assess the validity of a research study are:

1. **Face Validity:** Face validity looks at the measuring tool and assesses whether it is actually measuring what the study sets out for it to measure (Collis and Hussey, 2013). It achieves this by testing the link between the measuring tool and the objective of the study (Kumar, 2012; Maree, *et al*., 2012).
2. **Construct Validity:** Construct validity refers to the problem that exists with unobservable phenomena (Collis and Hussey, 2013), phenomena such as anxiety, ambition or motivation. These phenomena, otherwise known as hypothetical constructs, are assumed to exist in creating observable phenomena such as shaking or sweating (Maree, *et al*., 2012; Kumar, 2012). With regard to validity, the researcher needs to explain that the observable phenomena are a result of the hypothetical construct (Collis and Hussey, 2013).

The importance of validity in determining the value of research findings is high. This answers the question of whether the results accurately portray the measured variables and if these results can be applied in the real world (Leedy and Omrod, 2010).

4.7. SUMMARY

Chapter 4 described the research methodology that was followed in conducting this study. It followed the research onion depicted in Figure 4-2. Figure 4-1 contained the outline of this chapter and identified the different sections that were discussed.

The chapter identified and described the research philosophy as being Interpretivist, making use of qualitative data. This was because the study observed aspects of human nature in seeking to understand practices and viewpoints of managers. It was identified as being an inductive study, moving from observing specific occurrences to the establishment of a trend or law.

The design and strategy of the research to achieve the research objective was decided by means of an exploratory study. This included a literature review [Chapter 2 and Chapter 3], and an empirical study. The empirical study, conducted to assess the current state of information management, was described under [Section 4.6]. It detailed the sample design [Section 4.6.1.1], data collection [Section 4.6.1.2], data analysis [Section 4.6.1.3] and research credibility [Section 4.6.1.4].

Chapter 5 will present the findings of the empirical study. It will identify and describe the results obtained by the measuring tool described under [Section 4.6.1.2] using descriptive statistics. Chapter 6 will follow with the FMIS model proposed for integrating all the data and information components.

5. RESEARCH FINDINGS

5.1. INTRODUCTION

Hydroponics, a production technique predominantly practised under-cover by using nutrient-enriched water and alternative growing mediums, has been identified as an important industry for future food production [Section 2.4]. It has been identified as important due to:

- Speed of growth;
- Water use efficiency;
- Increased yields;
- Possible production; and
- Less space requirements.

The above points highlight the challenges being faced globally and locally. Challenges such as climate change [Section 2.2.1], population growth [Section 2.2.2], urbanisation [Section 2.2.3], food security [Section 2.2.4] and water scarcity [Section 2.2.5]. Challenges that are placing pressure on producers to meet the needs of consumers and their own business requirements.

Additional to these challenges is progress in technology and the ability to adapt to the change [Section 3.2], being able to adapt and make use of available resources to accomplish efficient production of food. One of the resources available is the automation and processing of internal data and external information for report generation, decision making and documentation. Report generation, decision making and documentation that will help to [Section 3.4]:

1. Improve farm activities;
2. Reduce uncertainty in decision making;
3. Facilitate compliance;
4. Manage overloads of information;
5. Reduce office time;
6. Create operational plans; and
7. Generate reports.

An empirical study was conducted to establish the requirements of an FMIS for the hydroponics industry. The study set out to identify the extent of the need for an FMIS, what the current information management practices are and what internal data and external information are important. The results from this empirical study, conducted via a structured interview with 30 farm owners/managers, will be discussed in this chapter. Chapter 4 detailed the methodology used to conduct this study and addressed the research philosophy, approach, design and strategy. It identified the time horizon and all the techniques and procedures applied for conducting this empirical study.

Chapter 5 will describe the results of the empirical study. The empirical study was conducted by the use of a structured interview in the form of a questionnaire [ANNEXURE B]. The questionnaire was broken down into 7 sections:

1. Biographic Details;
2. Need for Farm Management Information System (NFMIS);
3. Current Information Systems (CIS);
4. Human Resource Management (HRM);
5. Field Operations Management (FOM);
6. Greenhouse Climate Control (GCC); and
7. Financial Information Management (FIM).

The biographic details of the respondents will be described. The extent of the need for an FMIS and current information practices as they relate to the sample will be discussed. The chapter will then detail what internal data and external information is important for the FMIS model as it relates to the four functional areas identified for this research: HRM, FOM, GCC and FIM, as in the sections of the questionnaire.

This chapter will address the following research objectives:

RO_4 – *Describe the current management of information.*

RO_5: *Determine what internal data and external information is required for a FMIS.*

With **RO_4** and **RO_5** being addressed the following research questions will be answered:

> **RQ_4** – *What is the current status of information management?*

> **RQ_5**: *What components need to be included in the FMIS?*

Figure 5-1: Chapter 5 Outline

1. SCOPE OF THE STUDY
2. SOUTH AFRICAN HYDROPONICS INDUSTRY
3. FARM MANAGEMENT INFORMATION SYSTEMS
4. RESEARCH DESIGN AND METHODOLOGY
5. RESEARCH FINDINGS
    - 5.1. INTRODUCTION
    - 5.2. BIOGRAPHIC DETAILS
        - 5.2.1. Gender
        - 5.2.2. Education
        - 5.2.3. Designation
        - 5.2.4. Birth Year
        - 5.2.5. Years Under Cover
        - 5.2.6. Area Under Cover
        - 5.2.7. Greenhouse Structure/Components
    - 5.3. NEED FOR FMIS
    - 5.4. CIS PERFORMANCE
    - 5.5. FMIS FUNCTIONAL COMPONENTS
        - 5.5.1 Field Opperations Management [FOM]
        - 5.5.2. Human Resource Management [HRM]
        - 5.5.3. Financial Information Management [FIM]
        - 5.5.4. Greenhouse Climate Control [GCC]
    - 5.6. CONCLUSIONS
6. CONCLUSIONS AND RECOMMENDATIONS

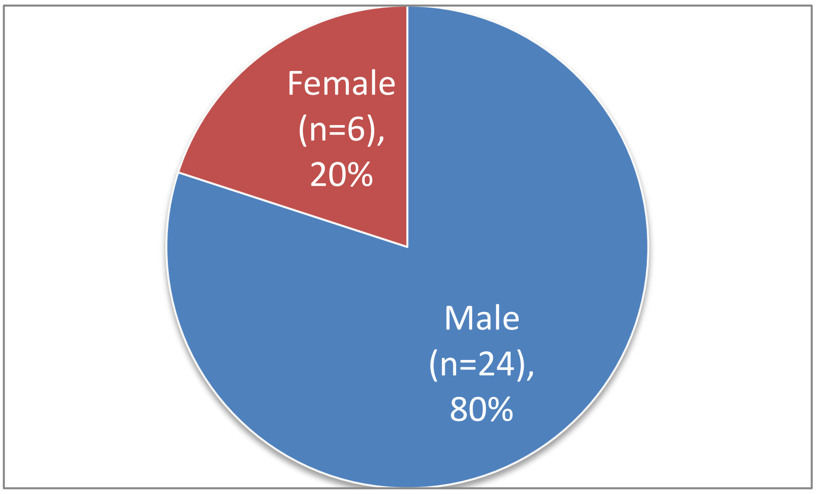
5.2. BIOGRAPHIC DETAILS

The biographic details of the 30 respondents were analysed according to data provided by the respondent and information about the related farm and its infrastructure. Information about the respondent includes gender, education, designation and birth year. Information about the farm and its infrastructure include when the farm started under-cover (hydroponic) farming, area under cover, type of infrastructure, ventilation type, whether or not the farm has insect nets or heating, crop type, the area produced outside and the number of staff.

5.2.1. Gender

In a predominantly male industry, the respondents in the sample make up a fairly accurate ratio of male to female for the hydroponic farming population. Figure 5-2 shows that 20% (n=6) of the respondents were female and the other 80% (n=24) male.

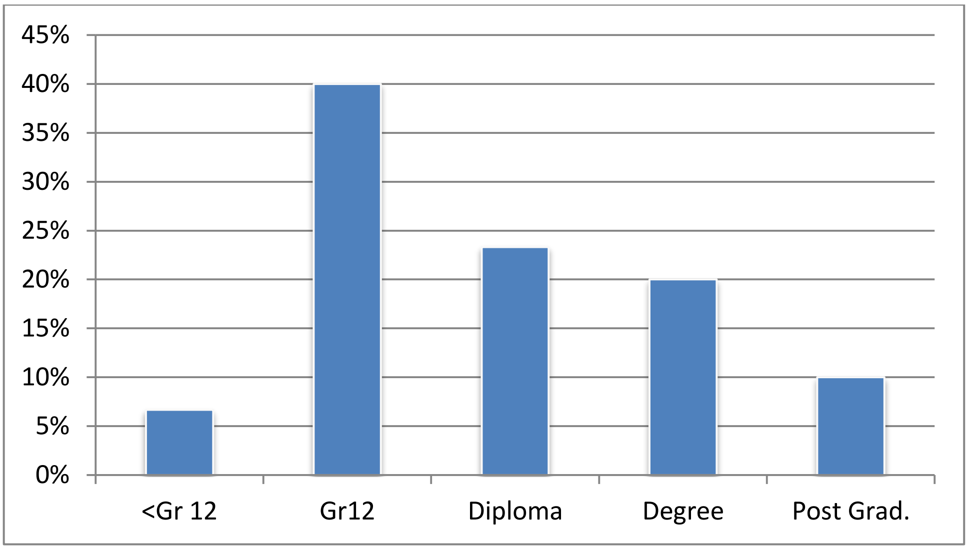
Figure 5-2: Gender



5.2.2. Education

Education or lack of education can have an influence on management practices and perceived value of new developments. Figure 5-3 shows 7% (n=2) of the sample have less than a Grade 12, 40% (n=12) have a Grade 12 qualification, 23% (n=7) have completed a diploma, 20% (n=6) a degree and 10% (n=3) a post graduate degree. With 40% (n=12) of the sample having only completed a Matric and no further degree there may be a lack of computer literacy and willingness to try something new. Especially when it comes to the more analytical aspects of reporting on farm performance there may be a perceived lack of relevance due to misunderstanding. The ability to grasp a new system and apply it may also be hindered due to the lack of learning as most farm managers are very hands-on in the practical aspects of the organisation and not so much is the business aspects.

