An Investigation into the Environmental Sustainability of the South African Ornamental Horticultural Industry

submitted by

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DECLARATION

Student number: 32484755

I, Cary Leigh Goodwin, declare that "An Investigation into the Environmental Sustainability of the South African Ornamental Horticultural Industry" is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of a complete reference list. An investigative literature review showed that no similar research had been conducted in South Africa prior to the commencement of this research project.

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Goodwin

28 January 2023

SIGNATURE DATE

(Miss Cary Goodwin)

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ABSTRACT / SUMMARY

The ornamental horticultural industry makes use of natural resources to grow plants and produce allied products to sell to consumers, landscapers, retail garden centres, hardware stores, supermarkets, and government, but at what cost to the environment?

The aim of this work was to determine the current environmental awareness of growers and garden centre retailers within the ornamental horticultural industry in South Africa. Followed by an investigation into the current business practices that promote sustainable natural resource use and management as well as the obstacles and challenges that the industry faces with implementing legislation and recommendations of best practices. The study was conducted over an 18-month period and 41 growers and retail garden centres in eight of the provinces in South Africa (Appendix 10) participated in research. In each case, the study participant was asked to complete the questionnaire and where possible, a site visit was conducted and / or a semi-structured interview as well as participatory observations followed to give a comprehensive overview of the sustainability practices of the businesses. These results were then compared to international best practices and similar research conducted globally by the ornamental horticultural industry. A review of international best practices in the ornamental horticultural industry showed six environmental resources namely soil, water, fertilizers, pesticides, energy, and waste. This was seen to be common to most studies involved in the production, growth, maintenance and sales of plants and allied products. This information was used to compile a best management practice manual for South African ornamental horticulture with guidelines and practical examples for conserving and managing natural resource usage and reducing the environmental impacts of the industry.

Much research has been done on the exploitation and degradation of resources due to urbanisation, industrial activities, and agricultural practices. The resources are essential to the ornamental horticultural industry but if exploited or misused, can have detrimental effects on the environmental productivity of the industry and ultimately the *"Sustainable Development Goals"* prescribed by the United Nations. The linking of the relevant sustainable development goals to the 9 key factors of

the green economy strategized by the South African government will enable the ornamental horticultural industry to play a greater part in the green and circular economy by providing nature-based solutions to environmental problems that it is facing such as climate change and pollution.

GLOSSARY (Key terms)

Climate change, circular economy, green economy, natural resources, nature-based solutions, ornamental horticultural industry, pollution, population growth and sustainable development.

LIST OF ABBREVIATIONS

ABSTA	Allied, Bulb and Seed Trade Association
AFP	Air-Filled Porosity
BPM	Best Management Practices
CARA	Conservation of Agricultural Resources Act 1983
DEA	Department of Environmental Affairs
EC	Electrical Conductivity
EF	Ecological Footprint
ESKOM	Electricity Supply Commission
FAO	Food and Agriculture Organization
GDEI	Global Development And Environment Institute
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GI	Green Industry
IGCA	International Garden Centre Association
ISO	International Organization for Standardization
IPM	Integrated pest management
IPPS	International Plant Propagators' Society
KAP	Knowledge, Attitudes and Practices
LCA	Life Cycle Assessment
MDG	Millennium Development Goals
NAAQS	National Ambient Air Quality Standard
NBS	Nature-Based Solutions
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NEWMBA	National Environmental Management Waste Act
NGIA	Nursery and Garden Industry Australia
NWA	National Water Act
OECD	Organization for Economic Co-operation and Development
OHI	Ornamental Horticultural Industry
OHISA	The Ornamental Horticultural Industry of South Africa
OPPASA	Outdoor Power Product Association of South Africa
PAR	Participatory Action Research

SA	South Africa
SADC	Southern African Development Community
SAGIC	South African Green Industries Council
SALI	South African Landscape Institute
SANA	South African Nursery Association
SDG	Sustainable Development Goals
SIZA	Sustainability Initiative of South Africa
UN	United Nation
UNDESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USA	United States of America
WEF	Water-Energy-Food Nexus
WHO	World Health Organization
WWAP	World Water Assessment Programme
WWF	World Wildlife Fund

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

DEFINITION OF TERMS

Allied trade: ornamental horticultural industry products that are not plants, often described as non-green goods or hard goods (South African Nursery Association, 2018). Examples are organics, pesticides, fertilizers, tools, garden furniture, irrigation etc.

Alternative fuels: materials and or substances that can be used as an energy source e.g., biomass energy other than conventional fuels like fossil fuels or nuclear fuel (Dinçer and Zamfirescu, 2011).

Best practice: ideas, methods or techniques that are accepted as effective in delivering results. These recommended methods should be able to be repeated and render similar results to be called a “best practice”. They are collaboratively researched, discussed, and often converted into policy by experts in the field.

Biosphere: an area where living organisms exist and have created products, habitats and more to survive. It is a global ecosystem where relationships between biotic and abiotic factors are formed.

Ecological Footprint: an area of land with access to water and other resources which a population needs to be able to survive. A space in which they can produce food and manufacture products for consumption and collect or dump the resultant waste. It can be greater than the physical piece of land occupied due to the importing and sourcing of resources and products globally (Wackernage and Rees, 1997).

Environmental management: for the purposes of this study is defined as the methodical manner to find innovative, practical, and sustainable ways for saving water, energy, and materials especially limited natural resources, while reducing detrimental environmental impacts such as pollution and creating excessive waste.

Farming for the Future: this is a business practice model that the suppliers of particular chain stores must adhere to. It is based on sound agricultural practices, adhere to legislations and regulations, and recommends sustainable environmental practices.

Fossil Fuels: hydrocarbon-containing material of biological origin formed over the course of millions of years and that can be burned for energy.

GlobalGAP: this initiative was started in the United Kingdom by the food chains to ensure that the farmers supplying them were following safe food handling practices and sustainable agricultural farming practices.

Green Economy: growing economic activity in the green industry sector while also shifting the economy towards cleaner industries and sectors with a low environmental impact.

Greenhouse Gases: refers to those gases int he atmosphere that influence the earth's energy balance by absorbing and emitting radiant energy within the thermal infrared range.

Environmental productivity factors: environmental productivity is the effective use of natural resources and related residues to produce an output (Repetto, 1990). The five key factors associated with environmental productivity for the purposes of this study are: energy production, nutrients, pesticides, soil / media, and water.

Garden centres or retail nurseries: these two are synonyms. They represent a retail operation that sells quality plants and associated (allied) products such as gardening hardware for home gardens and landscaping (Crafer, 2015).

Green Industry: those role-players involved in environmental services e.g., landscaping, lawn mowing, plant production, garden centres, irrigation specialists, indoor plant producers including the gardening public (Hoy, 2009).

Natural resources: substances or stock of the earth, and include air, water, land and biodiversity which are essential to ecosystem functioning and service provision (Brown, Bergstrom and Loomis, 2007; Green *et al.*, 2017).

Nursery: is an area where plants are propagated and grown to a size at which they are then sold to retail nurseries, the general public, landscapers, government departments, institutions and / or developers (Singh, Meena and Singh, 2017). There are various types including, wholesale, retail, online, specialised growing, forestry to name a few. This study focused on wholesale and retail nurseries.

Ornamental Horticulture: is a broad field that includes the production of annuals, perennials, trees, shrubs, water plants and bulbs but excludes the growing of fruits and vegetables for commercial purposes. These plants can be used for landscape design, retailing, garden tourism, developments, and wholesale projects. It also encompasses the manufacturing of garden goods which are allied to the sale of plants e.g., fertilizers, chemicals, garden furniture, water features, wooden products as well as arboriculture (Oxford Economics, 2018).

The South African Ornamental Horticultural Industry (OHISA): this industry is represented by the South African Green Industries Council (SAGIC) which includes members such as the South African Nursery Association (SANA), South African Landscapers Institute (SALI), The Cape Green Forum, Outdoor Power Product Association of South Africa (OPPASA) and others.

Plant production nurseries, wholesale nurseries or growers: these sites are where plant propagation, seedling cultivation and growing occurs to produce a saleable plant (Sharp and & Shah, 2019).

Chapter 1: Background

Globally, there are concerns surrounding environmental conservation within the process of economic progress and this has necessitated the evolution of “green” growth models or environmentally sustainable guidelines, particularly in developing nations (Jiang, 2015). International development strategies encourage the green industry to develop resources with a reduced effect on the environment (United Nations Industrial Development Organization (UNIDO), 2009). These resource developments strive to strike a balance between environmental protection (conservation) and social and economic progress and include the use of low carbon mechanisms, energy-efficient use of waste materials and the application of environmental policies and schemes that meet global commitments such as the Sustainable Development Goals (SDGs) and the Paris Agreement on climate change (United Nations Educational scientific and cultural organization, 2005).

In South Africa, environmental resources such as water, land, flora, fauna and minerals provide a foundation for human interactions and economic activity (South African Statistics, 2017). Thus, the measurement and management of these resources is vital to ensure sustainable development within the country (National Development Plan, 2012). On this basis, the ornamental horticulture industry in South Africa is dependent on these natural resources, and their use and impact should be continually assessed.

This chapter presents the background and context of the study where the aims were to explore:

- Environmental awareness of growers (plant producers or wholesalers) and nurseries or retail garden centres
- Business practices within the ornamental horticulture industry in terms of the sustainable use of South Africa’s natural environmental resources such as soil, water, and energy
- Obstacles facing the industry with regards to the implementation of legislative requirements and conservation of these resources.

1.1 Problems motivating the study

Within the 20 years to 2020, the world population has increased by 21,18% to over 7,795 billion (United Nations, 2020) and this figure is projected to increase to 9.7 billion by 2050 (Leridon, 2020). This will increase natural resource usage and degradation of the ecosystems (Mittal and Gupta, 2015). In developing countries where population growth is relatively high, especially in sub-Saharan Africa, the success of sustainable development is further hampered by this increasing population as well as by climate change and unpredictable weather patterns (United Nations, 2020b). In South Africa, the population grew by 24,18% in the last two decades to 59,309 million people in 2020 (Worldometer, 2019). The increasing world population is placing ever-increasing demands on agricultural resources such as land (Barthel *et al.*, 2019) and water, thus forcing agricultural activities that require water use in crop production processes to find improved and economically viable systems (Davis *et al.*, 2016).

Ornamental horticulture has followed the changes that have happened in international agriculture (Ingels, 2009) and it follows that ornamental horticulture will similarly place demands on natural resources. However, due to its intensive nature, compared to agriculture in general, the effects of horticulture can be significantly greater on a smaller land area (Lillywhite, 2014).

In addition, it has become apparent that governments, businesses, and individuals can no longer indiscriminately waste natural resources or pollute the existing ecosystems without being accountable to local community stakeholders (United Nations Environment Programme, 2013). Unfortunately, basic resources such as power (electricity), water, arable land, and employment opportunities that we have taken for granted are no longer a given. This affects the way in which both individuals and businesses must think about the true costs of energy supply and demand, petro-dictatorship, climate change, poverty, and biodiversity loss. All these factors are becoming more visible, measurable and the experience of them within the industry and individual’s lives is becoming more evident (Friedman, 2008).

According to the South African Department of Environmental Affairs, estimates of environmental sustainability show that South Africa has already exceeded its ecological carrying capacity (Department of Environmental Affairs, 2016). An ecological footprint (EF) is a method of measuring ecological carry capacity (Cao and Xie, 2007) and environmental degradation (Danish, Hassan, *et al.*, 2019). The area (m^2) of land and resources needed for a population to conduct their daily tasks which involves e.g., production, consumption and waste assimilation determines their ecological footprint (Ulucak and Bilgili, 2018). Expanding on this EF is biocapacity which calculates the "productivity of the ecological assets" of an area i.e., it is a measurement tool that reflects the ability of renewable resources to regenerate considering the effects of the EF. The greater the EF, the higher the probability of a biocapacity deficit where the land and resources cannot support and regenerate fast enough for current and growing population and their lifestyles. The population size per capita (of people) measured in "global hectares" affects both the EF and biocapacity of the country (Global Footprint Network, 2022b). South Africa has a negative ecological footprint which has increased from 1,18 gha per person in 2012 to 3.8gha per person in 2018 (Table 1.1) (Global Footprint, 2012; Global Footprint Network, 2022b) compared to the world average in 2018 of 2.8gha/person. According to recent research, humans are depleting 1.8 earths instead of just one, causing an "over-shoot" of resource utilization resulting in greater environmental stresses, reducing the recuperative capacities of renewable resources and, in turn, resulting in more challenges for survival of the human population (Blum and Wackernagel, 2020; Global Footprint Network, 2022a).