Figure 5-3: Education Level

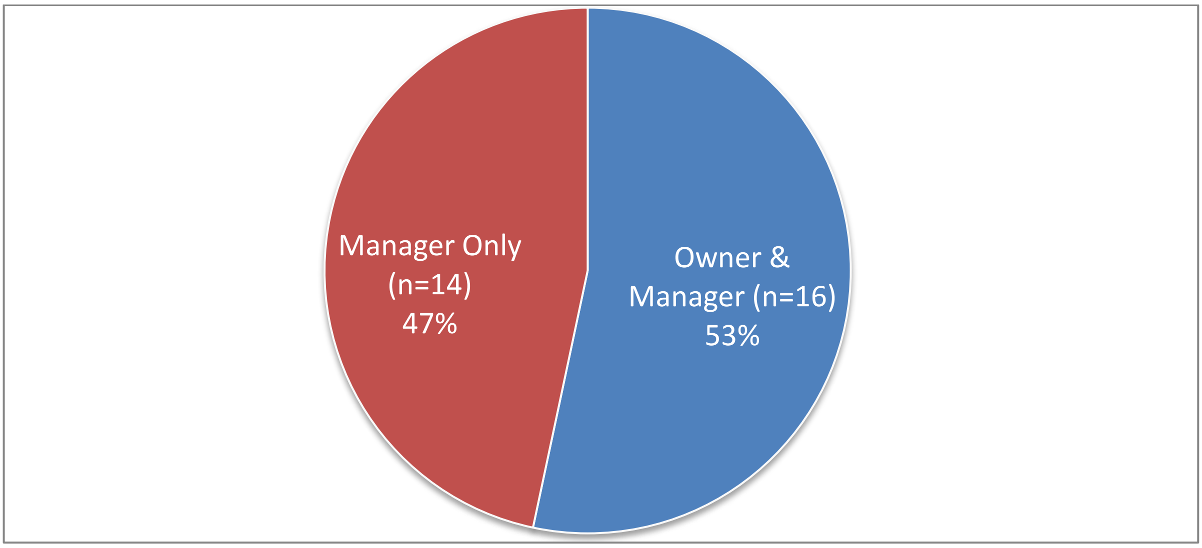


5.2.3. Designation

Designation refers to whether a respondent is an owner and manages the farm or if he/she as a manager is working for someone else. If 47% (n=14) of the respondents were managers only and 53% (n=16) were owners who were also managing then more than half of the respondents were managers only.

Designation could affect new system introduction as farm managers often have little say on the introduction of new systems due to reluctance of farm owners. Farm owners can often be pessimistic about new technologies, especially those that they do not understand or see direct benefit from them. On the owner's and manager's side, owners do have autonomy in decision making and therefore have authority to implement change.

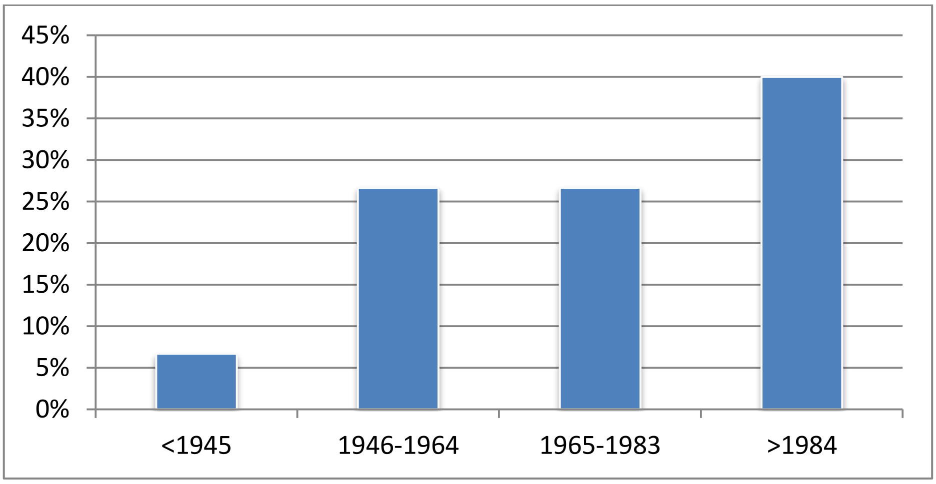
Figure 5-4: Designation



5.2.4. Birth Year

The birth year of participants was taken into account to determine the generation classification. Figure 5-5 shows that 7% (n=2) of the sample were born before 1945 (Traditionalists), 27% (n=8) between 1946 and 1964 (Baby Boomers), 27% (n=8) between 1965 and 1983 (Generation X) and 40% (n=12) of the sample born after 1984 (Generation Y). Receptibility of new technologies and systems is likely to be higher amongst Generation X and Generation Y members. Conversely amongst Traditionalists and Baby Boomers it is likely to be more resisted.

Figure 5-5: Birth Year

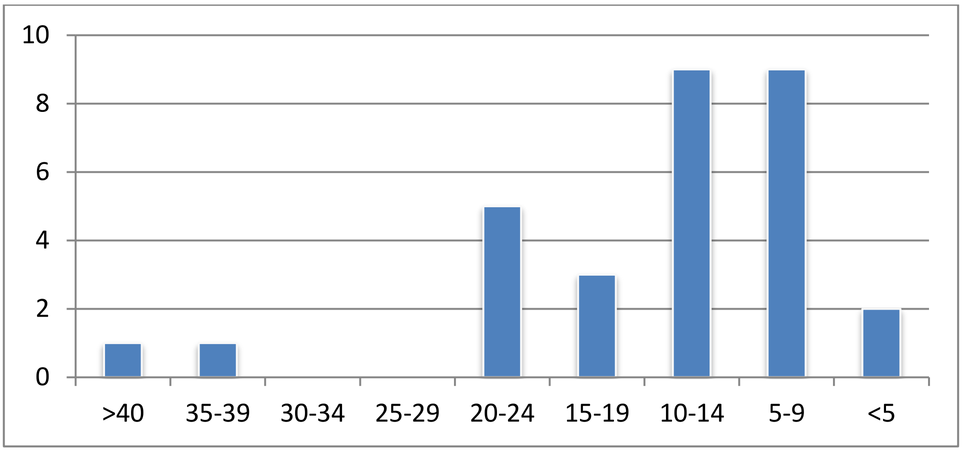


67% (n=20) of the respondents fall within Generation X and Generation Y. This provides an indication that the majority of the respondents would adapt to technological changes more readily.

5.2.5. Years Under-Cover

Years under-cover refers to how long the farm has been practising hydroponics/CEA. It provides an indication as to how established the structures and systems are. Figure 5-6 shows from left to right the number of years respondents have been practising hydroponics. Directly seen in Figure 5-6 are the 2 respondents who have been practicing under-cover for 35-40 years. Well established farms that have developed their systems, whether manual or computer orientated are less likely to change unless the need arises. Newer, younger farmers may be more likely to adopt and try new systems as they grew up in a rapidly changing environment.

Figure 5-6: Years Under Cover



5.2.6. Area Under-Cover

The questionnaire asked respondents the number of square meters, standard measure of area in hydroponics, under-cover. When the statistical analysis was complete the unit of measure used was hectares. The mean area under-cover of the sample as seen in Table 5-1 was 5.62 Hectares and 56 200m^2 in square meters. The smallest was 100m^2 and the largest 250 000m^2. Farm size gives an indication of turnover with regard to scale. Generally speaking, with regard to greenhouses, the larger the infrastructure the larger the risk and greater the opportunity for reward.

Effective management systems and real-time knowledge of company performance is a proven method of mitigating risk.

Table 5-1: Central tendency & Dispersion: Area Under Cover (Ha)

Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum
5.62	5.07	0.01	1.80	5.00	7.90	25.00

5.2.7. Greenhouse Structure / Components

The responses to questions regarding the type of structure [Figure 5-7: Type of Structure], ventilation [Figure 5-8: Types of Ventilation], ventilation type [Figure 5-9], heating [Figure 5-11] and inset nets [Figure 5-10] are summarised. These components of a greenhouse determine what tools are available for manipulating the Greenhouse environment. Accompanied by the tool are different management practices and additional costs and benefits.

Figure 5-7: Type of Structure

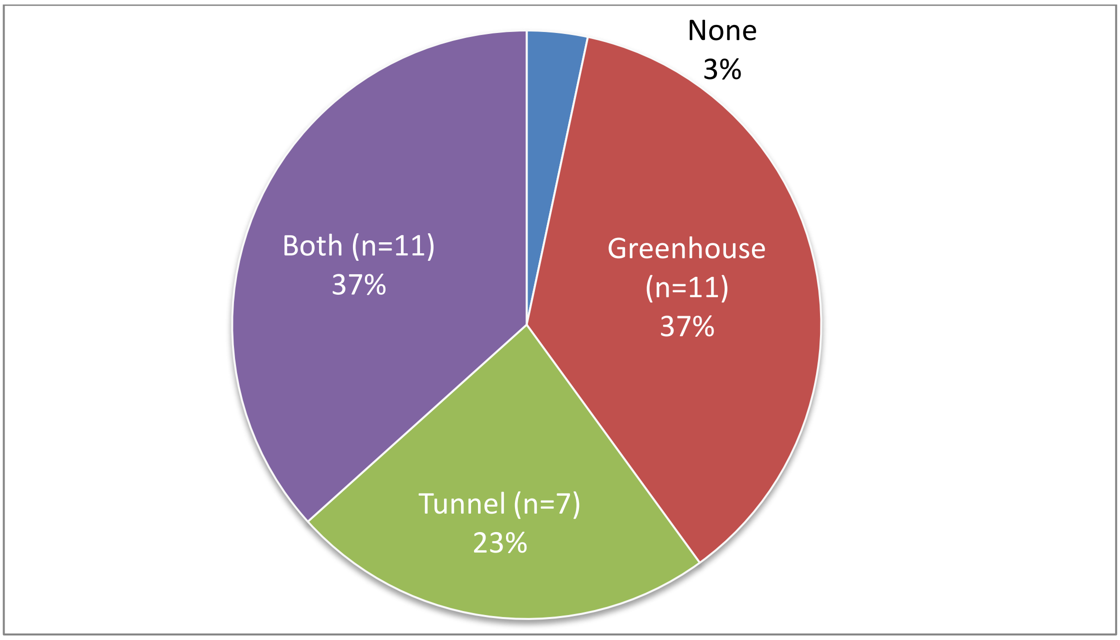


Figure 5-7: Type of Structure shows that 37% (n=11) of the respondents grow in both tunnels and greenhouses. Tunnels are single units of area spanning one arch/bay. Greenhouses on the other hand are multi-span units spanning multiple arches/bays. Another 37% (n=11) of the respondents grow in greenhouses only and 23% (n=7) in tunnels only. Greenhouses generally cover a larger area per unit than a tunnel. Greenhouse establishment costs are much higher than those of tunnels.

With regard to the management of the two (Greenhouse vs. Tunnel), they are very different. The volume of air in a tunnel is vastly smaller than the volume of air in a greenhouse. The larger volume of air acts as a buffer for internal climate control and knowledge of the various components, such as temperature and humidity influence how that climate is managed. The results achieved in growing a more productive crop needs to be known. The smaller volume of air in tunnels is more susceptible to external climate conditions and little can sometimes be done to curb the effect. This, therefore, makes it less likely that farm managers who only have tunnels would benefit from knowing the effects of external climate on internal temperature and humidity.

Figure 5-8: Types of Ventilation

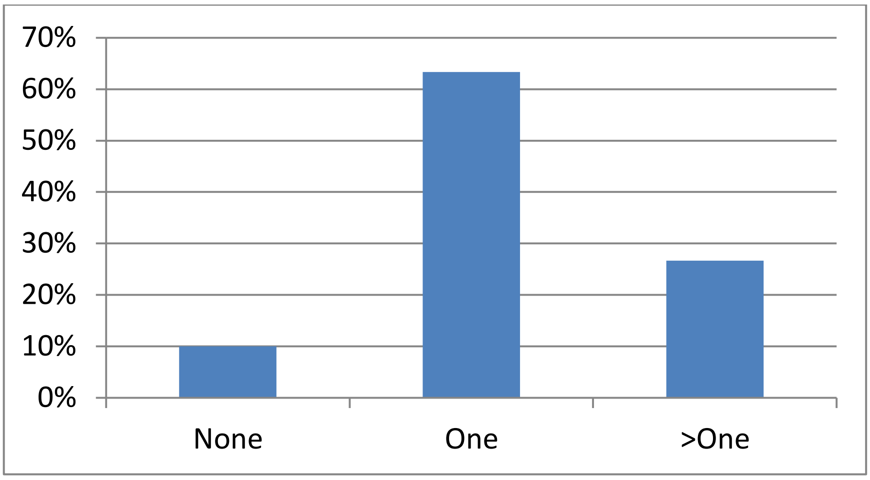


Figure 5-8 shows that 10% (n=3) of the sample did not have a ventilation type that was listed in the questionnaire. 63% (n=19) had one ventilation type that they are working with and the remaining 27% (n=8) have more than one type of ventilation on their structures. Whether farm managers have one or more than one type of ventilation would not affect whether they would be more likely to need internal data. The type of ventilation is of importance due to the system having varying degrees of control.

Pad and fan is a ventilation type that is highly energy dependent but has arguably the greatest control of a greenhouse environment and is also the most expensive. Therefore, knowledge of the growing environment and its response to implemented changes is necessary. Alternatively, single vents and curtains have limited options with regard to controlling the environment in the greenhouse. The environmental and plant factors to take into account are a lot less than that of Pad and Fan. Therefore the need for knowledge is less likely to be important.

Figure 5-9: Ventilation Type

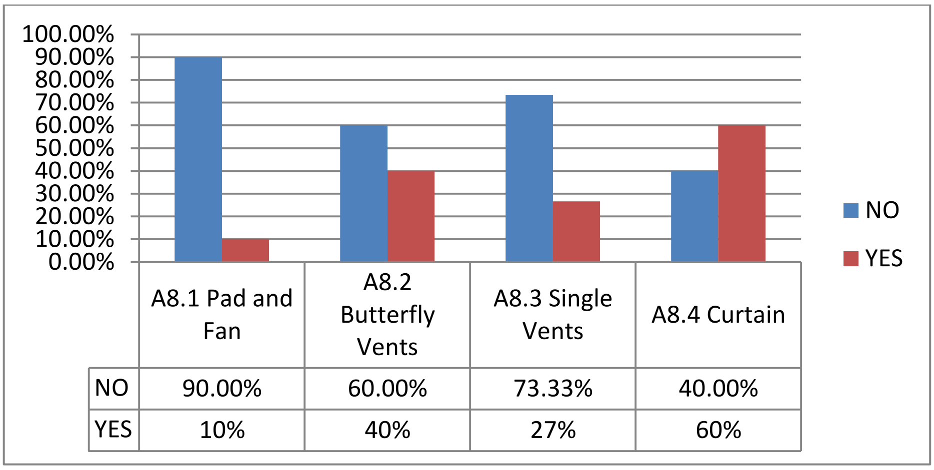


Figure 5-9 shows the different ventilation types that are being used by the respondents. Curtains and butterfly vents are the most commonly used, 60% (n=18) and 40% (n=12) respectively. Followed by single vents and pad and fan, 40% (n=12) and 10% (n=3), respectively.

Figure 5-10: Insect Nets Installed

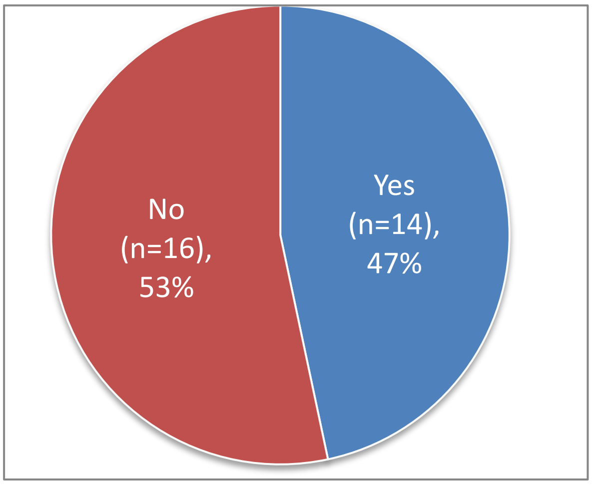


Figure 5-11: Heating Available

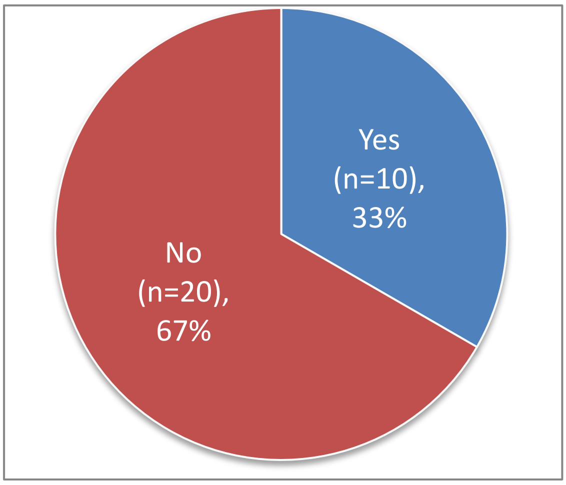
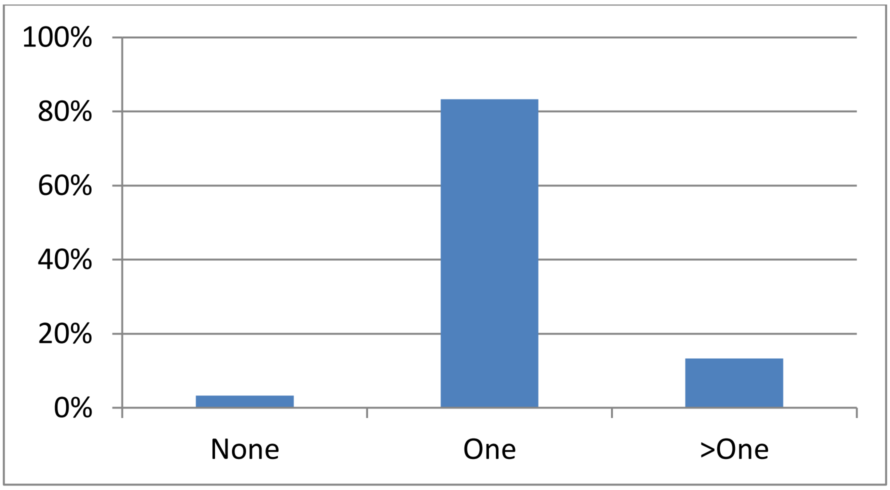


Figure 5-10 shows that 53% (n=16) of the respondents do not have insect nets and 47% (n=14) of the respondents do have insect nets. Figure 5-11 shows that 67%

(n=20) of the respondents do not have additional heating available and 33% (n=10) of the respondents do have heating.

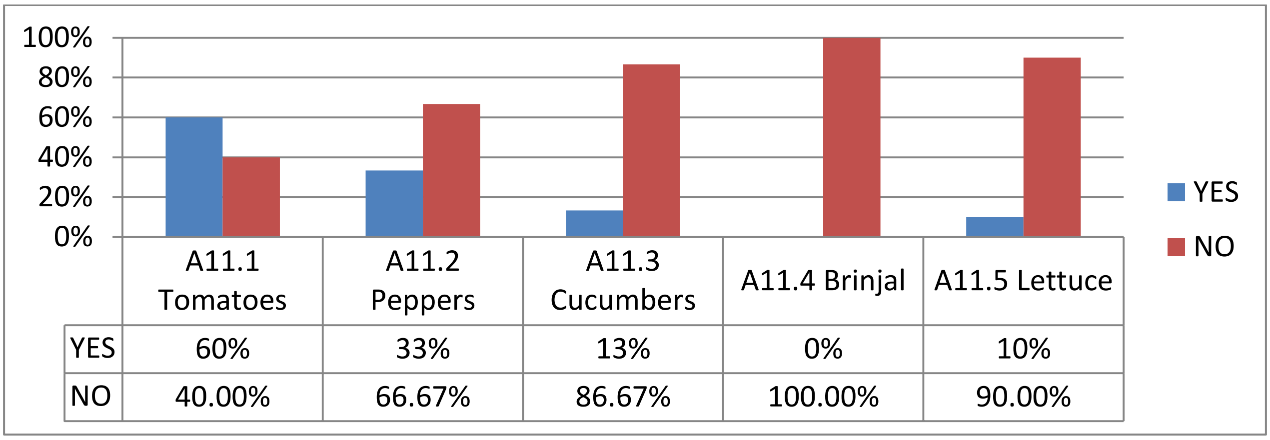
Besides ventilation and farm size insect nets and heating are additional tools that a farm manager can have to control the environment of the tunnel/greenhouse. Each of these has its own concerns and practices requiring knowledge and information. With insect nets the concern is broader, and they are dependent on application so and the effects of use may vary. With regard to heating, unless a farm manager has heating facilities, knowledge of heating temperatures and humidity will be of no use and of little value. But if farm manager does have the option of heating, those data points are very important, especially when it comes to decision making, report generation and documentation.

Figure 5-12: Number of Crops Under-Cover



Over 80% (n=25) of the respondents focus on growing one crop. This can be seen in Figure 5-12. Only a few respondents have more than one crop.

Figure 5-13: Crops Grown Under-Cover



	A11.1 Tomatoes	A11.2 Peppers	A11.3 Cucumbers	A11.4 Brinjal	A11.5 Lettuce
YES	60%	33%	13%	0%	10%
NO	40.00%	66.67%	86.67%	100.00%	90.00%

Figure 5-13 shows that Tomatoes 60% (n=18), is the most commonly grown crop amongst the respondents, followed by Peppers 33% (n=10) and Cucumbers 13% (n=4). A common trend seems to be of manager's preference to focus on one crop in which he/she can specialise and maximise. Growing of one crop does simplify crop management.