Table 1.1: Ecological footprint of some countries as at 2018. Adapted from (Global Footprint Network, 2022a)

Country	Per Capita GDP	Population (millions)	Total Ecological Footprint (Production)*	Total Ecological Footprint (Consumption)*	Total biocapacity*	Ecological (Deficit) or Reserve*	Number of Earths required
Australia	$57,03	24.9	10.8	7.1	11.5	4.4	4.5
Canada	$51,52	37.1	11.7	8.1	14.7	6.7	5.1
China	$7,469	1,459.4	3.5	3.8	0.9	2.9	2.4
India	$2,085	1,352.6	1.2	1.2	0.4	(-0.8)	0.8
Nether-lands	$55,36	17.1	3.6	5.7	0.8	(4.9)	3.6
Nigeria	$2,384	195.9	1.0	1.1	0.7	(0.4)	0.7
South Africa	$7,440	57.8	3.4	3.8	1.0	(2.8)	2.4
United Kingdom	$42,89	67.1	2.7	4.2	1.0	(3.2)	2.6
United States of America	$54,72	327.1	7.8	8.1	3.4	(4.7)	5.1
World		7,631.1	2.8	2.8	1.6	(1.2)	1.8

*gha per person

Population growth is one of the factors contributing to natural resource exploitation and over the last two centuries, activities have increased mechanization of processes, technological innovations, and agricultural advancement in the name of progress. This industrial revolution has increased the rate at which human activities have contributed towards altering the climate and the environment to increase temperatures (global warming), as well as unstable and extreme weather patterns (climate change) such as flooding and droughts, and environment degradation (Mgbemene, 2011).

Climate change is a certainty, and the effects thereof will not only influence the way we live and the ecosystems around us but more specifically horticulture e.g., global water cycle changes causing droughts and flooding, and warmer temperatures resulting in a variations in expected crop yields (Khan & Hakeem, 2015). In Africa, population growth, increased pressure on agricultural crops and livestock and water stress resulting from climate change was already documented in 2007 (IPCC, 2007) and in sub Saharan Africa it was predicted to get worse with a decrease of productive land becoming more arid. The predicted loss of agricultural productivity from 21% to 9% by 2080 was reiterated in 2016 by the World Food Programme (World Food Programme, 2016). Its negative effects were highlighted again in the discussion of the water-energy-food nexus of the Southern African Development Community (SADC) region where agricultural enterprises and subsistence farming support over 60% of the population. In this region, it is predicted that rainfall will decrease by 20% by 2080, thus detrimentally impacting populations because of the resultant food shortages and energy supply (Mpandeli *et al.*, 2018). In South Africa, the effect of climate change on food security has been noted over some years especially during the droughts of 2016 (Masipa, 2017), which continued in some provinces until 2018 so that the ornamental horticultural industry weakened and businesses had to change their product range to include more succulents, water wise plants and water-saving products such as water tanks and spray bottles (SANA, 2018). The industry had to enhance their knowledge and skills to be resilient and survive.

1.2 Significance of the study

Human activity has always generated environmental impacts e.g., animal and plant extinctions, biodiversity loss, land degradation, pollution etc., but the relationship between humans, plants, insects and soil is essential to human existence. Amongst others, plants provide sustenance and through the process of photosynthesis they use carbon dioxide (CO_2) from the atmosphere, produce oxygen (O_2) and organic matter, which sustains earthly ecosystems of which humans are a part (Ingels, 1994; Cavicchioli *et al.*, 2019).

Sustainable development strives to strike a balance between environmental protection (conservation) and social and economic progress (UNESCO, 2005). More simply, it incorporates social, economic, and environmental factors when considering growth. According to Rockström, Klum and Miller, (2015), we must swiftly fortify the earth’s resilience and move away from the exploitation of its natural resources. It is for this reason that the United Nations Department of Economic and Social Affairs (UNDESA) uses the term “green economy” to facilitate policy development, international cooperation, and support sustainable development (United Nations Department of Economic and Social Affairs, 2011).

The objectives of sustainability and associated development goals defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO) are reiterated in the South African constitution, which states that everyone has the right to “*.. an environment that is not harmful to their health or well-being and…an environment protected for the benefit of the present and future generations through reasonable legislation and other measures that prevent pollution and ecological degradation, promote conservation (and) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development*” (Republic of South Africa, 1996).

According to the King III Report, in the 21st century, sustainability and the measure thereof is of vital importance both morally and economically (Institute of Directors in Southern Africa, 2009). Superficial changes in the name of sustainability are no longer enough in today’s environmental and economic climate and business leaders need to understand the way that the natural, social, cultural, and economic environments interact. Such an understanding will allow them to make informed and responsible decisions and to implement dramatic changes in operations and management in their companies.

There is thus a great deal of pressure on the ornamental horticultural industry to optimise its production of quality plants as this industry makes extensive use of environmental resources such as land and water as well as fertilizers and chemicals that could indirectly pollute land, water, and other natural resources (Wainwright et al., 2014). Furthermore, ornamental horticulture also uses resources to produce quality plants for food, medicine, timber, fuel lubricants, flowers, fragrances, shade, clothing as well as for inspiration and their aesthetic value (Ingels, 1994; Crafer, 2015). In addition, there are many businesses involved in the process of plant production and sales including production nurseries, greenhouse growers, horticultural services, landscapers, sod growers, retail garden centres, home improvement garden centres (box stores), and chain stores. These businesses also include allied trade (the manufacturers, distributors of inputs for growing e.g., fertilizer suppliers, pesticides, hardware etc.). Together these businesses are referred to as the “green industry” (Hall and Dickson, 2011). Although this industry is part of agriculture, it is unique because once the plant or product is sold to the consumer, it has a “second life” under the care of the consumer that can last for decades. This “second life” also generates a significant economic impact through the services sector of ornamental horticulture (Maxime et al., 2014). “*We have the only product sold at retail that goes on to have a positive impact on the environment - the plants*” (Ball & Ball, 2022).

The reality of responsibility towards the environment within the horticultural industry has brought about new research being conducted internationally on the effect of horticultural practices and how these affect the environment (Dominguez, Mibus-Schoppe & Sparke, 2017; Havardi-Burger, Mempel and Bitsch, 2020; Bonaguro *et al.*, 2021). The need to develop methods of assessing environmental productivity and reducing the carbon footprint associated with the horticulture industry has become important (Dennis *et al.*, 2010; Maxime *et al.*, 2014; Soode *et al.*, 2015; De Silva and Forbes, 2016; Michigan State University, 2016; Horticulture Innovation Australia, 2021).

Plant production nurseries in Australia and the United States were some of the first to start assessing and improving their business practices hoping to increase profitability by reducing costs for inputs such as water, fertilizer, and pesticides (Smith and Lopes, 2009; Nursery & Garden Industry Australia, 2010; Rideout et al., 2011). Production nurseries also started conserving and enriching these resources rather than wasting and polluting them so becoming part of the green economy and being “good neighbours” for their communities (Johnson, Mangiafico and Obropta, 2011a). Following on from these, the Canadian Ornamental Horticultural Alliance produced a best practises manual for their industry (Maxime et al., 2014).

Best management practices (BMPs) can be defined as voluntary practices, schedules of activities, maintenance procedures, and structural or other management decisions that have been found to be the most effective and practical means to prevent or reduce impacts on the environment. As described in preceding paragraphs, the production and sale of plant material involves the intensive use of natural resources and the unmitigated use thereof in concentrated areas such as nurseries can cause resource depletion and negative environmental impacts in that area (Lillywhite, 2014; Maxime et al., 2014; Wainwright et al., 2014).

More recently, European plant producers and retail garden centres started investigating the sustainability of their business practices (Lazzerini *et al.*, 2018; Havardi-Burger, Mempel and Bitsch, 2020). When similar searches in best practices or sustainability of ornamental horticulture were undertaken with specific reference to South Africa, relatively few scientific articles were found. Examples of South African-related research in the field of study focused on:

- The trade of indigenous plant species for medicinal purposes (Xego, Kambizi and Nchu, 2016; Maseko *et al.*, 2017; Omotayo *et al.*, 2020)
- The effects and management of invasive species on the natural environment (Dew *et al.*, 2017; McLean *et al.*, 2017; Potgieter *et al.*, 2019; van Wilgen, Measey, David M. Richardson, *et al.*, 2020)
- Sustainability and floriculture (Coetzee & Hoffman, 2018; Reinten et al., 2018)
- Sustainability and ornamental horticulture – biodiversity (Wynberg, 2002).

A search of the SAGIC and International Plant Propagators' Society (IPPS) websites provided no specific reports or standards that provide advice, guidance, or standards for sustainability within this South African industry. The SANA website has only basic guidelines as to chemical usage and waste recyclers (SANA, 2017). This preliminary research suggests that there is a gap in the literature and knowledge with regards to the sustainability of the ornamental horticultural industry in South Africa and it requires investigation.

This current research project includes the current situation of growers and garden centres in terms of their environmental policies, their impact and prospective recommendations and changes they would need to make to decrease their impact on South Africa's environment into the future. Having taken these factors into consideration, the current research project was designed to investigate the knowledge, attitudes, and practices (KAP) of industry role players towards environmental legislation, the business practises regarding environmental management and resource usage as well as obstacles with regards to environmental sustainability in the ornamental horticultural industry in South Africa.

1.3 Aims and objectives of the study

In addressing these aims, the following study objectives were formulated to develop sustainability guidelines and best practices for conservation and management of natural resources within the South African ornamental horticultural industry:

- Study objective 1: To identify the nature and extent of current environmental awareness and knowledge including environmental and / or resource management legislation, goals and policies and its application in the ornamental horticultural industry in South Africa.
- Study objective 2: To contribute the green economy and optimum use of resources within the South African ornamental horticultural industry by identifying the nature and extent of current environmental business practices that promote sustainable natural resource management and development.
- Study objective 3: To investigate obstacles preventing the South African ornamental horticultural industry from implementing "environmental and sustainability" regulations, recommendations and "best practice".
- Study objective 4: To develop a comprehensive manual using KAP principles for training on environmental sustainability and best practices for the conservation and management of natural resources within South Africa targeted for growers and retailers within the ornamental horticultural industry.

1.4 Research Questions

The overall aim of the study was to investigate how the South African ornamental horticultural industry could contribute sustainably towards the environment while still being viable, thus improving the environmental sustainability of the industry.

To address this, the following research questions guided the research methodology as well as the analysis and interpretation of study results to achieve the aims and objectives of the study:

1. How has environmental legislation, management policies and their practical implementation affected natural resource sustainability?
2. What knowledge do members of the ornamental horticultural industry of South Africa (OHISA) have with regards to relevant environmental legislation that affects their business?
3. Which environmental legislation does OHISA find the most difficult to implement?
4. What environmental management policies and practices are implemented by South African ornamental horticultural businesses in terms of natural resource use and impact?
5. What are the obstacles that members of the South African horticultural industry face in reducing their impact on the environment?
6. What affect does natural resource depletion have on the South African ornamental horticultural industry?
7. What are the challenges experienced by the South African horticultural industry in terms of natural resource sustainability?
8. How do the business practices of the industry have the potential to make a positive contribution or harmful effect to the environment, namely land, soil, water, or air?
9. What are the similarities and differences in the environmental sustainability factors influencing the ornamental horticultural industry both locally and internationally?

These questions focused the attention of the researcher on the ornamental horticultural industry of South Africa and how its members related to factors such as environmental legislation and management policy and their practical and sustainable implementation, and the obstacles faced by members in reducing the impact of the industry on natural resources and the environment.

1.5 Research methodology (Theoretical framework)

The way the data is collected, controlled, and interpreted meaningfully is the research methodology (Leedy, 1997). This study is a descriptive study using quantitative and qualitative research techniques. Questionnaires, in-depth, face-to-face, semi-structured interviews, and observations during sites visits were conducted to provide an accurate description of the ornamental horticultural industry throughout South Africa and ensure the reliability of the research. A sample of selected businesses within the industry were researched as sub-case studies and most of the information collected from these sub-case studies was qualitative.

Semi-structured interviews:

The researcher chose the use of interviews for this study as they would yield the highest response rate. They were semi-structured and conducted in the manner of an informal discussion where the interviewer was someone they knew and trusted (Leedy and Ormrod, 2013). These interviews focused on participant knowledge, attitude, and business practises towards environmental sustainability with regards to soil, water, fertilizers, pesticides, energy, and waste. Thus, the researcher obtained valuable information with regards to the business practises and the topics of the study. Results from the interviews demonstrated the extent to which businesses within the ornamental horticultural industry had already taken steps to implement change and decrease their dependency on non-renewable resources and impact on the environment.

Case Studies:

The case studies involved participatory exploration which entailed the researcher undertaking in-person-site inspections to observe examples of how each business produced or sold plants and what natural resources were used or affected. A sample of both ornamental plant production nurseries (growers) and retail garden centres throughout South Africa were involved in the research process and their results were incorporated into a best practices manual.

1.6 Assumptions, Limitations and Scope (Delimitations)

This research project aimed to contribute to the body of knowledge with reference to sustainability and environmental productivity of the ornamental horticulture industry in South Africa and thus the topic itself sets limitations for the study in terms of scope and location.

The literature reviewed for the study included global sources, both recent and older, to understand the evolution of the literature. The literature focused on the key environmental factors determined by the research e.g., water, soil, land and their relationship to other resources used in producing a healthy plant, namely fertilizers and chemicals and it ends with the production of the plant and waste products that were part of the process or life cycle. Other factors such as labour, location, and industry type could also influence the environmental productivity of the ornamental horticultural industry but are not investigated in this study.

The participants involved in this study were recruited through a non-probability sampling strategy and the sample took part in the study. There were no participants from Northern Cape but as there were participants from the other eight provinces. The researcher believed that this research was representative of the South African population of growers and retail garden centres within the ornamental horticultural industry. It does not include allied trade, landscapers, irrigation specialists, green industry machinery sectors and thus the results of this study cannot be extrapolated to all South African ornamental horticultural businesses.

1.7 Summary

Starting with a holistic view, this research outlines the problems facing the biosphere and progresses to ultimately focus on the ornamental horticultural industry, more specifically, South African Nursery Association members and their impact on the environment. The biosphere is experiencing unprecedented resource depletion resulting from amongst others, population increase. Globally the effects of population growth and industrial development have caused problems such as climate change, global warming, and pollution. In South Africa, these problems are also being experienced and are resulting in environmental degradation and sustainability challenges. A lack of information and data about environmental awareness, policies, and practices of the South African ornamental horticultural industry (specifically the South African Nursery Association members) in the context of sustainable development prompted this research, the result of which is a best practice manual which can be implemented by SANA members and organisations forming part of OHISA.

1.8 Thesis layout

Chapter 1: This chapter established the background to the study and introduced the research problem: “Does the ornamental horticulture industry in South Africa include sustainable business practices in the production and sale of healthy plants?” Following on from this is the question, “Is ornamental horticulture (the production and sale of healthy plants) a sustainable option with regards to the utilisation of natural resources namely water, soil and sources of energy, in South Africa into the future?” This chapter defines the research problems and describes the significance of the study and its aims and objectives.

Chapter 2: In this chapter the researcher investigates the literature related to the terms firstly stating the causes of the current environmental problems e.g., population growth, climate change and pollution, then discusses the international solutions and recommendations to these problems e.g., sustainable development, green productivity, green economy, nature-based solutions as well as the six factors needed to produce a healthy, saleable plant. From this global picture the researcher then refines the research findings to Africa and progressively focuses the study on the ornamental horticultural industry within South Africa for each of these concepts and best practices.

Chapter 3: This chapter describes the conceptual framework of the study and defines key terms and their significance. It explains the green economy in relation to environmental productivity and sustainability. The relevance of associated concepts regarding this research, such as climate change, circular economy, and nature-based strategies, is also described and depicted via a conceptual framework. The suitability of the KAP model is validated together with other methods which can be used to determine the knowledge, attitudes, and practices of the participants with regard to sustainability.

Chapter 4: The choice of the research design and methodology is discussed in this chapter. It focuses on the methodology used to obtain and evaluate data from interviews, case studies (participatory action research - PAR) and documentation analysis of individual businesses and international best practices. Qualitative and quantitative data was collected and analysed to determine current practises of environmental resource management within the horticultural industry in South Africa.

Chapter 5: In this chapter the collected data from garden centre retailers and growers is described and graphically represented and explained in relation to the research questions, linking these to the knowledge, attitudes, and practices within the industry. The data was collated into indicators which was further compared to the indicators of the related sustainable development goals mentioned in Chapter 2. These results were used to design the best practise or environmental sustainability manual for implementation by the South African ornamental horticultural industry businesses.

Chapter 6: The results of Chapter 5 are compared to research done by different retail garden centres, growers, institutions, and associations of horticulture internationally. The answers to the research questions were analysed and the data was re-ordered linking the indicators from this research to the relevant sustainable development goals.

Chapter 7: In the final chapter, the conclusions from the results and discussion of the study were reviewed and recorded in relation to each of the study objectives and associated research questions. The implications of the research and the resulting recommendations are mentioned in relation to encouraging more of OHISA members to take up the challenge of improving their environmental sustainability.

Chapter 2: Literature

The literature review provides background theory and demonstrates via a conceptual framework the connections between the research questions and the researched concepts (Rocco and Plakhotnik, 2009). It consists of a systematic review of the key terms mentioned in Chapter 1, including green economy, nature-based solutions, and sustainable development. Published articles, legislation, unpublished articles, books, dissertations, previous studies, conventions, and conferences proceedings (Knopf, 2006) were used to define these key terms and explain them from a global perspective and then show how they are applied in South Africa.

Both peer reviewed and grey literature were examined to develop research streams which provided the background for content analysis in relation to the key terms. The references were used to determine trends related to the study. The linking of these various trends, key terms, indicators, practices, concepts and relationships is best described using a conceptual framework (Farias *et al.*, 2019; Govindan, Shaw & Majumdar, 2021). The researcher has thus created Chapter 2 for the literature review as described above and Chapter 3 for the development of the conceptual framework to better understand the correlations of the concepts of this study and the alignment of the themes (trends) in relation to ornamental horticulture within the South African context.

2.1 Environmental resources and management

The human population is challenged by the depletion and degradation of natural resources due to industrialisation, manufacturing and intensive farming practices resulting in erosion, drought, degradation of habitats, freshwater shortages, and species loss (United Nations, 2015).

Management of natural resources involves a balance between the harvest rate in comparison to its regeneration rate and, secondly, to ensure that waste discharge and accumulation rates, whether gas, liquid or solid, are equivalent to the self-regulating and self-cleaning facilities provided by natural ecosystems (Daly, 1990).

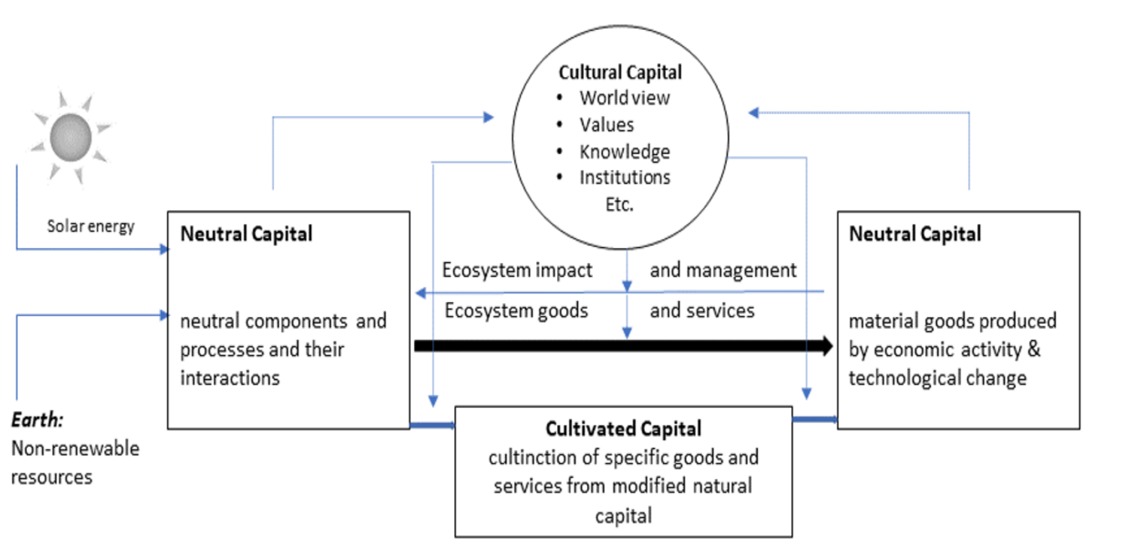
There are various strategies developed to attempt to manage these resources and reduce the impact of humans on the environment to ensure a sustainable future. One of these is the implementation of the Sustainable Development Goals (Appendix 1) (United Nations, 2015). These will be discussed in more detail later in this chapter.

Air, water, and land, also described as environmental resources, can be referred to as natural capital which is fundamental to all life on earth and together provide a flow of services and support to the economy. Analysts have assigned economic value to the resources provided by the ecosystem which allows for better comparison in cost-benefit calculations and decision making (Missemer, 2018; Russell *et al.*, 2020).

Traditional economics denoted capital as land, labour, and man-made products (Ekins, 1992). However, this evolved over time and separated into “manufactured capital or cultivated capital”, “human capital”, “social / organizational capital / cultural capital” and “environmental or ecological capital” (Ekins, Folke and De Groot, 2003).

As shown in Figure 2.1, these natural assets are considered as natural capital because they provide:

- Goods (minerals, timber, and food)
- Essential services (energy production)
- Regulation of life support systems (pollution control and purification of water and air)
- Habitat maintenance and restoration (beauty and recreation) and
- Information functions (research opportunities) to the economy and human welfare (Daily *et al.*, 2000; Ekins, Folke and De Groot, 2003; Barbier, 2019).



Types:	*unique systems*	*semi-natural or modified systems*	*sustainable cultivated systems*	*intensive cultivated systems*	*urban green space*	*built environment*
Examples:	prime forests original wetlands coral reefs	sustainable forestry Extensive rangeland: bufferzone	agroforestry organic farming shifting cultbe	tree plantations agriculture equaculture	parks, greenbelts greenhouses zoo's, botanical gardens	infrastructure housing industrial area
Characteristics:		Increasing: ecological footprint, domestication, inputs of energy, kbar etc. (more entrophy) Decreasing: uniqueness, self-renewability, multi-functionality, ecological space				

Figure 2.1 Capital approach to man-environment interactions. (Adapted by author from: Ekins, Folke & De Groot, 2003; Terama et al., 2016).

Throughout the ages as man has evolved, so has the use, influence and later, exploitation of natural resources, from natural wetlands to agriculture to the built environment. The evidence also shows that restoration and rehabilitation of the ecosystems and their functioning to maintain or increase stocks of renewable natural capital actually pays and should be seen not only as a cost by investors and private businesses (Blignaut, Aronson and Groot, 2014).

2.1.1 Air (atmosphere / climate)

The atmosphere is one of the most valuable natural resources as it plays an essential role in regulating the earth's temperature and makes it possible for biological processes to occur, which in turn, allows for human survival (Thornes and Randalls, 2007; Ringrose, 2017). This is because the properties of the atmosphere provide a suitable space for gaseous exchange e.g., land-atmosphere cycle which includes the carbon cycle, nitrogen cycle, oxygen cycle and the ocean-atmosphere cycle as well as the regulation of climatological processes (the hydrological cycle, air quality and wind) (Ekins *et al.*, 2003).