Figure 5-14: Size of Staff Complement

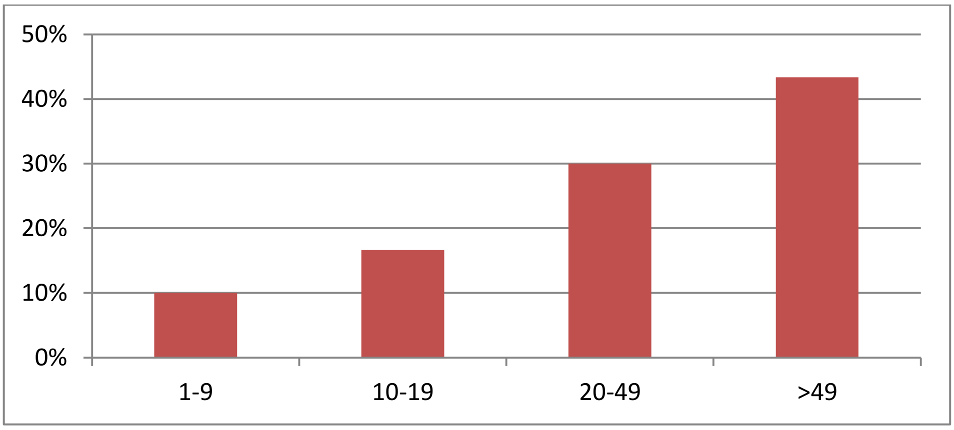


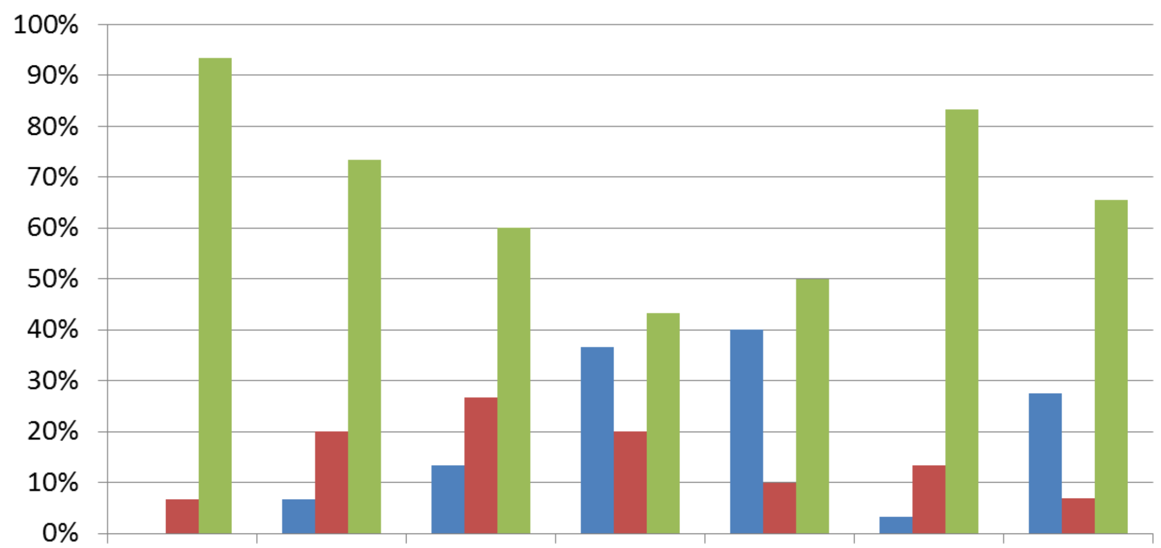
Figure 5-14 shows that 43% (n=13) of the respondents have a staff complement of more than 49 employees. Followed by 30% (n=9) with 20-49 employees and 17% (n=5) with 10-19 employees. Only 10% (n=3) of the respondents have between 1 and 9 employees.

The number of employees is an important factor. When it comes to HRM, the larger the organisation the greater the need for team leaders, supervisors and managers, all of whom need to be managed and monitored to ensure progress. Management requires the use of software solutions, to ease the task of tedious effort to manually collate all the necessary documents for practical and legal purposes.

5.3. NEED FOR FMIS (NFMIS)

In the literature review section of this study [Section 3.4] the purpose of an FMIS was described. Seven key points were identified as outcomes of a FMIS. Based on these outcomes, questions were asked of the respondents in the structured interview [ANNEXURE B – NFMIS).

Figure 5-15: Need for FMIS Responses



	B1.1.	B1.2.	B1.3.	B1.4.	B1.5.	B1.6.	B1.7.
SD-D	0% (n=0)	7% (n=2)	13% (n=4)	37% (n=11)	40% (n=12)	3% (n=1)	28% (n=8)
N	7% (n=2)	20% (n=6)	27% (n=8)	20% (n=6)	10% (n=3)	13% (n=4)	7% (n=2)
A-SA	93% (n=28)	73% (n=22)	60% (n=18)	43% (n=13)	50% (n=15)	83% (n=25)	66% (n=19)

Figure 5-15 shows a summarised description of the responses given. The 5-point Likert scale (SD, D, N, A, SA) was converted to a 3-point scale, SD-D (SD-Strongly Disagree and D-Disagree), N (Neutral) and A-SA (A-Agree and SA-Strongly Agree). For each of the questions the responses show that there is a need for an FMIS. Question B1.7 was a negative phrased question and also shows a positive need for a FMIS.

B1.1. asked whether there is a need to improve farm activities. This addresses general efficiency improvement, cost reduction improvement and production improvement. B1.2. asked whether there was a need to decrease uncertainty in decision making. As described in Section 2 agriculture is facing both global and local challenges and making well informed decisions is proven to assist. B1.3. asked whether certification was difficult as it is a mundane and tedious task. B.1.4. asked if the respondents have an overload of information. Literature identified that farmers were not short of information but rather the ability to use it. B1.5. asked about the amount of time respondents spent in the office working with data and information. Through the application of an FMIS the objective is to decrease office time where possible. B.1.6. asked the respondents what sources of information he/she consulted when making decisions. An FMIS would assist in bringing data together. B.1.7. asked whether there was a need for report generation. This is said, in section 3.4.7., to be the second most important role of an FMIS.

B1.1. 93% (n=28) of the respondents agree that there is a need to improve farm activities (Question 1 of FMIS). This confirms what Brynjolfsson, *et al*. (2011) states in mentioning that there is a positive correlation between information decision making and organisational performance.

B1.2. 73% (n=22) of the respondents agree that there is a need to reduce uncertainty in decision making (Question 2 of FMIS). This confirms Kaloxylos, *et al.* (2012) research in that farmers are challenged by varying forces and there is a great need to make more efficient decisions.

B.1.3. 60% (n=18) of the respondents agree that certification is not an easy process (Question 3 of FMIS). Certification as mentioned by Verdouw, *et al.* (2015) is a requirement to ensure that quality, the environment, health, safety, labour and production standards are met. But it is not a simple process in guaranteeing these factors to consumers.

B.1.4. 43% (n=13) agree that they have an overload of information (20% neutral, 37% disagree) (Question 4 of FMIS). Fountas, *et al.* (2006) address the point of not being able to use available information effectively with this being a stumbling block to progress. The key it seems then is not the quantity of data and information but it usefulness in decision making.

B.1.5. 50% (n=15) of respondents agree that they spend too much time in the office (Question 5 of FMIS). With increasing amounts of information available and an increasing need to reduce uncertainty in decision making, time to make sense of all the data is required. Sørensen, *et al*. (2010) mentions the economic benefit of data against the amount of time used to obtain that benefit. This is where automation in an FMIS would assist.

B.1.6. 83% (n=25) of the respondents agree that they consult many information sources when planning (Question 6 of FMIS). As information both internal and external becomes more accessible the need to consult information will increase. As mentioned by Kruize, *et al.* (2013) this information will then form the basis of planning.

B.1.7. 66% (n=20) respondents agree that they do have a need for report generation (Question 7 of FMIS). Fountas, *et al.* (2015) found that reporting was one of the most important roles of an information system. 66% of the respondents agree with while the other 44% do not.

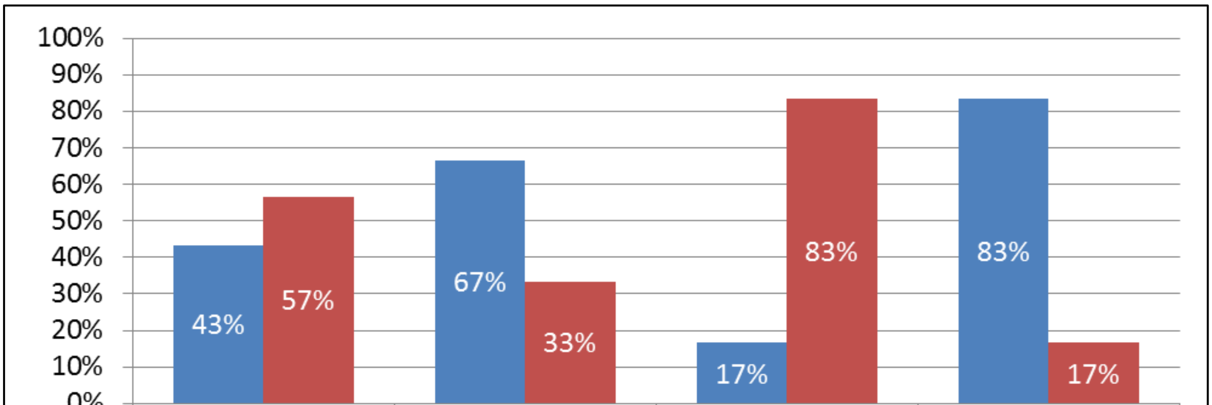
In some instances as mentioned above the literature study what the respondents disclosed while in others the results were not so clear. Further questions would have to be asked to determine reasons for deviations.

5.4. CIS PERFORMANCE

CIS Performance is covered in the structured interview [ANNEXURE B – CIS]. This sought to establish the current state of information management amongst farm managers in the hydroponics industry. The questions asked were based on the literature review [Section 3].

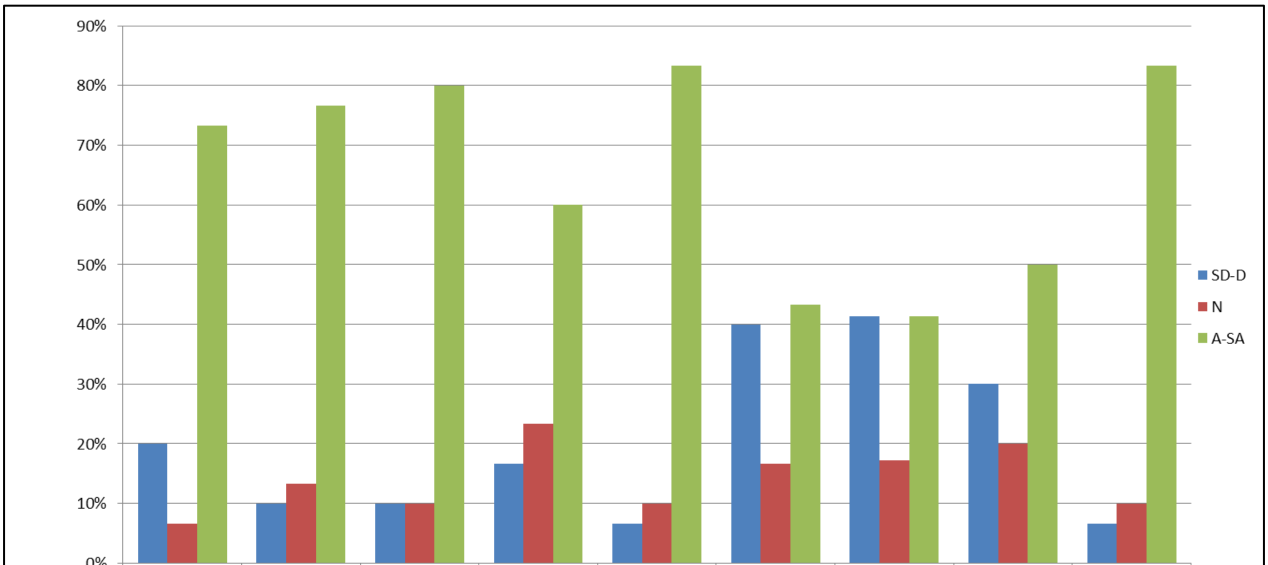
Most of the respondents, making use of computer software and pen and paper had more than one type of system in place. Figure 5-16 shows some of the systems in place. It can be seen that the most used are pen and paper (83% n=25), Microsoft Excel (67% n=20) and Proprietary Software (43% n=13). This does provide an indication as to a possible gap in the market place for an FMIS.

Figure 5-16: CIS in Place



	C1.1. Proprietary	C1.2. Microsoft Excel	C1.3. Microsoft Access	C1.4. Pen and Paper
YES	43% (n=13)	67% (n=20)	17% (n=5)	83% (n=25)
NO	57% (n=17)	33% (n=10)	83% (n=25)	17% (n=5)

Figure 5-17: CIS Performance Responses



	C2.1.	C2.2.	C2.3.	C2.4.	C2.5.	C2.6.	C2.7.	C2.8.	C2.9.
SD-D	20% (n=6)	10% (n=3)	10% (n=3)	17% (n=5)	7% (n=2)	40% (n=12)	41% (n=12)	30% (n=9)	7% (n=2)
N	7% (n=2)	13% (n=4)	10% (n=3)	23% (n=7)	10% (n=3)	17% (n=5)	17% (n=12)	20% (n=6)	10% (n=3)
A-SA	73% (n=22)	77% (n=23)	80% (n=24)	60% (n=18)	83% (n=25)	43% (n=13)	41% (n=25)	50% (n=15)	83% (n=25)

With reference to Figure 5-17 there is an indication of how managers perceive their CIS. Questions C2.1. – C2.4 show that the respondents are happy with their systems. C2.1 asks whether their system stores all the relevant data, to which 73% (n=22) agree that it does. C2.2 asks whether their system provides adequate information for planning purposes, to which 77% (n=23) agree that it does. C2.3 asks whether their system provides adequate information for decision making, to which 80% (n=24) agree that it does. C2.4 asks whether their system gives an accurate indication of how the farm is doing and 60% (n=18) agree that it does. Question C2.5 however does highlight a need to capture data that is not currently being captured by their CIS, 83% (n=25) agree on this. Question C2.6 and C2.7 asked whether their CIS time consuming to manage and whether it is difficult to maintain. Responses are evenly distributed on these two points 41% (n=12) agree and 41% (n=12) disagree. Question C2.8 asked whether respondents are happy with the reports that their CIS can provide and only 50% (n=15) responded in the affirmative. The remaining 50% (n=15) are either indecisive or have a greater need for reports. Question C2.9 finally shows an affirmative attitude, 83% (n=25), towards considering different alternatives.

Table 5-2: Pearson Product Moment Correlations - Need for FMIS vs. CIS Performance

	n	CIS Performance
1. Need for FMIS	30	*-.468*

Table 5-2 shows the correlation between NFMIS and CIS to be a negative statistical correlation of -.468. For n = 30 practical significance r >= .300 and for statistical significance r >= 361 (Gravetter and Wallnau, 2009)**.** This shows that the greater the need for a FMIS the greater the dissatisfaction of managers with their CIS and *vice versa.*

From these results it can be identified that amongst the respondents in this sample there is a need for a FMIS. This study seeks to develop a model of such a system by integrating all the important internal data and external information.

5.5. FMIS FUNCTIONAL COMPONENTS

The objective of this section is to determine what internal data and external information is required for a FMIS. Grouped according to 4 functions, identified in [Section 3.5], the following empirical results identify the internal data and external information for the FMIS.

The data from the empirical study has been analysed and summarised in Internal Data for FOM [Table 5-3], External Information for FOM [Table 5-4], Internal Data for

HRM [Table 5-5], External Information for HRM [Table 5-6], Internal Data for FIM [Table 5-7], External Information for FIM [Table 5-8], Internal Data for GCC [Table 5-10] and External Information for GCC [Table 5-11]. These tables group the 5 point rating scale (1 – 5, Not Important – Very Important) into 3 categories of responses. These responses are 1-2, 3 and 4-5. The format and grouping of Important – Not Important grouping is done according to the rating scale used in the questionnaire.

The summarised data in the tables has been analysed to include a priority column. This column indicates a level of priority with regard to the data point under question. Where 0-33% of the respondents rated 4-5 for importance the priority level is low, where 34-66% of the respondents rated 4-5 for importance the priority level is medium and where 67-100% of the respondents rated 4-5 for importance the priority level is high. The priority rating has been done to guide any further research or development with regard to internal data and external information points to be included in an FMIS application.

5.5.1. Field Operations Management [FOM]

Field operations management entails the every-day operational aspects of the farm. It involves the allocation of resources, such as labour, machinery and equipment. It involves planning and implementation of strategies and ensuring that regulatory requirements are met with regard to policies and procedures.

It can be seen in Table 5-3 that all 17 points were rated as very important for the greater majority of the managers. Harvesting data, pest and disease levels and variety performance were rated important by 100% of the respondents. Electricity consumption and machine maintenance were rated the lowest in this function but still above 60%. All the data points are shown to have a high priority.

Table 5-3: Internal Data for FOM

Data	SD-D	N	A-SA	Priority
E1.7. Harvesting Data	0%	0%	100%	**HIGH**
E1.8. Pest and Disease Levels	0%	0%	100%	**HIGH**
E1.10. Variety Performance	0%	0%	100%	**HIGH**
E1.15. Crop Performance: Lettuce, Tomatoes, Peppers, etc.	0%	0%	100%	**HIGH**
E1.3. Production Volumes	0%	3%	97%	**HIGH**
E1.4. Planting Dates	3%	0%	97%	**HIGH**
E1.2. Work Plans	0%	3%	97%	**HIGH**
E1.1. Labour Allocation	0%	7%	93%	**HIGH**
E1.5. Chemical Application Records	0%	7%	93%	**HIGH**
E1.6. Fertilizer Application Records	0%	7%	93%	**HIGH**
E1.9. Plant Growth	3%	7%	90%	**HIGH**
E1.16. Production Plan: Production Forecast or production budgets	3%	10%	87%	**HIGH**
E1.13. Harvest Quality: 1st, 2nd, 3rd grades and waste	10%	7%	83%	**HIGH**
E1.11. Fuel Usage	3%	14%	83%	**HIGH**
E1.17. Mortalities	3%	17%	80%	**HIGH**
E1.12. Machinery Maintenance	7%	17%	77%	**HIGH**
E1.14. Electricity Consumption	7%	20%	73%	**HIGH**

With regards to external information Table 5-4 shows that the point regarding study groups has a medium priority. Amongst the respondents it was found that the hydroponic industry is still fairly small and managers are still very protective of technical know-how. Technical assistance 80% (n=24) agree, supplier information 80% (n=24) agree and accreditation institutions 80% (n=24) agree that these points are high priority in this function with Training, 60% (n=18), receiving a medium priority rating.

Table 5-4: External Information for FOM

Information	SD-D	N	A-SA	Priority
E2.1. Technical Assistance: Agronomists, Consultants, etc.	3%	17%	80%	**HIGH**
E2.3. Suppliers: Product Information, medium, seed, plastic, etc.	0%	20%	80%	**HIGH**
E2.4. Accreditation Institutions: Global G.A.P., HASSP, Fair Trade, etc.	13%	7%	80%	**HIGH**
E2.2. Training: External Training and Development.	17%	20%	63%	**MEDIUM**
E2.5. Study Group.	30%	27%	43%	**MEDIUM**

5.5.2. Human Resource Management [HRM]

HRM is all the data and information relating to employee records, performance and development. It includes points that are important for company use but also those that are required by government institutions, such as the DoL.

Table 5-5: Internal Data for HRM

Data	SD-D	N	A-SA	Priority
D1.4. Employee Attendance Record.	0%	0%	100%	**HIGH**
D1.2. Employee performance.	0%	3%	97%	**HIGH**
D1.3. Employee Disciplinary Record.	3%	3%	93%	**HIGH**
D1.7. Hours Worked.	3%	10%	87%	**HIGH**
D1.6. Employee Contracts.	3%	10%	87%	**HIGH**
D1.13. Contract Termination Records.	7%	10%	83%	**HIGH**
D1.14. Employee Rates.	3%	13%	83%	**HIGH**
D1.11. Record of Training and Development.	17%	3%	79%	**HIGH**
D1.17. Health and Safety Records.	7%	14%	79%	**HIGH**
D1.5. Job descriptions.	17%	13%	70%	**HIGH**
D1.9. Details of Terms and conditions.	10%	20%	70%	**HIGH**
D1.8. Employee Employment History.	17%	17%	67%	**HIGH**
D1.1. Employee personal details.	10%	23%	67%	**HIGH**
D1.15. Skill Levels.	13%	27%	60%	**MEDIUM**
D1.12. Record of Trade Union/Employee Representative Meetings.	43%	27%	30%	**LOW**
D1.10. Pension Records.	53%	20%	27%	**LOW**
D1.16. BEE Status.	53%	27%	20%	**LOW**

Table 5-5 shows that 13 out of the 17 points were given a rating high priority with employee performance (97% n=29), disciplinary record (93% n=28) and attendance records (100% n=30) showing the highest importance. Pension records, skill development (60% n=18), record of trade union/employee representative meetings (30% n=9) and BEE Status (20% n=6) were given a rating of medium and low priority. Though the participants rated these points as unimportant it is not to say they are not.

External information sources for HRM, shown in Table 5-6, indicate that for the respondents, the only important point is the DoL which was rated important by 80% (n=24) of the respondents. The other 3 points, employee equity 37% (n=11), trade unions 31% (n=9) and government incentives 52% (n=16) were all given a priority rating of medium and low. These points will therefore have a lower priority when an FMIS model is developed. It was found that managers who rated these points as unimportant did not have trade unions or policy in place for employment equity.

Table 5-6: External Information for HRM

Information	SD-D	N	A-SA	Priority
D2.1. Department of Labour.	10%	10%	80%	**HIGH**
D2.4. Government Incentives.	28%	21%	52%	**MEDIUM**
D2.2. Employment Equity.	27%	37%	37%	**MEDIUM**
D2.3. Trade Unions.	45%	24%	31%	**LOW**

5.5.3. Financial Information Management [FIM]

Financial management as described in Section 3.5.3. is the attainment and utilisation of resources by a farm or business and the safe keeping of its equity capital from financial and business risk. Management accounting, also described in the same section, is the recording, estimating, organising and summarising of financial data for purposes of managerial use in decision making.

The following data and information points are those required to achieve the financial objectives of resource utilisation and safe keeping of equity capital from business and financial risk. In Table 5-7 it can be clearly seen that the respondent’s selection of financial data points listed is unanimous. All the data points have been given a high priority rating, between 80% (n=24) and 100% (n=30), for the FMIS model.

Table 5-7: Internal Data for FIM

Data	SD-D	N	A-SA	Priority
G1.2. Cost of Sales: Fertilizer, medium, chemical etc.	0%	0%	100%	HIGH
G1.3. Labour costs	0%	0%	100%	HIGH
G1.8. Over-head costs	0%	0%	100%	HIGH
G1.5. Sales volumes	0%	3%	97%	HIGH
G1.10. Cash Flow	0%	3%	97%	HIGH
G1.1. Capital Expenses: Buildings, Machinery, equipment	0%	3%	97%	HIGH
G1.4. Sales prices	3%	3%	93%	HIGH
G1.11. Budgets	3%	7%	90%	HIGH
G1.9. Machinery performance: Repairs and Maintenance	3%	13%	83%	HIGH
G1.7. Administrative costs	10%	10%	80%	HIGH
G1.6. Marketing costs	10%	10%	80%	HIGH

Of the external information points listed in Table 5-8, only 1 point was less than 66% (n=20) where the respondents did not give a rating of high importance. This was the point regarding foreign exchange rates 57% (n=17). However, when the question was asked slightly differently in G2.9 Economic indicators the respondents were unanimously in the majority for it being important 75% (n=22).