Climate change is one of the leading environmental challenges. The impacts of pollution and human activities have caused *"the global mean temperature to be about 1.1^{o}C above the pre-industrial level (1850-1900)"* (United Nations, 2021). In 2021, the United Nations published the *"First Global Assessment of Air Pollution Legislation*" which focused on managing and governing air quality (UNEP, 2021). These guidelines provided governments the opportunity to update their policies and set standards to try and achieve Sustainable Development Goals (SDG) 3, 11 and 12.1, and to also facilitate the fulfilment of SDG 7.2 and 17.3. In a study undertaken in 194 countries, only 170 had relevant data and of these, 57 of them had no air quality standards, which was distressing as research has shown that high levels of air pollution contribute to greater economic risks because of related health issues of the population and environmental degradation (Joss *et al.*, 2017). Within the African region, there were 47 countries investigated of which 17 had standards governing a minimum of at least one pollutant e.g., O_3, NO_2, CO or SO_2, but 21 countries had no policies to regulate air pollution and nine had no information to contribute to the study (Joss *et al.*, 2017).

In many developing nations, both indoor and outdoor air pollution are cause for concern due to increased economic activity, urbanisation, and the utilisation of fossil fuels for energy. An Environmental Performance Index was developed by Yale University (2020) which assesses environmental health and ecosystem vitality according to a variety of indicators. Using the indicator for air quality, South Africa's results have been chaotic. In 2006, South Africa ranked 61, in 2018, 49 and in 2020, 131 out of 180 countries in terms of safe air quality. These results are variable due to the absence of reliable data because of unevenly dispersed air quality monitoring systems throughout the country, multiple fuel sources used for cooking indoors and over the years the accuracy of various air pollutants have changed (Garland *et al.*, 2017; Yale University, 2020). Data gathering techniques have improved in South Africa and numerous amendments (2008, 2009, 2013 and 2014) have been made to the National Environmental

Management: Air Quality Act 39 of 2004 (Government Gazette of South Africa, 2005). e.g., South Africa created air pollution priority areas e.g., Highveld Priority Area whereby air monitoring systems were put in place to record and assess the high levels of domestic combustion and coal burning activities in affected areas in Gauteng and Mpumalanga (Department of Environmental Affairs, 2012). Considering these positive steps and the fact that the South African National Ambient Air Quality Standard (NAAQS) is $PM_{2.5}$ 20 μg/m^3, which is more lenient than that of the World Health Organization's recommendation of $PM_{2.5}$ of 10 μg/m^3. South Africa's measured average $PM_{2.5}$ was still higher than both, at 22 μg/m^3. In 2020, the World Health Organization stated that the air pollution levels in South Africa were slightly unsafe despite the regulations, standards and monitoring equipment now being used (International Association for Medical Assistance to Travelers, 2020).

Internationally, ornamental horticulture contributes to climate change and global warming due to the energy it uses for heating and cooling of greenhouses and tunnels, transportation of materials and products, cold-room storage and inorganic inputs such as fertilizers and pesticides (Wainwright, Jordan and Day, 2014; Darras, 2020b). The irrigation systems used in the agricultural industry uses an average of 30% of all energy consumed. This could be lower for Northern hemisphere nurseries where energy is primarily used for temperature control within greenhouses (Rideout *et al.*, 2011).

Since 1995, there have been global regulations and restrictions applied to agriculture (including horticulture and floriculture) with regards to environmental sustainability and more specifically greenhouse gas emissions and the pollution produced e.g., GLOBALGAP (started in United Kingdom), Milieu Programma Sierteelt (MPS) (Dutch) and Veriflora (American) (Darras, 2020b) and EcoHort (Australia) (Australian Nursery and Garden Indstry, 2014). The industry's contributions have the potential to negatively affect air quality and yet the production of ornamental plants such as trees, shrubs, perennials, and indoor plants also positively enhances air quality both indoors and outdoors by carbon sequestration which reduces greenhouse gas emissions (Darras, 2020b). Can a balance be found, or can nature-based solutions place the industry in a positive carbon credit situation?

2.1.2 Water

Water, like air, is a finite natural resource and understanding its value is essential to achieving Sustainable Development Goal 6 (Appendix 2: Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development) – "*achieving universal, safely managed water and sanitation services by 2030*" (Garrick *et al.*, 2017). The water crisis has been under investigation for decades, particularly regarding freshwater usage and conservation (Abu-Zeid, 1998; Rogers, 2008; Darwall *et al.*, 2018) and continues to be a challenge. It is important to find practical ways to conserve this resource and use it more carefully e.g., recycling and reusing it, minimising its contamination to ensure sustainability (Valhondo and Carrera, 2019) and improved water conservation education (Hoy and Stelli, 2016; Turner *et al.*, 2016). This resource is not only essential to humanity for safe drinking water and sanitation but a lack of water poses a threat to agriculture (global food security), power generation, the natural environment and many businesses and industries (Bisbis, Gruda and Blanke, 2019; Knox *et al.*, 2020) . Using the water-energy-food (WEF) nexus is one of the methods being used to analyse the inter-connectedness of these resources in regards to policies, strategies and risks (El Youssfi *et al.*, 2020).

There is a scarcity of water within South Africa, and this natural resource, is protected by the National Water Act (36) of 1998, which was amended in 2014 (South African Government, 1998b, 2014). This Act and Amendment regulate the source of water, its extraction and use and the quantity used for which purposes to ensure it is managed fairly and sustainably (South African Government, 1998, 2014). Water conservation isn't specified within the Act but is implied in its administration (Bonthuys, 2018) and a detailed National Water Resource Strategy (2004 and 2013) was developed to manage water *"efficiently and effectively for equitable and sustainable growth and development"* (DWA, 2013). The challenge is that according to the World Wildlife Fund (WWF), 98% of all

South Africa’s water resources are already accounted for and being used, leaving minimal stock for future use and the increasing demand due to population growth and food production, urbanisation and development (Goldblatt, 2018).

World-wide, agriculture is one of the greatest water users, using about 70% of the freshwater extracted (World Bank, 2020). This is true in South Africa as well, where 63% of extracted water is used for irrigation(Bonthuys, 2018). Similarly, the ornamental horticultural industry is dependent upon water for the production and care of plants.

The ornamental horticultural industry recognises that managing water proficiently and configuring irrigation systems correctly is key to sound environmental sustainability. This will improve the efficiency of water use and energy expenditure in plant production. Irrigation is a significant component of nursery operations, not only in terms of the plants but also in terms of employee hours and operational costs (Rideout *et al.*, 2011; Yeary, Fulcher and Leib, 2016).

Growers and garden centre retailers have the potential and opportunity to conserve water and aligned to this, manage fertilizer usage better (Florida Department of Agriculture and Consumer Services, 2014). Horticultural businesses have at least 40-60% plant material as part of their product range. Plant tissue consists of 98% water allowing the plant cells to remain turgid and perform various metabolic processes e.g., photosynthesis and transpiration. Other properties of water which are beneficial to plants are that it is an excellent solvent and it regulates temperature throughout the plant (heating capacity and transfer) which are essential management tools in horticultural practises. Thus, high quality plant production and reduced plant loss is dependent on a reliable source of clean water during the germination, growth, and maintenance of the plant (Durner, 2013).

In conclusion, efficient water use will not only minimise the consumption of this natural resource but also reduce the use of energy and improve fertilization of the plants. These benefits are highlighted as part of this study and the ornamental horticultural members will be encouraged to implement the various methods and technologies described in the best practice manual to improve their overall profitability.

2.1.3 Land and soil

The last of the natural capital resources investigated in this study is land but more specifically soil, and in the case of ornamental horticulture, growth media. In the 1800’s research on soils was predominantly done with regards to its origin and properties which contribute to plant growth and nutrition (Hartemink, 2016). It was discovered that weathering, a geomorphological process, breaks down the bedrock e.g., granite, limestone, sandstone etc., to produce soil. The composition and characteristics of soil varies in texture, fertility, minerals, and micro-organism make-up, depending on the type of original rock and the geological processes causing the breakdown e.g., water erosion, glacial movement, volcanoes, earthquakes etc., that were involved (Ekins *et al.*, 2003). Different plants grow more successfully in some soils compared to others and this led to the study of soil chemistry (Hartemink, 2016). As the study of soil science evolved so did the definition of soil but those most significant to this study are:

1. Soil is the layer found between the atmosphere and the earth’s subsurface. It is part of the lithosphere which provides a surface and substrate for human interactions and industries. It is also an essential component of the hydrological cycle. As described above, soil is formed from bedrock (parent material) through biological and other factors of weathering. If given enough time, soil layers or horizons form which have different physical and chemical properties (Warrick, 2003).

The definition above re-enforces those from earlier years considering the formation of soil. It also links it to the importance of the relationship between soil, water and people which is highlighted in the Revised World Soil Charter (Food and Agriculture Organization of the United Nations, 2015) which promotes soil health productivity to ensure food security. Although soil isn’t mentioned directly in the Sustainable Development Goals, its conservation and use as described by the Soil Charter, and the research and collaboration of soil scientists with other related disciplines is important to achieve some of the Sustainable Development Goals (Keesstra *et al.*, 2016); namely to end poverty (SDG 1) and relieve hunger

(SDG 2) and promote well-being (SDG 3) for the population. For the environment, soil is essential to maintain functioning ecosystems (SDG 13) and safeguarding biodiversity on land (SDG 15) (Appendix 1). (United Nations General Assembly, 2020)

2. “Soil is comprised of a mixture of inorganic and organic matter, air, water and living organisms” (Wallander, 2014).

In agriculture this make-up is essential for plant growth (Passioura, 2002) and more specifically ornamental horticulture. The transition from growing plants in soil to more of a specialised growth medium is of vital importance to the development and performance of the plant. Soil make-up for growers has become a science and as the earliest people noted, certain plants grow better in certain types of soil. In the production of plants, soil is essential. From the earliest times in agriculture, subsistence crop farming to intensified cultivation of crops today, 99% of the world-wide food production is dependent on soil (Hatfield, Sauer & Cruse, 2017).

3. The nature of soil allows it to be a habitat for organisms including bacteria and fungi, a catcher for biological waste, a filter for poisonous substances and a storage place nutrient-ions. As previously mentioned, soil is a product of its environment, but this definition highlights the importance of it as a component of it too (Binkley and Fisher, 2000).

This last definition highlights the beneficial properties of soil. As well as being a growing medium, it again links the soil and human activity together. It highlights the importance of soil’s ability to purify the surroundings by removing polluting residues and toxins and allow for gaseous exchange which is advantageous for humans e.g., absorbing methane and nitrogen (Smith *et al.*, 2018). In this study, this definition will be used not only within the soil section of the best practice manual but also in the importance of organic waste management and the beneficial properties the waste can have on soil properties and structure (Hossain, Fragstein and Niemsdorf, 2017) which can thus improve plant quality.

Figure 2.2 is a diagrammatic summation of the definitions cited above and it demonstrates the significance of soil in the water-energy-food nexus which according to Hatfield, Sauer and Cruse (2017) and Kopittke *et al.* (2019) should be adapted to include soil.

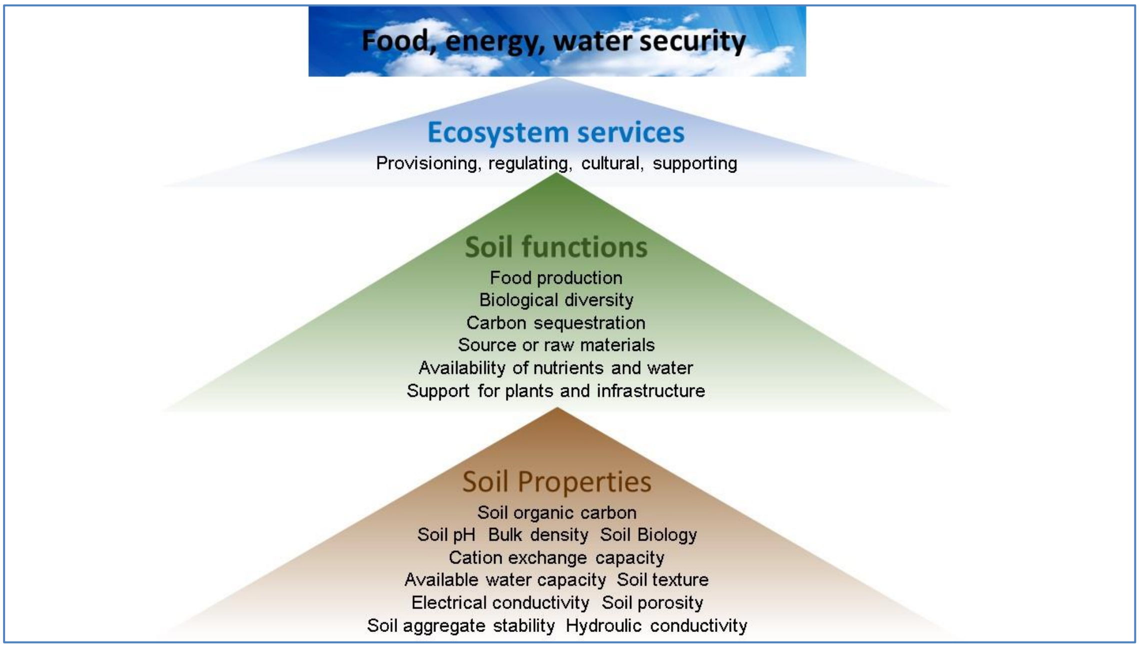


Figure 2.2 Interface of soil properties relative to soil functions and ecosystems services (Hatfield, Sauer & Cruse, 2017)

With regards to the importance of soil, the international community has set the standards which have continually been updated as research has progressed. Similarly South Africa realised its importance and produced the Soil Conservation Act 45 (South African Government, 1946) which was amended in 1969 (South African Government, 1969) and repealed in 1983 by the Conservation of Agricultural Resources Act 43 which consolidated all measures regarding soil utilisation and conservation (South African Government, 1983b). With regards to soil conservation there have been further amendments (South African Government, 2013a) and draft documents drawn up e.g., the Sustainable Utilisation of Agricultural Resources Bill (South African Government, 2003), but according to the researcher's findings these have not been approved and implemented. Soil conservation and management not only is part of the Department of Agriculture, land reform and rural development but also Department of Environment, Forestry and Fisheries and is thus governed by the National Environmental Management Act (Government of South Africa, 1998) as well.

To summarise, finite resources or our natural capital provided for by the environment for humans to survive, such as air, water and soil are continually being utilised, exploited, and degraded to such an extent that their availability and beneficial properties may not be easily accessible in the future. This is because the ever-increasing human population is using the natural resources unsustainably and causing harmful impacts on the planet by polluting the rivers and oceans, contaminating the soil, and releasing toxic gases into the atmosphere in the name of industrialisation, and development.

2.2 Factors influencing environmental resources

The concept of the water-soil-food-energy nexus emphasizes the importance of the human population on our natural resources and how intricately intertwined the two are. The increasing threat of global food security due to interconnectedness (Figure 2.3) of climate change, population growth and poverty was reaffirmed at the Conference of Parties in Glasgow (COP26, 2021).

2.2.1 Population growth

In Chapter 1, it was explained how the global population had grown and continues to do so to the detriment of the environment but also to humans themselves by causing food shortages, increased health issues and fresh-water shortages (Figure 2.3) (Dodson *et al.*, 2020). According to Karieva, Akhmetshina and Mottaeva, (2020), in addition to the increasing population, the world Gross Domestic Product (GDP) has grown eight-fold from 1980 to 2019 also at the expense of natural environments and resources. Peterson, (2017), argued that population growth and an increasing GDP are related but there are so many factors that play a role in this debate. The more important correlation for this current study is that both have been documented to have damaging effects on finite resources. The UNESCO World Water Assessment Programme (WWAP) reported that the use of water use has increased by 1% per annum since 1980 due to a growing population so that by 2050 about 50% of society will not have access to a safe water supply. This dilemma is intensified in water-scarce regions such as sub-Saharan Africa where there is a high population growth and greater associated demands for food, energy, jobs and education (UNESCO World Water Assessment Programme, 2019).

Another global challenge with regards to population growth is food provision and the variety of food consumed due to urbanisation and the change in lifestyles (Food and Agriculture Organisation of the United Nations, 2009; Pretty *et al.*, 2010; Ganivet, 2020). Worldwide, agriculture is already using at least 70% of the freshwater reserves available and this percentage is forecasted to grow by 19% by 2050 (UNESCO World Water Assessment Programme, 2019). Figure 2.3 also shows how a unified approach to reducing population size will allow civilization to adapt more successfully to the effects of climate change and ease its impact.

The linking of population growth and climate change is shown in Figure 2.3. It highlights the cyclic nature of the relationship between the growing population which causes the production of more greenhouse gases which in turn results in climate change. The effects of climate change affect food and water security as well as human health which ultimately affects the population and so the cycle continues.

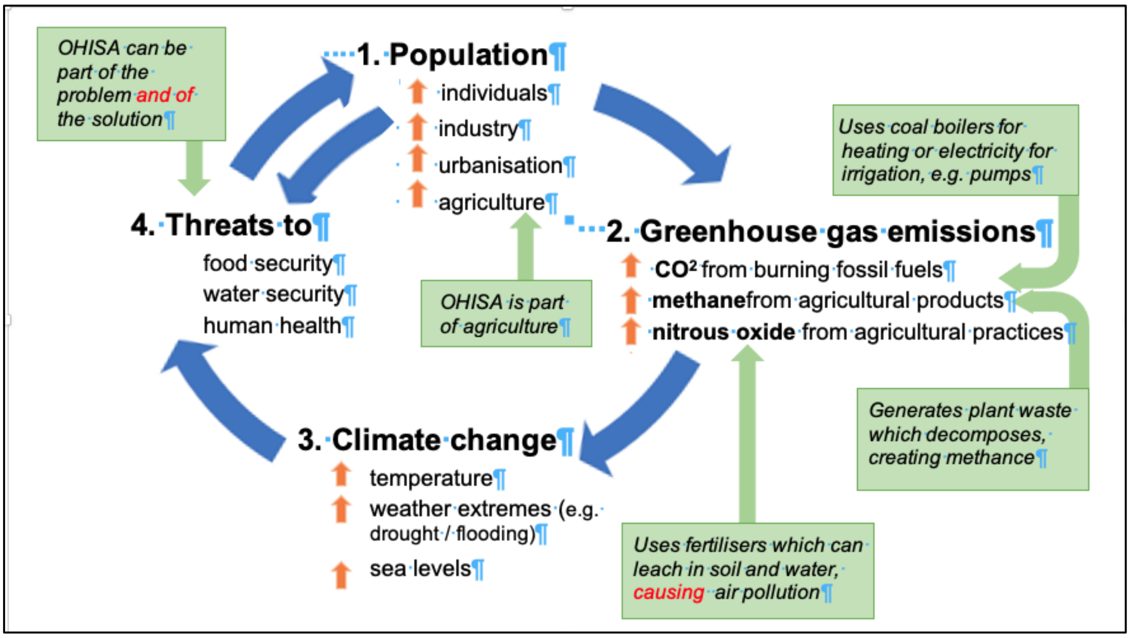


Figure 2.3 Graphical description of Population Growth and Climate Change (adapted by author from Dodson et al., 2020).

In 2018, research stressed the importance of the combination of population management through policies but more importantly superior agricultural practises to boost food security (Mekuria, 2018). These include innovations and technological advances made in agricultural practises over the last decade such as no till farming (reducing erosion), precision farming (reducing the excess pesticides and fertilizers applied) and the use of genetically modified crops (increase yields and reduce pesticide and herbicide usage) (Peterson, 2017; Navath, 2021).

Have these advances been shared internationally, and can they make a difference? Masipa, (2017) noted that in South Africa the limited access to technology and the inefficient and ineffectiveness of the relevant institutions were a liability towards food security especially considering the country's susceptibility to climate change. As an example, research showed that the adoption of climate-smart agricultural technology such as conservation agriculture or rainwater harvesting either required too high an initial investment or labour costs or intensive management, whereas seed varieties that were drought resistant with shorter growing times were a preferred option especially for small scale farmers (Senyolo *et al.*, 2018).

Following on from this, have the agricultural advances filtered into ornamental horticulture plant production practises and can they be applied to ornamental crops, not only edible ones? These questions will be investigated and discussed in the results of this study.

2.2.2 Pollution

Pollution is associated with population growth and climate change, both of which cause irrevocable damage to the environment. Urbanisation, industrialisation, and greenhouse gases which are a result of civilisation are also a source of pollution, affecting not only the atmosphere but also land, soil, and water.

Over the years many studies have been conducted on the serious human health issues caused by pollution e.g., air pollution can result in shorter lifespans and breathing problems, drinking polluted water can cause sickness and in some cases even death and solid waste pollution e.g., sewerage and heavy metal contamination can cause disease and deformities in humans (Khan & Ghouri, 2011; Vardoulakis *et al.*, 2015; Landrigan *et al.*, 2018; Lakhouit & Alsulami, 2020; Schikowski, 2022). Although investigated, pollution was initially overlooked as a global health threat especially in children, yet in 2015 it resulted in 9 million deaths worldwide and severe economic loss (Landrigan *et al.*, 2018). A couple of the sustainable development goals highlight the importance of pollution reduction to promote human and environmental health and thus reduce the spread of disease (Appendix 2) e.g., SDG 6 – access to clean water and better sanitation, and SDG 7 that promotes clean energy (reducing air pollution) (Nilsson *et al.*, 2018; Rafaj *et al.*, 2018). This research and that of Herrera (2019) stressed that although these goals are in place, guidelines are needed for their implementation by policy makers within each country, at local government level and even at an industry level. Tools are also needed to gain a true report of what is happening.

As one focuses from global to local, the causes and effects of pollution within South Africa are similar to equivalent global features, such as the higher number of health issues and cardiovascular deaths in cities and towns with greater air pollution (Edlund *et al.*, 2021; Thabethe, Voyi & Wichmann, 2021).

Pollution not only affects human health but has a detrimental effect on the functioning of ecosystems and our environment. In the 1960s, industrialisation and economic growth led to ecosystem destruction following its pollution and from the unsustainable use of resources. According to Gao *et al.*, (2018), *"the pollution-economy nexus"* is initricate and poverty also contributed towards pollution and sanitation problems. Agricultural practises also changed from subsistence and small-scale local farming where the land and water could support and absorb relatively few pollutants and waste matter and represented a closed, sustainable agricultural system included recycling of crop wastes where husks were fed to pigs and manure was used as fertilizer. This changed to large scale, monoculture farming using pesticides and fertilizers to increase yields to feed the nations (Carpenter *et al.*, 1998; Novotny, 1999; Conway & Pretty, 2009;

Martinho, 2019). This intensification of agricultural practises involving crops, livestock and aquaculture impacted the water quality and volume (Mateo-Sagasta *et al.*, 2017). A positive trend, however, is that conventional farming practises are continually evolving to become more sustainable (Foley *et al.*, 2011; Mateo-Sagasta *et al.*, 2017; Wang, Qian & Deng, 2020).

As with population growth and climate change, agricultural pollution and, in turn, the pollution caused by the ornamental horticultural industry, affects all aspects of the environment:

- Water pollution through leaching of fertilizers and pesticides
- Pollution by ploughing land for tunnel infrastructure or planting which has the potential to cause erosion
- Air pollution from heating and cooling of greenhouses and tunnels and fertilizer production and use.

These are the obvious causes of pollution but through better management with an enhanced understanding of the nutrient pathways, their associations and impacts on the land, soil, water and air there can be a minimising in damage to the environment and humans by pollutants (Serra, 1994; Martinho, 2019).

2.2.3 Climate change

There is much debate about the actual definition and causes of climate change and whether it is due to increased use of fossil fuels that result in greater levels of carbon dioxide and other gases being released into the atmosphere resulting in variable global and / or regional weather patterns. Nonetheless, the effects on the environment are significant and the decision-making with regards to climate change has to be robust and yet allow for flexibility of a policy or model due to the uncertainty of change (Pielke, 2005; Giuliani & Castelletti, 2016; Cook, Mankin & Anchukaitis, 2018).