Table 5-8: External Information for FIM

Information	SD-D	N	A-SA	Priority
G2.5. Government: Minimum wage determination	3%	0%	97%	**HIGH**
G2.6. SARS: New tax legislation	3%	10%	87%	**HIGH**
G2.3. Suppliers: Price changes	3%	13%	83%	**HIGH**
G2.4. Bank: Financing	10%	17%	73%	**HIGH**
G2.9. Economic Indicators: Rand value, trends etc.	3%	23%	73%	**HIGH**
G2.8. Social Environment: Strikes, attacks, etc.	20%	13%	67%	**HIGH**
G2.2. Bank Interest Rates	17%	17%	67%	**HIGH**
G2.7. Political Environment	20%	13%	67%	**HIGH**
G2.1. Foreign Exchange Rates	23%	20%	57%	**MEDIUM**

5.5.4. Greenhouse Climate Control [GCC]

Greenhouse climate control entails the monitoring and recording of the greenhouse environment. Recording and monitoring of this is all necessary for strategy development and implementation when it comes to daily planning. This function of an FMIS is important for greenhouse management. Due to the ability to control the growing environment of the crops this aspect has a significant impact on plant growth.

It was found amongst the respondents that much of what was given high priority was dependent on their infrastructure. If a respondent did not possess the equipment required for measuring solar radiation it was not deemed as highly important. The same applied to outside temperature, CO_2 (Carbon Dioxide), light levels inside the greenhouse, slab/pot weights and heating temperature. Managers therefore who possessed such tools did give a high priority rating for the data regarding those tools.

Table 5-9 shows the rating for question F1.17 asking whether data on heating and temperature is important, and when the respondents who have heating were compared with those who do not. The table clearly shows that data regarding heating temperatures is important if the manager possesses the tool, otherwise it is not important. The same applies to the other points regarding CO_2, light levels inside the greenhouse and slab/pot weights.

Table 5-9: Frequency distribution according to heating/no-heating

	SD-D	N	A-SA	TOTAL
Heating	0	0	8	8
No-Heating	14	1	5	20

With regard to this discussion, Table 5-10 shows all the data points regarding greenhouse climate control. 10 points have been given high priority ratings, 7 data points have been given a medium priority rating and 1 data point given a low rating. The data points given a high rating refer to components that can be measured with easily available and affordable equipment. These tools are generally available to all hydroponic growers. When it comes to the more costly tools growers tend to use what they can work with. Carbon dioxide levels in the greenhouse, 31% (n=9) of the respondents rated that it was important.

Table 5-10: Internal Data for GCC

Data	SD-D	N	A-SA	Priority
F1.7. Quantity of water given	0%	0%	100%	HIGH
F1.13. Water Quality	0%	0%	100%	HIGH
F1.9. EC and pH of water given	3%	3%	93%	HIGH
F1.18. Irrigation start and stop times	7%	0%	93%	HIGH
F1.8. Quantity of over drain	3%	7%	90%	HIGH
F1.10. EC and pH of over drain	3%	7%	90%	HIGH
F1.16. Over-drain percentage	7%	14%	79%	HIGH
F1.14. Moisture Levels	14%	10%	76%	HIGH
F1.1. Greenhouse/tunnel temperature	7%	17%	76%	HIGH
F1.4. Wind speed	11%	21%	68%	HIGH
F1.2. Greenhouse/tunnel humidity	14%	21%	66%	MEDIUM
F1.5. Wind direction	14%	21%	64%	MEDIUM
F1.6. Solar radiation	17%	24%	59%	MEDIUM
F1.3. Outside temperature	7%	38%	55%	MEDIUM
F1.12. Light levels inside greenhouse	28%	17%	55%	MEDIUM
F1.15. Slab/pot weight	29%	21%	50%	MEDIUM
F1.17. Heating Temperatures	39%	11%	50%	MEDIUM
F1.11. CO2 levels inside greenhouse	52%	17%	31%	LOW

All external information points with regard to GCC should be included in an FMIS model. All the data points listed in Table 5-11 show that the majority of the respondents rated the points as important. Weather forecasts was rated high priority by 83% (n=25) of the respondents, professional technical assistance was rated high priority by 79% (n=24) of the respondents and training development had 69% (n=20) of the respondents rating high priority.

Table 5-11: External Information for GCC

Information	SD-D	N	A-SA	Priority
F2.3. Weather Forecasts	3%	14%	83%	**HIGH**
F2.1. Professional technical assistance	10%	10%	79%	**HIGH**
F2.2. Training and development	10%	21%	69%	**HIGH**

5.6. Reliability and Validity

Reliability and Validity as mentioned in [Section 4.6.1.4] are a means to determining the credibility of research findings. The credibility of the research, through various methods mentioned, will ascertain the accuracy of the measuring instrument as it relates to the study. With regard to the findings described the following provides an indication of credibility.

Table 5-12: Cronbach's alpha coefficients for the factors (n = 30)

Measured Factors	Cronbach Alpha	Reliability
Need for FMIS	0.68	Acceptable
CIS Performance	0.80	Moderate
HRM Data Importance	0.77	Low
HRM External Info Importance	0.66	Acceptable
FOM Data Importance	0.79	Low
FOM External Info Importance	0.52	Acceptable
GCC Data Importance	0.89	Moderate
GCC External Info Importance	0.76	Low
FIM Data Importance	0.85	Moderate
FIM External Info Importance	0.85	Moderate

The questionnaire [ANNEXURE B] was sent to Dr Venter for approval prior to the study and corrections were made. This ensured face validity and determined that the questionnaire was measuring what the study was set out to measure. With regard to reliability Table 5-12 indicates the reliability of the measured factors to be between 0.52 (acceptable for new studies and experimental research) and 0.89 (moderate reliability). The factors Cronbach Alpha’s therefor indicate the reliability of the questionnaire. With this assessment the measuring instrument can be deemed credible.

5.7. Conclusions

Chapter 4 described the empirical study and the methodology used. It addressed the research philosophy, approach, design and strategy. It defined the time horizon and all the techniques and procedures applied to conduct this empirical study.

Chapter 5 then described the results of the empirical study. The biographic details of the sample under study were described. The extent of the need for an FMIS and current information practices as they relates to the sample were discussed. With regard to the need for FMIS the study showed that there is definitely a gap in the industry for a software package to alleviate the burden of information management. Coupled with this gap is an enthusiasm or willingness from the farmers to trying different alternative options. The chapter then detailed what internal data and external information was important for the FMIS model as it related to the four functional areas:

1. Field Operations Management [FOM];
2. Human Resource Management [HRM];
3. Financial Information Management [FIM]; and
4. Greenhouse Climate Control [GCC].

It was also found with these functions, and the data points that accompany them, that there is a lot of data that needs to be taken into account and farm managers do not have the current infrastructure to adequately monitor all the bases.

In so doing this chapter addressed the following research objectives:

> **RO_5**: *Determine what internal data and external information is required for a FMIS.*

> **RO_4** – *Describe the current management of information*

With **RO_5** being addressed the following research questions were answered:

> **RQ_4** – *What is the current status of information management?*

> **RQ_5**: What components need to be included in the FMIS?

The current status of information management is largely dependent on the scale of an organisation. The larger an organisation is, the more advanced/developed the information system is and the tools for gathering that information. The smaller the organisation the more manual and less developed the information system. It was also found that larger organisations with capital intensive components like pad and fan ventilation, heating and greenhouse structures [Section 5.2.7.] were more interested in ensuring the full benefit of the component be obtained.

With regards to what components need to be included in an FMIS for hydroponic farmers the four components give a good indication as what is important. But as mentioned earlier in this chapter there is a need for information as far as it relates to the value it can contribute to a farmer. If a farmer does not have heating components or infrastructure, any heating related information will be of no use. If direct value can be seen by farmer for use of the information that will be the information that is worth-while. This can be seen in Field and Operation management [Section 5.5.1 and Table 5.3] where all the components are of good value and the tools required easily available. Green-house climate control [Section 5.5.4] alternatively lists data points that are easily available to the farmer but also data points that related to expensive equipment [Table 5-10] that is of no value to some farmers.

Chapter 6 will follow by concluding the study and presenting the FMIS model. It will bring together all the research objectives and ensure that the research questions have been answered as stipulated in Chapter 1.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. INTRODUCTION

This research study began with an introduction to the context of the research problem, questions and objectives. Context regarding the global and local challenges that farm managers are facing in their businesses. Global challenges regarding climate change, population growth, urbanisation, food security and water scarcity. The local challenges regarding the GDP of South Africa, the decreasing number of farmers, productivity and national consumption.

It was in light of this context that hydroponics was identified and motivated as a significant industry for future growth. Accompanying the global and local challenges that identify hydroponics as an important industry for future growth, is the development and advancement of ICT in agriculture. Section 3.2 described how the agricultural industry has transformed significantly to incorporate increasingly the elements of automation through computer technology. With this automation comes the increased access to information for decision making, report generation and documentation.

The initial problem statement identified in Section 1.2 was therefore: internal and external information is being disseminated and of limited value in information and knowledge creation. Information and knowledge that are vital for decision making, reporting and documentation. From this problem statement the following research objectives and questions were developed.

The primary objective of this research study was:

> **RO_m**: *To develop a conceptual model for an FMIS for the South African Hydroponic Industry that will help to transform data into information and knowledge.*

Building on this objective six secondary objectives were developed, accompanied by six research questions. Five of which have been answered in previous chapters. This chapter will answer RO_6 which is:

RO_6: Develop a conceptual model of an FMIS.

In meeting this objective RQ_6 will be answered. This question asks:

RQ_6: How can all the data and information be integrated into an FMIS?

In answering this last research question, all the research objectives and research questions from Section 1.4 will have been addressed and answered. This section will then continue to summarise all the research objectives and questions as listed in Section 1.3 . Limitations of the research and future research will be discussed to end this study. Section 6.4 will present the conceptual model of an FMIS at determined by this study.

Figure 6-1: Chapter 6 Outline

1. SCOPE OF THE STUDY
2. SOUTH AFRICAN HYDROPONICS INDUSTRY
3. FARM MANAGEMENT INFORMATION SYSTEMS
4. RESEARCH DESIGN AND METHODOLOGY
5. RESEARCH FINDINGS
6. CONCLUSIONS AND RECOMMENDATIONS
   - 6.1. INTRODUCTION
   - 6.2. RESEARCH SUMMARY
     - 6.2.1. RO_1: Determine the significance of the South African Hydroponics Industry
     - 6.2.2. RO_2: Describe the environment in which farm managers operate
     - 6.2.3. RO_3: Determine the purpose to be fulfilled by an FMIS
     - 6.2.4. RO_4: Describe the current management of information
     - 6.2.5. RO_5: Determine what internal data and external information is required
     - 6.2.6. RO_6: Develop a conceptual model of an FMIS
   - 6.3. AN FMIS MODEL
   - 6.4. LIMITATIONS OF THE RESEARCH
   - 6.5. FUTURE RESEARCH
   - 6.6. SUMMARY

6.2. RESEARCH SUMMARY

The study from the outset set out to meet the following research objectives and answer the research questions. Those objectives and questions are summarised below to ensure they have been satisfactorily answered.

6.2.1. RO_1: Determine the significance of the South African Hydroponics Industry

The reason for this objective was to determine how hydroponics has potential for future production increases to meet the needs of a growing population despite varying challenges. The outcome of this was to draw a link between global and local challenges and opportunities and the hydroponic industry. A production technique that is water efficient, doesn't need large areas, has significantly higher yields and quicker growth cycles. This therefore answers RQ_1 which asks what the significance of the hydroponics industry is in SA.

6.2.2. RO_2: Describe the environment in which farm managers operate

Agriculture was described as having an important role in society and of recent has an increased focus on production methods and techniques from a policy and efficiency perspective. The focus has moved from quantity to quality and sustainability. It incorporates the elements of ecological footprints, labour welfare, nutritional responsibility, plant and animal health and welfare, information transparency and economic responsibility. It is the responsibility of the farm manager to pay attention to the concerns of society and adhere to the applicable rules and regulation that govern and protect society's health and wellbeing. While doing so, farm managers also need to ensure business efficiency and profitability.

The environment therefore, which farmers find themselves in, is that of ensuring rules and regulations are adhered to and that business survive. This is a description of the environment in which farm managers are operating. In trying to run an operation they are under pressure from varying organisations and institutions. The objective being met in Section 3.2 RQ_2 which asks what factors are placing demands on famers.

6.2.3. RO_3: Determine the purpose to be fulfilled by an FMIS

The purpose of an FMIS as detailed in Section 3.4 is to accomplish the following goals:

- Improve farm activities;
- Reduce uncertainty in decision making;
- Facilitate Compliance;
- Manage overloads of information;
- Reduce office time;
- Create operational plans; and
- Generate reports.

These goals were identified in [Section 3.4] and were included in the questionnaire under NFMIS. The empirical study, especially questions regarding the need for FMIS of the findings, found that there is a need for an FMIS. This answers the question to what extent is there a need for an FMIS.

6.2.4. RO_4: Describe the current management of information

The empirical study asked respondents questions regarding their current information system (CIS) and found that all farmers use a combination of tools. The most popular were pen and paper (83% n = 25), Microsoft excel (67% n=20) and Proprietary software (43% n=13).

The performance of these systems, in regard to meeting the needs of the farmer, was found to be insufficient. [Section 5.4] highlights the details of these findings but it was found that there is a need for FMIS due to the lack of performance of the CIS. Farmers are generally happy with their systems but problems arise when it does not provide the desired reports, are difficult to use and maintenance of the systems is tedious. Concluding findings with regards to this objective is that farmers were predominantly open to considering alternative software solutions.

6.2.5. RO_5: Determine what internal data and external information is required

The empirical study set out to meet RO_5 and the findings were discussed in [Section 5.5]. The literature review in [Section 3.5] identified 4 functional areas to which internal data and external information points were identified. These points were used in the empirical study questionnaire [Annexure 2] to identify what points were required for an FMIS model. Section 5.5 detailed all the points that were used for developing an FMIS model and therefor answered RQ_5 which asked what components need to be included in and FMIS. The results from the empirical study were used to develop the FMIS presented in Figure 6-2: A BI FMIS.

6.2.6. RO_6: Develop a conceptual model of an FMIS

In Section 6.2 of this chapter RO_6 was met by the development of a FMIS model. The purpose of which was to integrate internal data and external information into a model that can be used by system developers to create systems to assist managers for decision making, report generation and documentation.

6.3. AN FMIS CONCEPTUAL MODEL

The purpose of this research was to develop a model for an FMIS that would integrate all the internal data and external information. Internal data and external information that farm managers need for decision making, report generation and documentation. This section of the study presents an FMIS model. The FMIS model is a BI (Business Intelligence) model that works on the principle of ETL (Extract, Transform and Load).

Figure 6-2: A BI FMIS

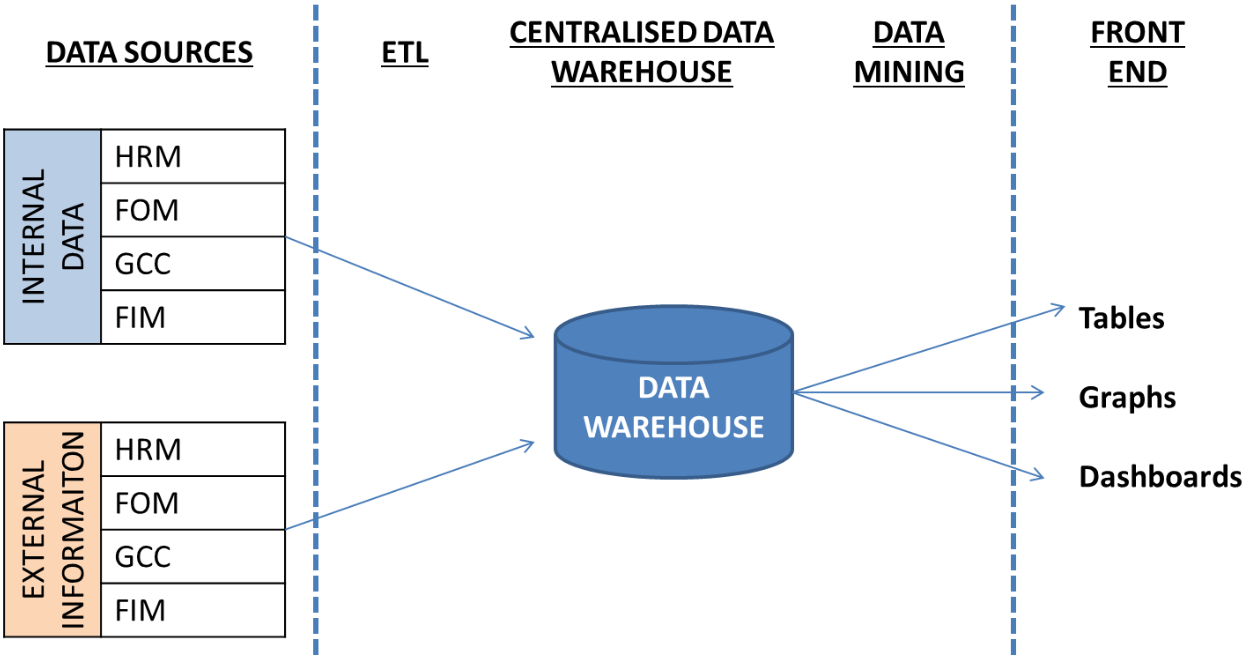


Figure 6-2 shows a BI FMIS. The basis of this model for an FMIS has been built on the premise that famers already have some systems in place that will benefit from BI. BI as discusses extracts data from internal (operational) data sources and external data sources. This model will address the problem of data and information being disseminated and of limited value in knowledge creation for decision makers. It brings all the different sources together upon which decisions can be made. Although, with a lot of data existing on paper, further investigation is required on capturing data which has been recorded on paper, in booklets and in journals.

6.4. LIMITATIONS OF THE RESEARCH

Limitations identified in this study were the following:

1. The study was limited to four functions out of a possible 11 functions.
2. The study was limited to internal data and external information and did not incorporate the various technological tools available for data and information modelling.
3. There were only 30 respondents.

6.5. FUTURE RESEARCH

Future research possibilities include the development of an actual product based on the model and farm manager's adoption of such a product. As mentioned in the findings the majority of managers are open to considering different alternatives to their current information system but literature mentions that adoption rates in the past have been poor. Possible explanation for this is due to lack of synergy between developers and manager who use the products. Future research could also investigate studying the 7 functional areas of an FMIS that are not covered in this study.

6.6. SUMMARY

The main objective of this study, RO_m was to develop an FMIS model for the SA hydroponic industry that will help to transform data into information and knowledge. This study started off by describing the rapid rate of change taking place within the business environment. It highlighted how sustainability is of great concern. It identified that farm managers in their capacity are under much pressure from various parties. Demands that have been placed on them by financial institutions, consumers, suppliers, government institutions etc. These demands have also resulted in accreditations and certification requiring large amounts of paper work and time.

The local and global environment in which farm managers are operating was also identified and hydroponics seen as potential production technique with great promise. Great promise to meet the rising food demand while remaining within the sustainability sphere.

And to help alleviate farmers from these demands placed on them this study set out to develop a conceptual model of an FMIS. A system making use of ICT that is capable of high speed processing, documentation and report generation.

This objective was broken down into 6 secondary research objective and questions that formed the framework of this study. Each of which was summarised in this chapter.

An FMIS model was developed to meet the following research objective and research questions.

RO_6: Develop a conceptual model of an FMIS.

RQ_6: How can all the data and information be integrated?

The model illustrated how the internal data and external information can be integrated to provide a base from which managers can make better decisions, generate reports and fulfil documentation requirements.

With this farm managers will be able to make better decisions and generate reports. Helping towards increasing sustainability, long-term survival and good application of knowledge.

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ANNEXURE A: COVER LETTER

COVER PAGE

Nelson Mandela Metropolitan University

for tomorrow

Information Management Questionnaire

Dear Sir / Madam,

I am a student at the Nelson Mandela Metropolitan University (NMMU) and am currently doing research for my Master's degree. The aim of the research is to determine the state of information management by farm managers in the hydroponics industry. I am creating a conceptual model of a Farm Management Information System (FMIS) for the industry. The questionnaire will address four functions described below:

1. Financial Information Management (FIM): This refers to the costs, revenues, financing, investing, input-output calculation, etc.;
2. Human Resource Management (HRM): This refers to labour records, contracts, employee performance, education, training, etc.;
3. Field Operations Management (FOM): This refers to greenhouse planning, pest and disease management, fertilizer application, nutrition, etc.;
4. Greenhouse Climate Control (GCC): This refers to the system that records and monitors greenhouse temperature and humidity, EC and pH water conditions, water usage, etc.

The purpose of developing this model would be towards assisting managers with decision making, report generation and documentation.

The information gathered from this questionnaire will be held strictly confidential. The use of which will be purely academic writing and reporting. The information given will also be presented anonymously in an aggregated fashion and no details of individuals or company names will be mentioned.

Thank you for your time.

Yours sincerely,

Justin Cork

MBA Student

Supervisor: Dr. Tony Simpson

Co-Supervisor: Prof Andre Calitz

ANNEXURE B: QUESTIONNAIRE

BIOGRAPHIC DETAILS

Please complete the following regarding details about you and your farm.

Personal Details			
1	Gender		Male
			Female
2	Education Level		<Gr 12
			Gr12
			Diploma
			Degree
			Post Grad.
3	Designation		Owner & Manager
			Manager Only
4	Born between		<1945
			1946-1964
			1965-1983
			>1984

Farm Details			
5	What year did you start Undercover?		
6	Area Under Cover (Square meters)		m^2
7	Structure		Greenhouse
			Tunnel
			Both
	If other please indicate:		
8	Ventilation Type		Pad and Fan
			Butterfly Vents
			Single Vents
			Curtain
	If other please indicate:		
9	Do you have insect nets?		Yes
			No
10	Do you have heating?		Yes
			No
11	What crops are you growing under cover?		Tomatoes
			Peppers
			Cucumbers
			Brinjal
			Lettuce
	If other please indicate:		
12	Area produced outside (Hectares)		Ha
13	Number of staff		1-9
			10-19
			20-49
			>49

NEED FOR FARM MANAGEMENT INFORMATION SYSTEM (NFMIS)

NEED FOR FMIS

The following statements relate to your need for a Farm management Information System. Indicate whether you Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A) or Strongly Agree (SA) with these statements.

		SD	D	N	A	SA
1	There is a need to improve farm activities.	1	2	3	4	5
2	There is a need to reduce uncertainty in decision making.	1	2	3	4	5
3	Certification is difficult.	1	2	3	4	5
4	I have an overload of information.	1	2	3	4	5
5	I spend too much time with data and information in the office.	1	2	3	4	5
6	I consult many information sources when making decisions.	1	2	3	4	5
7	I have little need for report generation.	1	2	3	4	5

CURRENT INFORMATION SYSTEMS (CIS)

CURRENT SITUATION

1	What information system/s do you currently use? Tick all applicable.		Proprietary
			Microsoft Excel
			Microsoft Access
			Pen and Paper
	If other please indicate:		

2. The following statements relate to your current information systems (CIS).Indicate whether you Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A) or Strongly Agree (SA) with these statements.