As shown in Figure 2.3, climate change is one of the elements affecting our natural resources and is often said to be because of industrialisation and population growth. It has a negative effect on everyone in one way or another, be it physical or mental wellbeing, food security, job availability and stability, travelling and living locations, access to resources and agriculture, economy and industry (Thomas *et al.*, 2019; Celik, 2020).

According the United Nations, (2015) climate change is a prominent threat to current human existence and biological support systems on earth. Its effects on the hydrological cycle ultimately affects the way we live (Khan & Hakeem, 2015) as every climatic change, in turn activates a change in the water system which is integrally part of the atmosphere, the geosphere, the lithosphere and the biosphere (Kundzewicz, 2008). The detrimental impacts of climate change on the environment e.g., increasing global temperatures , melting icecaps causing rising sea levels, extreme and unpredictable weather patterns (droughts and flooding) and increased soil erosion undermine many nations' potential to achieve sustainable development (Sathaye, Shukla and Ravindranath, 2006; Ray *et al.*, 2019).

Using the carbon footprint of a product or plant is one of the measures to calculate the effect of climate change by determining the greenhouse gas emissions of that product or plant. Within the horticultural industry this is imperative (Soode *et al.*, 2015) and within the last decade has started to be implemented (Darras, 2020b; Havardi-Burger, Mempel and Bitsch, 2020). The increased application of CO_2 on some edible crops can actually have a positive effect on their growth e.g., C_3 crops (soybean, rice and wheat) but it can decrease the nutritional value of the crop in terms of protein and minerals (Leisner, 2020). For non-edible ornamental crops such as perennials, shrubs and trees, similar deductions can be made with species similarities. The reference to a carbon footprint in ornamental horticulture relates to the production of the plant from seed to ending up in a landscape or customer's garden (Lazzerini, Lucchetti and Nicese, 2014; Darras, 2020b; Bonaguro *et al.*, 2021). Ornamental horticultural plants can provide solutions to climate change by minimising its effect and making congested cities more liveable by improving air quality and the quality of the environment (Maxime *et al.*, 2014).

The ornamental horticultural industry has started to make positive changes in their production methods with regards to climate change by creating industry standards that growers have to adhere to, to be able to supply into certain retailers as mentioned above (GLOBALGAP (UK), Milieu Programma Sierteelt (MPS) (Dutch) (Dennis *et al.*, 2010) and Veriflora (American) (Darras, 2020b). States in USA, such as Oregon (Rideout *et al.*, 2011) and Massachusetts (Smith and Lopes, 2009) created best practices which suggest practical ways to make a change. Much like this, in Australia both standards and best practices were established (Nursery & Garden Industry Australia, 2014; Horticulture Innovation Australia and Nursery & Garden Industry Australia, 2018). In Canada a study was conducted showing that research needs to be done to encourage growers to change to more innovative practises and technologies that will lower their costs of production. The way to do this was by more efficient use of inputs e.g., water, nutrients, energy, and labour (Maxime, Gauthier & Ciraig, 2014). On a par with this SANA added a carbon calculator to their website for members although it isn't specific for ornamental horticulture or related to the production and sale of plants, it would provide a starting point (SANA, 2018). The Dutch are in the process of final testing the "HortiFootprint Calculator" which is specific to the ornamental horticultural industry (MPS and LetsGrow.com, 2022).

This research will investigate which of these standards and best practices are being utilised and implemented by any of the South African growers or garden centre retailers to reduce their carbon footprint and improve their use of natural resources.

2.3 Proposed solutions to the earth's crises

The proposed solutions to population growth, pollution, and climate change are sustainable development, green economy, and environmental productivity. These key terms were introduced in Chapter 1 and are detailed below with their related concepts, first as global goals then national policies then more specifically international industry related best practices and local practices if documented. It is from the description of these key terms that the relevant research questions for the South African ornamental horticultural industry were posed and answered.

2.3.1 Sustainable development

Initially, sustainable development was concerned with the detrimental impact of humans on our environment and leaving the earth of today with equal opportunities for *"future generations to meet their own needs"* (United Nations General Assembly, 1987). For sustainable development to be achieved, a balanced relationship must exist between its three pillars of environment, the economy and society, all of which influence each other (Mensah, 2018). Elkington, (2018) referred to these pillars as the "*triple bottom line"*. They were meant to change the way businesses operated – not only focus on economics but include society, communities, ecosystems, and habitats into their decision-making processes. This hasn't happened and thus Elkington chose to "recall" this definition as the time for sustainable practises was immediate, and positive changes towards human welfare and the environment must be made. Other researchers refer to these pillars as planet, people, and profit (Fisk, 2010; Böcker and Meelen, 2017).

The Global Development And Environment Institute (GDEI) and others have indicated that these *"three pillars"* have remained a constant in the evolutionary process of sustainable development (GDEI, 2001; UNESCO, 2009; Amos & Lydgate, 2020). For the purpose of the current study, sustainability and sustainable development have been linked to have similar meanings and are interchangeable, as was done by other researchers (Hopwood, Mellor and O'Brien, 2005; Helne and Hirvilammi, 2015).

The history of sustainable development (Appendix 3) shows that everchanging processes have often been triggered by significant moments in society so that, from 1960-1980, caring for the environment and ensuring biodiversity was triggered by economic development following the Second World War that was associated with extensive environmental destruction (Purvis, Mao and Robinson, 2018). The progression continued and during the late 1980's into the new millennium, the focus of sustainable development was adapted to include more social aspects, and this is reflected in the Brundtland Report – "Our Common Future" whereby social welfare is as important as environmental protection, and both must be embraced when considering economic development (World Commission on Environment and Development, 1987).

The path of sustainable development continued and between 2000 - 2015 the target was to work towards the accomplishment of the eight Millennium Development Goals (Grainger-Brown & Malekpour, 2019). Papers were written, policies created, and projects developed in the name of sustainability but often the implementation of these policies and operational changes were not measurable nor achievable within the given time frames (Bell and Morse, 2003).

In 2015, the members of the United Nations General assembly who initially compiled Agenda 21 (UNED, 1992) developed the framework for the Sustainable Development Goals since progress towards the previous goals and environmental commitment, although noteworthy, was not universal, especially in developing countries, particularly Africa (United Nations, 2015). Due to the challenges faced by the African continent with regards to the Millennium Development Goals (MDG), the African Union created their own Agenda 2063 whereby the goals are paralleled to the Agenda 2030 goals (The African Union Commission, no date) but on a more realistic schedule (Gopaldas, 2019) (Appendix 4). The current call to action for the achievement of sustainable development is the 17 Sustainable Development Goals (Appendix 2) which were proposed by the United Nations 2030 Agenda. These goals focus on five elements: "*people, planet, prosperity, peace, and partnership"* (United Nations, 2015; Mensah, 2018).

In addition to the counteractive opinions regarding the definition of sustainable development, was the idea of putting it into practice (Dumanski, 1997; Parkin, 2000). Even into the new millennium, researchers still suggested that sustainable development was impractical and unrealistic and that the focus should be on the processes involving the environment, namely SDG 6, 13,14, 16 with humans re-aligning and reconnecting with the earth and it's systems (Skene, 2021). Not only this, but sustainability had been hybridized and due to corporate responsibility it now included numerous other activities within a company such as marketing, annual reports, corporate communication, and company endeavours related to anything social, environmental or economic (Springett, 2003; Pérez Cañizares, 2021).

One of the initial methods proposed by the Commission of Sustainable Development members included 134 indictors (United Nations, 2001). During the testing phase of this report, the involved countries commented that there were too many indicators for easy management. When the second edition of the report was published in 2001, it only included 58 indicators which were grouped together into related sub-themes and these were then clustered into connecting key themes namely social, environmental, economic, and institutional (United Nations, 2007). The third edition of the “blue book” as it was now known, was completed by the United Nations in 2007 and it described the goals and targets resulting from the United Nations Millennium Declaration (United Nations, 2007). In addition to international parties trying to measure sustainability via indicators, others were using alternative methods such as a sustainable development framework based on ecological principles (Becker, 2005; Gallego, 2006). The Global Reporting Initiative started in 1997 and developed its first guidelines in 2000. These guidelines later became Sustainability Reporting Standards 2016 in response to the changes because of the Sustainable Development Goals by the United Nations in 2015. This independent institution continues to update these standards and related information (Global Reporting Initiative, 2016).

Added to this, other sustainable development methods and measurements have been developed based on mathematical, index or indicator factors. *“The Sustainability Assessment by Fuzzy Evaluation*” was developed to address the characteristically unclear assessment of sustainable development using fuzzy logic that unlike traditional mathematics can systematically match vague concepts to give “crisp” answers and convert information such as human values and opinions into verbal variables that can be used to provide a measurement (Phillis and Andriantiatsaholiniaina, 2001). This method has been used numerous times in the measurement of sustainability (Hincu, 2011; Jaderi *et al.*, 2014; Phillis, Kouikoglou and Verdugo, 2017; Mordeson and Mathew, 2020; Clauberg *et al.*, 2021).

"*The Aura Method"* was designed more specifically to concentrate on the assessment of progress and the fulfilment of the sustainable development goals within an urban environment (Herrera-Limones *et al.*, 2021). This method focuses on qualitative analysis linked to the societies and human development and decision making within a city.

Each of the above methods have advantages and disadvantages but it was documented that the method a researcher chooses to assess and measure sustainability can greatly influence the outcomes, even if the input data is the same (Gallego, 2006; Grainger-Brown & Malekpour, 2019).

In the current study, the researcher chose to use the framework of Rahdari and Rostamy (2015) as the starting point for sustainable development indicator choices for the South African ornamental horticultural industry. Their research started with 1826 raw indicators and through an extensive filtering process resulted in 10 main criteria shown in Table 2.2, 30 sub-criteria and 70 most common indicators with regards to corporate sustainability (Figure 2.4).

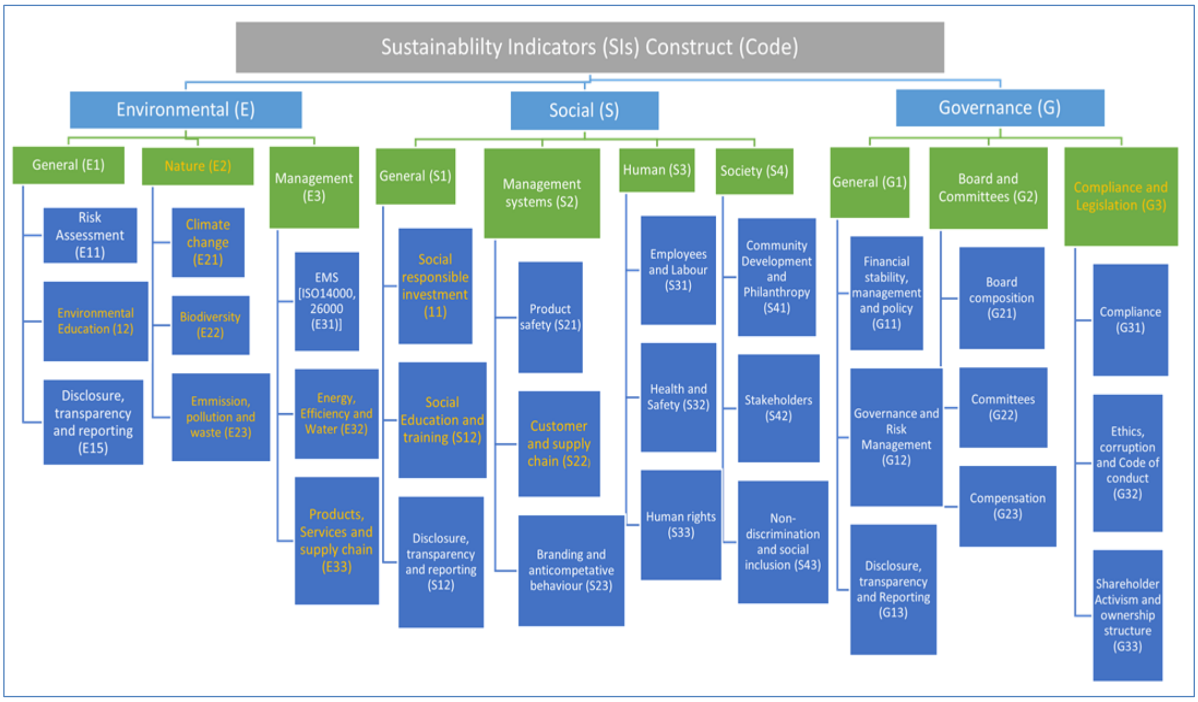


Figure 2.4 Environmental, social and governance construct derived from the evaluation process. (Rahdari & Anvary Rostamy, 2015).