		SD	D	N	A	SA
2.1	It stores all the relevant data.	1	2	3	4	5
2.2	It provides adequate information for planning purposes.	1	2	3	4	5
2.3	It provides adequate information for decision making.	1	2	3	4	5
2.4	It gives me an accurate indication of how the farm is doing.	1	2	3	4	5
2.5	There are some things I would like to know that are not provided by my CIS.	1	2	3	4	5
2.6	Too much time is spent managing my CIS.	1	2	3	4	5
2.7	My CIS is difficult to maintain.	1	2	3	4	5
2.8	I am happy with the reports that it can give me.	1	2	3	4	5
2.9	I am open to considering an alternative.	1	2	3	4	5

HUMAN RESOURCE MANAGEMENT (HRM)

HUMAN RESOURCE MANAGEMENT

1. The following is a list of data items relating to human resources. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (very important) how important this data is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

1.1	Employee personal details.	1	2	3	4	5
1.2	Employee performance.	1	2	3	4	5
1.3	Employee Disciplinary Record.	1	2	3	4	5
1.4	Employee Attendance Record.	1	2	3	4	5
1.5	Job descriptions.	1	2	3	4	5
1.6	Employee Contracts.	1	2	3	4	5
1.7	Hours Worked.	1	2	3	4	5
1.8	Employee Employment History.	1	2	3	4	5
1.9	Details of Terms and conditions.	1	2	3	4	5
1.10	Pension Records.	1	2	3	4	5
1.11	Record of Training and Development.	1	2	3	4	5
1.12	Record of Trade Union/Employee Representative Meetings.	1	2	3	4	5
1.13	Contract Termination Records.	1	2	3	4	5
1.14	Employee Rates.	1	2	3	4	5
1.15	Skill Levels.	1	2	3	4	5
1.16	BEE Status.	1	2	3	4	5
1.17	Health and Safety Records.	1	2	3	4	5
If any other, please indicate the item and level of importance.						
1.18		1	2	3	4	5
1.19		1	2	3	4	5

2. The following is a list of information available from external sources relating to human resource. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (Very important) how important this information is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

2.1	Department of Labour.	1	2	3	4	5
2.2	Employment Equity.	1	2	3	4	5
2.3	Trade Unions.	1	2	3	4	5
2.4	Government Incentives.	1	2	3	4	5
If any other, please indicate the item and level of importance.						
2.5		1	2	3	4	5
2.6		1	2	3	4	5

FIELD OPERATIONS MANAGEMENT (FOM)

FIELD OPPERATIONS

1. The following is a list of data items relating to field operations. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (Very important) how important this data is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

1.1	Labour Allocation	1	2	3	4	5
1.2	Work Plans	1	2	3	4	5
1.3	Production Volumes	1	2	3	4	5
1.4	Planting Dates	1	2	3	4	5
1.5	Chemical Application Records	1	2	3	4	5
1.6	Fertilizer Application Records	1	2	3	4	5
1.7	Harvesting Data	1	2	3	4	5
1.8	Pest and Disease Levels	1	2	3	4	5
1.9	Plant Growth	1	2	3	4	5
1.10	Variety Performance	1	2	3	4	5
1.11	Fuel Usage	1	2	3	4	5
1.12	Machinery Maintenance	1	2	3	4	5
1.13	Harvest Quality: 1st, 2nd, 3rd grades and waste	1	2	3	4	5
1.14	Electricity Consumption	1	2	3	4	5
1.15	Crop Performance: Lettuce, Tomatoes, Peppers, etc.	1	2	3	4	5
1.16	Production Plan: Production Forecast or production budgets	1	2	3	4	5
1.17	Mortalities	1	2	3	4	5

If any other, please indicate the item and level of importance.

1.18		1	2	3	4	5
1.19		1	2	3	4	5

2. The following is a list of information available from external sources relating to field operations. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (Very important) how important this information is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

2.1	Technical Assistance: Agronomists, Consultants etc.	1	2	3	4	5
2.2	Training: External Training and Development	1	2	3	4	5
2.3	Suppliers: Product Information, medium, seed, plastic etc.	1	2	3	4	5
2.4	Accreditation Institutions: GlobalG.A.P., HASSP, FairTrade etc.	1	2	3	4	5
2.5	Study Group	1	2	3	4	5

If any other, please indicate the item and level of importance.

2.6		1	2	3	4	5
2.7		1	2	3	4	5

GREENHOUSE CLIMATE CONTROL (GCC)

GREENHOUSE ENVIRONMENT CONTROL

1. The following is a list of data items relating to greenhouse climate. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (Very important) how important this data is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

1.1	Greenhouse/tunnel temperature	1	2	3	4	5
1.2	Greenhouse/tunnel humidity	1	2	3	4	5
1.3	Outside temperature	1	2	3	4	5
1.4	Wind speed	1	2	3	4	5
1.5	Wind direction	1	2	3	4	5
1.6	Solar radiation	1	2	3	4	5
1.7	Quantity of water given	1	2	3	4	5
1.8	Quantity of over drain	1	2	3	4	5
1.9	EC and pH of water given	1	2	3	4	5
1.10	EC and pH of over drain	1	2	3	4	5
1.11	CO2 levels inside greenhouse	1	2	3	4	5
1.12	Light levels inside greenhouse	1	2	3	4	5
1.13	Water Quality	1	2	3	4	5
1.14	Moisture Levels	1	2	3	4	5
1.15	Slab/pot weight	1	2	3	4	5
1.16	Over-drain percentage	1	2	3	4	5
1.17	Heating Temperatures	1	2	3	4	5
1.18	Irrigation start and stop times	1	2	3	4	5

If any other, please indicate the item and level of importance.

1.19		1	2	3	4	5
1.20		1	2	3	4	5

2. The following is a list of information available from external sources relating to greenhouse climate. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (Very important) how important this information is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

2.1	Professional technical assistance	1	2	3	4	5
2.2	Training and development	1	2	3	4	5
2.3	Weather Forecasts	1	2	3	4	5

If any other, please indicate the item and level of importance.

2.4		1	2	3	4	5
2.5		1	2	3	4	5

FINANCIAL INFORMATION MANAGEMENT (FIM)

FINANCIAL INFORMATION MANAGEMENT

1. The following is a list of data items relating to financial information. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (Very important) how important this data is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

1.1	Capital Expenses: Buildings, Machinery, equipment	1	2	3	4	5
1.2	Cost of Sales: Fertilizer, medium, chemical etc.	1	2	3	4	5
1.3	Labour costs	1	2	3	4	5
1.4	Sales prices	1	2	3	4	5
1.5	Sales volumes	1	2	3	4	5
1.6	Marketing costs	1	2	3	4	5
1.7	Administrative costs	1	2	3	4	5
1.8	Over-head costs	1	2	3	4	5
1.9	Machinery performance: Repairs and Maintenance	1	2	3	4	5
1.10	Cash Flow	1	2	3	4	5
1.11	Budgets	1	2	3	4	5

If any other, please indicate the item and level of importance.

1.12		1	2	3	4	5
1.13		1	2	3	4	5

2. The following is a list of information available from external sources relating to financial information. Based on your experience and needs please indicate on a scale of 1 (Not important) to 5 (Very important) how important this information is to your planning, reporting and decision making.

NOT IMPORTANT ⟷ VERY IMPORTANT

2.1	Foreign Exchange Rates	1	2	3	4	5
2.2	Bank Interest Rates	1	2	3	4	5
2.3	Suppliers: Price changes	1	2	3	4	5
2.4	Bank: Financing	1	2	3	4	5
2.5	Government: Minimum wage determination	1	2	3	4	5
2.6	SARS: New tax legislation	1	2	3	4	5
2.7	Political Environment	1	2	3	4	5
2.8	Social Environment: Strikes, attacks, etc.	1	2	3	4	5
2.9	Economic Indicators: Rand value, trends etc.	1	2	3	4	5

If any other, please indicate the item and level of importance.

2.10		1	2	3	4	5
2.11		1	2	3	4	5

THANK YOU FOR YOUR PARTICIPATION.
IF YOU WOULD LIKE FEEDBACK PLEASE PROVIDE YOUR E-MAIL ADDRESS.

e-mail:

ANNEXURE C: ETHICS CLEARANCE

Nelson Mandela Metropolitan University

for tomorrow

FORM E

ETHICS CLEARANCE FOR TREATISES/DISSERTATIONS/THESES

Please type or complete in black ink

FACULTY: BUSINESS AND ECONOMIC SCIENCES

SCHOOL/DEPARTMENT: BUSINESS SCHOOL

I, (surname and initials of supervisor) Simpson, A. P.

the supervisor for (surname and initials of candidate) Cork, J. T. J.

(student number) 204 091 577

a candidate for the degree of MBA.

with a treatise/dissertation/thesis entitled (full title of treatise/dissertation/thesis):

A CONCEPTUAL DESIGN OF AN INTEGRATED FARM MANAGENT INFORMATION SYSTEM FOR THE HYROPONIC INDUSTRY OF SOUTH AFRICA.

considered the following ethics criteria *(please tick the appropriate block)*:

	YES	NO
1. Is there any risk of harm, embarrassment of offence, however slight or temporary, to the participant, third parties or to the communities at large?		X
2. Is the study based on a research population defined as 'vulnerable' in terms of age, physical characteristics and/or disease status?		X
2.1 Are subjects/participants/respondents of your study:		
(a) Children under the age of 18?		X
(b) NMMU staff?		X
(c) NMMU students?		X
(d) The elderly/persons over the age of 60?		X
(e) A sample from an institution (e.g. hospital/school)?		X
(f) Handicapped (e.g. mentally or physically)?		X

3. Does the data that will be collected require consent of an institutional authority for this study? (An institutional authority refers to an organisation that is established by government to protect vulnerable people)		✓
3.1 Are you intending to access participant data from an existing, stored repository (e.g. school, institutional or university records)?		✓
4. Will the participant's privacy, anonymity or confidentiality be compromised?		✓
4.1 Are you administering a questionnaire/survey that:		
(a) Collects sensitive/identifiable data from participants?		✓
(b) Does not guarantee the anonymity of the participant?		✓
(c) Does not guarantee the confidentiality of the participant and the data?		✓
(d) Will offer an incentive to respondents to participate, i.e. a lucky draw or any other prize?		✓
(e) Will create doubt whether sample control measures are in place?		✓
(f) Will be distributed electronically via email (and requesting an email response)? Note: • If your questionnaire DOES NOT request respondents' identification, is distributed electronically and you request respondents to return it *manually* (print out and deliver/mail); AND respondent anonymity can be guaranteed, your answer will be NO. • If your questionnaire DOES NOT request respondents' identification, is *distributed via an email link and works through a web response system (e.g. the university survey system); AND* respondent anonymity can be guaranteed, your answer will be NO.		✓

Please note that if ANY of the questions above have been answered in the affirmative (YES) the student will need to complete the full ethics clearance form (REC-H application) and submit it with the relevant documentation to the Faculty RECH (Ethics) representative.

and hereby certify that the student has given his/her research ethical consideration and full ethics approval is not required.

SUPERVISOR(S) — DATE: 17/8/2015

PP HEAD OF DEPARTMENT — DATE: 10/9/2015

STUDENT(S) — DATE: 17/04/2015

Please ensure that the research methodology section from the proposal is attached to this form.

Please note that by following this Proforma ethics route, the study will NOT be allocated an ethics clearance number.

ANNEXURE D: TURNITIN REPORT