The current research focussed more on the environmental indicators which are highlighted as the “building blocks” for developing industry-specific questions for sustainability (research questions 4 and 6) and in producing a comprehensive best practise manual (study objective 4). These indicators have been chosen because of their encompassing nature to include a combination of the factors highlighted in research done internationally with regards to sustainability (Dominguez, Mibus-Schoppe & Sparke, 2017; Kumar et al., 2017; Havardi-Burger, Mempel & Bitsch, 2020) or best practices in the ornamental horticulture industry (Fain *et al.*, 2000; Smith and Lopes, 2009; Nursery & Garden Industry Australia, 2010; Southern Nursery Association, 2013; Maxime *et al.*, 2014).
In combination with the preceding details, it would be remiss for the research not to include the indicators related to the relevant sustainable goals put forward in Agenda 2030 (United Nations, 2015) and link these to the highlighted indicators in Figure 2.4 resulting in Table 2.1

Table 2.1 Combination of indicators relevant to this research

Indicators from Rahdari and Anvary Rostamy (2015)	**Sustainable Development Goals**	**Indicator Commonality**
Nature	Goal 11, 15	Protect and conserve natural and cultural heritage
Climate Change	Goal 7, 9, 12, 13	Efficiently use resources
Energy, Efficiency and Water	Goal 6, 7, 9	Improving water quality and reducing quantity used Improve energy usage Support local development
Environmental Education	Goal 11, 12	Teach about sustainable consumption and production and living in harmony with nature
Biodiversity	Goal 11, 15	Protect and promote natural eco-systems and biodiversity
Emission, Pollution and Waste	Goals 3, 11, 12	Contamination of resources Reduce effect or pollution both waste and air Reduce, reuse, recycle
Products, Services and Supply Chain	Goal 8, 12	Increased economic activity through diversification and innovation Improve sustainable consumption and production

Indicators from Rahdari and Anvary Rostamy (2015)	Sustainable Development Goals	Indicator Commonality
Socially responsible investment	Goal 8,17	Job creation and entrepreneurship Creating partnerships
Health and Safety	Goal 3, 9	Health and well-being Upgrade infrastructure for sustainability both environmental and social
Compliance and Legislation	Goal 12, 16	Comply with international frameworks for pollution in terms of air, water, soil and waste Include sustainability in reporting

In summary, sustainable development and striving to achieve the goals is an imperative for policy makers, not only at international and national levels but also from a management level for businesses and industry (Fleurbaey France *et al.*, 2014; Gusmão Caiado *et al.*, 2018). This all-encompassing approach, embedded with the principles and polices prescribed by national governments, formed the background literature and basis for the questionnaire the researcher used to propose ways in which sustainability and a movement towards a green economy SA (study objective 2) could be achieved by OHI.

2.3.2 Green economy

The United Nations Environment Programme (UNEP) described "green economy" as economic growth but not at the expense of human health, social equality, or welfare, while minimising the impact on natural ecosystems (UNEP, 2013). Since 2008, governments have searched for tools to support sustainable development at a policy level while adhering to international treaties as well as growing their gross domestic product (GDP). The United Nations Department of Economic and Social Affairs (UNDESA) and the United Nations proposed the green economy as one of the solutions (UNDESA, 2011; United Nations, 2012).

The globally accepted umbrella term, "green economy", describes a balancing development both socially and environmentally. It has numerous approaches to ensure that it is attainable. These include energy usage governance, environmentally-friendly technology, pollution management, bioeconomy, circular economy, nature-based solutions and recycling (Loiseau *et al.*, 2016; D'Amato *et al.*, 2017). These all contribute to *"green growth*" that is the practical application of the green economy, where the manufacturing and consumption of products and / or services provided by industry are energy and natural-resource-use efficient, have a reduced pollution effect in terms of air, water and land while still preventing the loss of biodiversity and natural ecosystems (Luukkanen *et al.*, 2019). The green economy further highlights the importance of investment and innovation towards sustainability which can be implemented at any level, global, national and within individual industries and businesses (OECD, 2011) which is aligned to research questions 4 and 8 of this study.

Water, soil, and air form part of the biosphere and either directly or indirectly affect the lives of all humans. More specifically the impact of the production processes involved in economic activities becomes more and more detrimental to the biosphere as the activities increase, Figure 2.5.

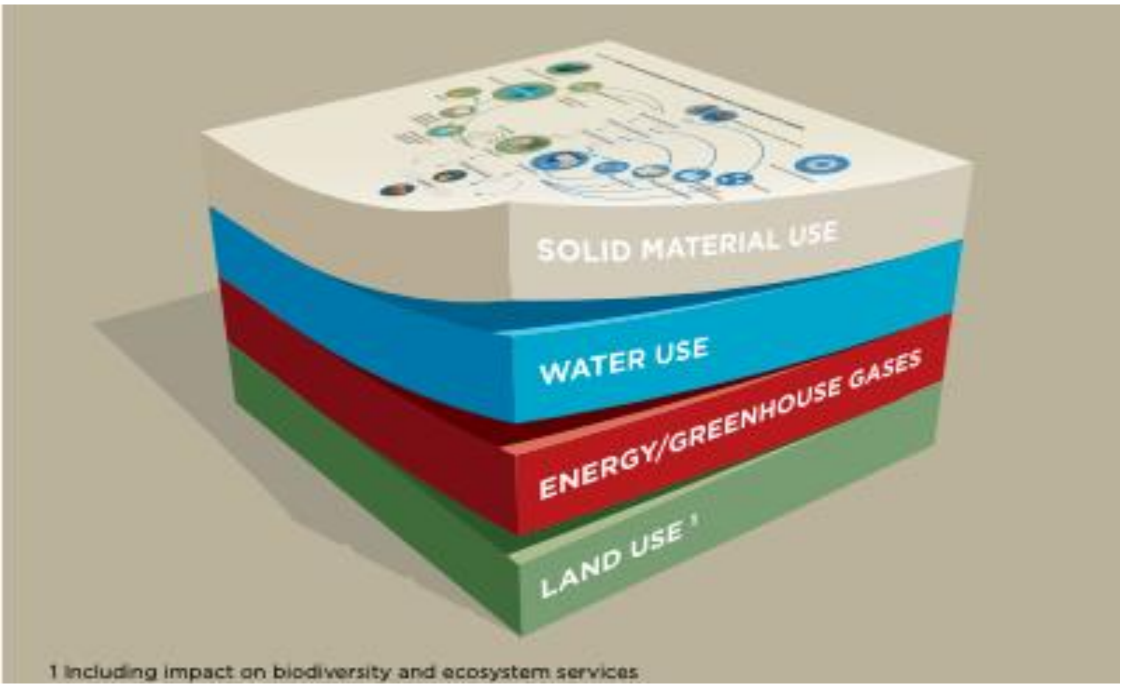


Figure 2.5 Towards the circular economy: Opportunities for the consumer goods sector (Ellen MacArthur Foundation, Macarthur and Ellen MacArthur Foundation, 2012).

In the Green Economy - Modelling Report of South Africa, these natural resources included ecosystems, non-renewable resources, energy, transport, agriculture, waste, and construction as the key focus sectors. Within the South African context, the pathway towards green growth would include increasing economic investments and jobs in the green industry sector and encouraging cleaner industrial development to reduce environmental impacts and better socio-economic involvement (United Nations Environment Programme, 2013). South Africa specified nine essential areas of focus to strive towards for their green economic development programmes (DEA, 2018) namely:

1. The greening of buildings and cities
2. Sustainable transport and infrastructure, promoting alternatives to motorised vehicles e.g., bicycles, rail etc.
3. Energy efficiency that causes less pollution and is more accessible for all
4. “Resource conservation and management”
5. Renewable waste management practices e.g., reusing and reducing waste, striving towards “zero waste households”
6. “Agriculture, food production and forestry
7. Water management by promoting water harvesting, improving waste water facilities, better metering and leak detection systems and reducing losses across all sectors and environments.
8. “Sustainable consumption and production” in all industries
9. Environmental sustainability promoting greening events, research and skill development

The ornamental horticultural industry is and can contribute even more so to this green economy by aligning its production and sale of plants with these focus areas.

2.3.3 Circular economy

Over time, sustainability and the practises involved in achieving it, as well as the related terminology, have progressed and evolved. As already stated, one of the practical approaches of the green economy is the circular economy which was prominent in the current research because it targeted the life cycle of products particularly relevant in biological systems. Many of these systems form part of the ornamental horticultural industry, not only in the production of plants and materials at wholesale nurseries (growers), but also in the services provided by the retail garden centres which have the potential to be part of a waste-free economy, simply conceptualized by the terms reduce, reuse and recycle (Ogunmakinde et al., 2021).

According to the Ellen MacArthur Foundation (2012), there are three principles and 14 related pillars underpinning a circular economy (Figure 2.6) (Ogunmakinde et al., 2021):

1. Products are designed for use and then broken down to be reused (Regenerative design). There is zero waste (cradle to cradle [C2C]) in additional to more energy efficient practises while less labour is used to create new materials or products (Industrial ecology).
2. The durability of products and consumables produced differs as input elements are predominantly of a biological nature or design (biomimicry) which can be returned to the environment with no or very little harmful impact (Eco Efficiency and Effectiveness and Permaculture). If plastics and metals are used, they are designed for reuse from the beginning of their life cycle (Material Passports and Performance Economy).
3. Energy usage within this economy is preferably renewable, to decrease non-renewable dependency and increase resilience (Natural Capitalism, Resource Efficiency and Blue Economy).

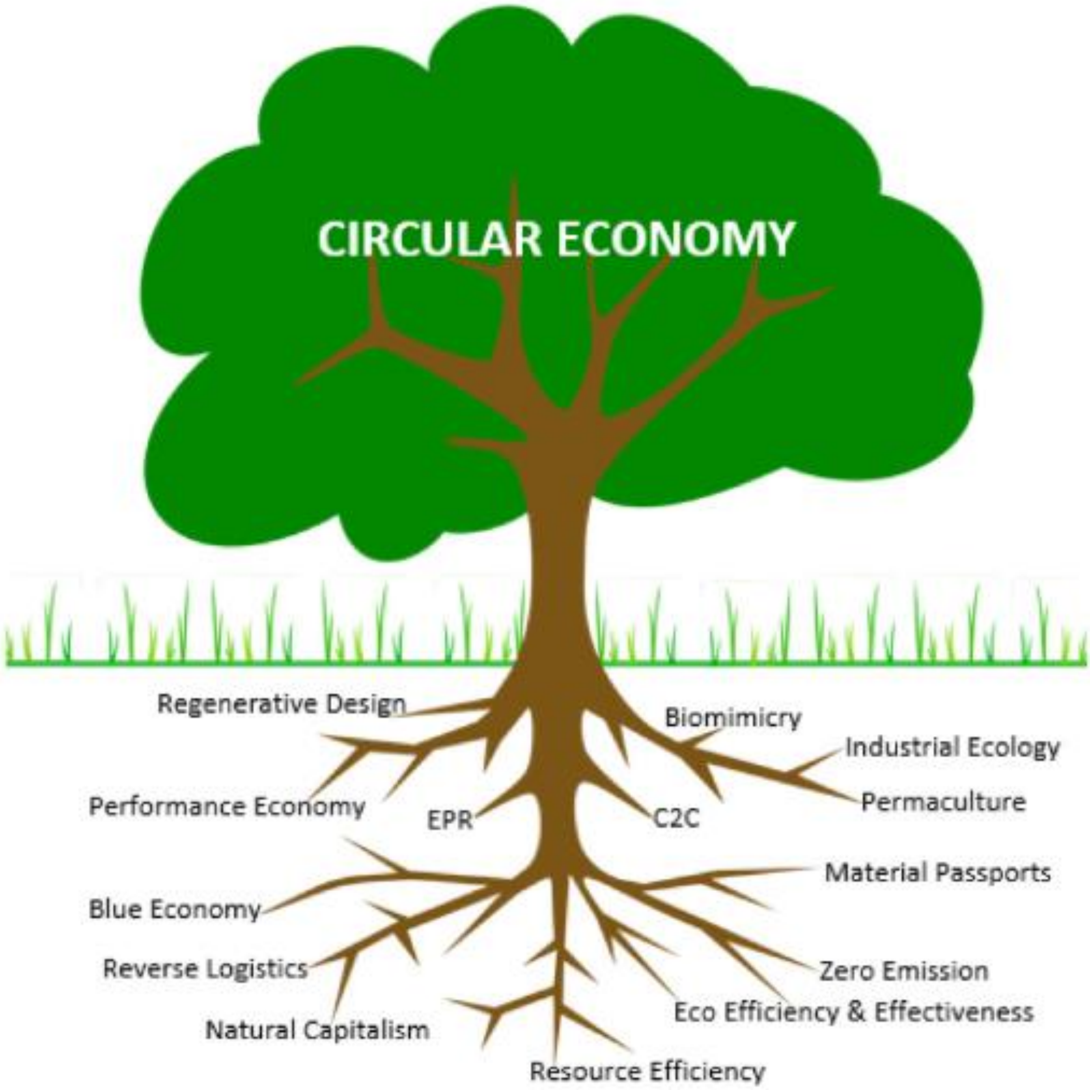


Figure 2.6 Circular economy roots (Ogunmakinde, 2019).

Three years later, the Ellen MacArthur Foundation proposed a checklist of actions to assist with circular economy implementation using the acronym "*ReSOLVE*": "*regenerate, share, optimise, loop, virtualise and exchange"* (Ellen MacArthur Foundation, 2015). Some of these principles and actions are already being applied within the ornamental horticultural industry currently but need to be highlighted and documented so that more members within the South African context may embrace and use them.

One of the methods to access the circularity of a product is *"Life Cycle Assessment"* (LCA) (Walzberg et al., 2021). This is to quantify the ecological consequences and avoid incurring additional impacts from primary resource extraction e.g., mining, manufacturing and processing, usage and consumption and then waste creation and disposal (Hellweg and Canals, 2014). This method can be used on a smaller scale by the ornamental horticultural industry especially as many of the products used within the industry are of a circular life cycle by their nature e.g., plant material, certain growth media and biological pest control.

Another is "*Environmentally Extended Input-Output Analysis"* which includes the assessment of services as well as products but is mainly used for formal trading and national economies which can be limiting with regards to this research (Walzberg *et al.*, 2021). There are numerous other methods from the Industrial Ecology Field such as "*Material Flow Analysis", "Energy or Exergy Analysis", "Discrete Event Simulation"* (Walzberg *et al.*, 2021). These all have pros. and cons. but the evidence from literature researched on those most favourable by the ornamental horticulture industry with regards to the carbon footprint of products (plants) was the LCA method (Nienhuis and De Vreede, 1996; Lazzerini, Lucchetti and Nicese, 2014; Darras, 2020b; Havardi-Burger, Mempel and Bitsch, 2020; Bonaguro *et al.*, 2021). To determine the ecological footprint of the ornamental horticultural industry and the impact it has had on the natural environment and resources, best practices have been used based on indicators e.g., resources water and soil, as shown above, have been clustered into themes linking the principles of circular economy with sustainability to improve the environmental sustainability (Ekins, 1992; Smith and Lopes, 2010; Johnson, Mangiafico and Obropta, 2011a; Florida Department of Agriculture and Consumer Services, 2014; De Silva and Forbes, 2016; Darras, 2020b).

The implementation of circular economy principles and concepts directly supports strong sustainability that is comparable and complimentary to the theories and practices of the green economy. The synergy between various methods most suitable to the research questions (1,4,6 and 8), the scale of the project and the type of analysis to be done from these concepts provides a comprehensive platform for evaluation and the development sustainability strategy (D'Amato *et al.*, 2017; Walzberg *et al.*, 2021).

South Africa is a developing nation and in the Green Economy Accord (Economic Development Department., 2011) the South African government is committed to:

- Increasing investments in the green economy,
- Procurement of renewable energy,
- Launching clean-coal initiatives to reduce emissions,
- Promoting energy efficiency,
- Encouraging waste recycling and
- Collaboration with others in the United Nations COP 17.

Since 2010 the green economy initiatives have increased particularly in Gauteng (transport), Western Cape (energy) and KwaZulu Natal (agriculture) Figure 2.7 (Department of Environmental Affairs & Partnership for Action on Green Economy, 2017).

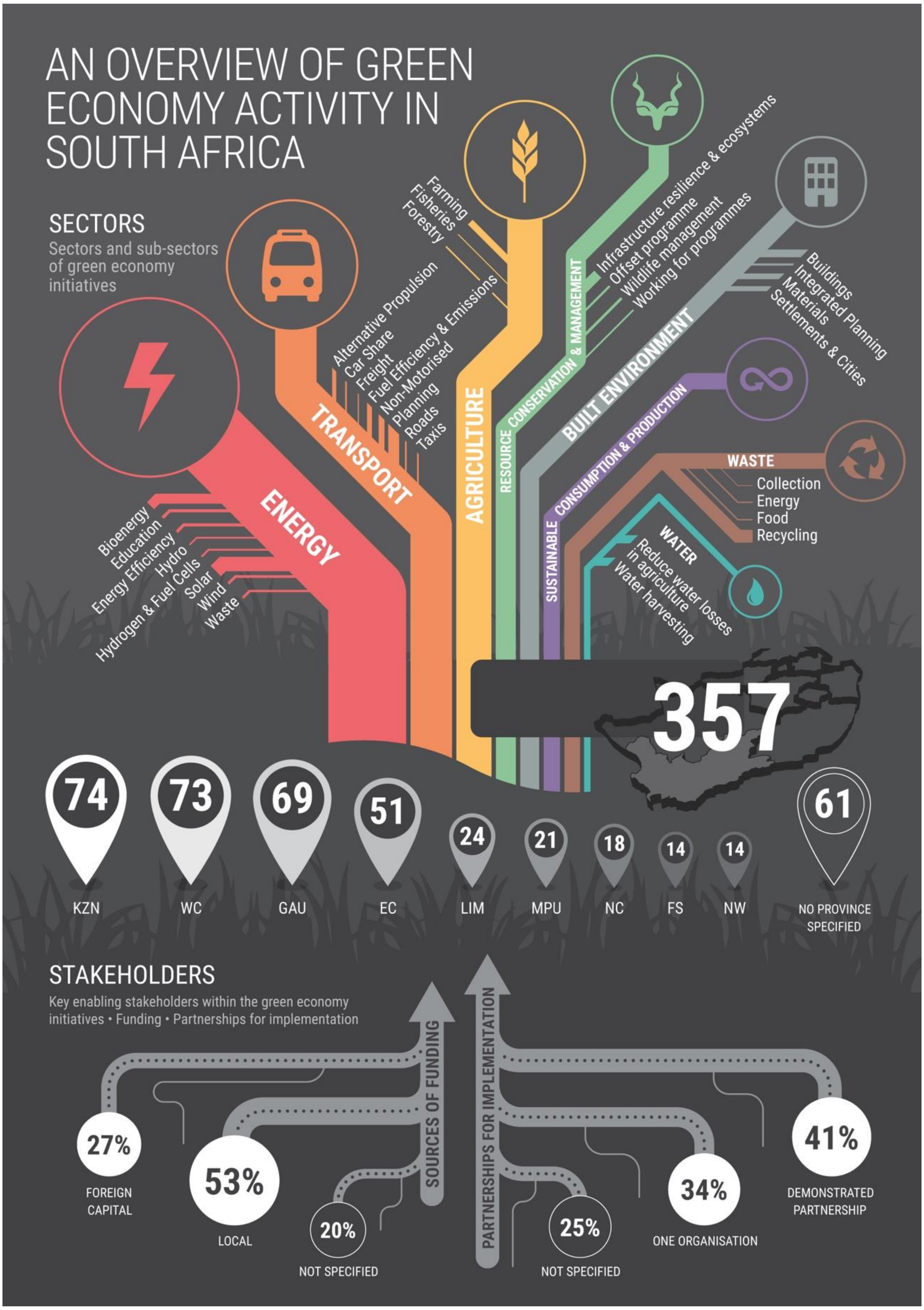


Figure 2.7 Overview of green economy activity in South Africa including sectoral, geographical representation and relevant stakeholders. (Department of Environmental Affairs & Partnership for Action on Green Economy, 2017).

When the COVID-19 crisis subsided, the South African government compiled a Reconstruction and Recovery plan that included an environmental component which re-iterated those commitments declared in the Green Economy Accord, in addition to water and energy conservation. This commitment by the government and the current repeated request for the economy to move from a linear model to a more circular one (Richards, 2020; Creecy, 2021) using the 9R Framework (Figure 6.9) highlights the importance of this research and provides an opportunity for the ornamental horticultural industry to align its sustainability objectives with those of the government.

In other words, this study will showcase environmentally sustainable concepts from the circular economy and nature-based solutions of the green economy for the members of SANA and others to implement which will improve their profitability and decrease their impact on the environment.

2.3.4 Nature-based solutions (NBS)

Numerous environmental, social and economic challenges of sustainable development can be solved using nature-based solutions whereby the actions of humankind are *"inspired by nature or supported by nature or copied from nature*" (biomimicry) (European Commission, 2015). Nature-based solutions are all around us using the natural environment to provide options different to those provided for by technology e.g., "*blue-green infrastructure" ",ecological engineering" and "ecosystem services"* (Keesstra *et al.*, 2018). It is another one of the concepts related to the green economy (Loiseau *et al.*, 2016). This concept was not originally part of the Climate Change proceedings in 1992 but was included in the Conference of Parties in 2011 along with *"climate-smart agriculture"* and "*agroecology"* (Hrabanski and Le Coq, 2022). In the last decade, nature-base concepts have grown in popularity, especially in Europe (Matsler *et al.*, 2021) and, more recently, globally as *"nature provides security and by protecting it we ensure that humankind has water to drink, food to eat and air to breathe"* (COP26, 2021).

The idea of nature-based solutions has progressed from ecosystem-based concepts (including natural capital) to now include social and economic actions that are resource-efficient using innovative concepts from technical, business, finance, governance, regulatory and social spheres to conserve, manage and rehabilitate natural or altered ecosystems (Figure 2.8), (Cohen-Shacham *et al.*, 2016; Ferreira *et al.*, 2020). Presently it is a holistic way of addressing both the climate and biodiversity problems facing global economies (COP26, 2021).

The following fundamentals are to be applied when creating a strategy using nature-based solutions according to the IUCN (Cohen-Shacham *et al.*, 2016):

1. Incorporate nature conservation guidelines
2. Can be stand alone or combined with e.g., technological and engineering innovations to achieve success
3. Are location specific in relation to natural and cultural e.g., traditional, local, and scientific knowledge
4. All benefit society equally from participation and transparent processes
5. Ensure all aspects of diversity, including biological and cultural, are sustainably maintained
6. Are applicable to specific locale in terms of scale and environment
7. Be aware of exchanges between the production of a small but instant economic gain over the long-term options to fully utilise a comprehensive range of ecosystem services
8. Are intrinsically incorporated into the development of policies, procedures and actions solving the challenge

These eight principles and their graphical representation in Figure 2.8 provide the practical guidelines for the ornamental horticultural industry to investigate its impact on natural resources, namely research question 4, and the resulting nature-based solutions.

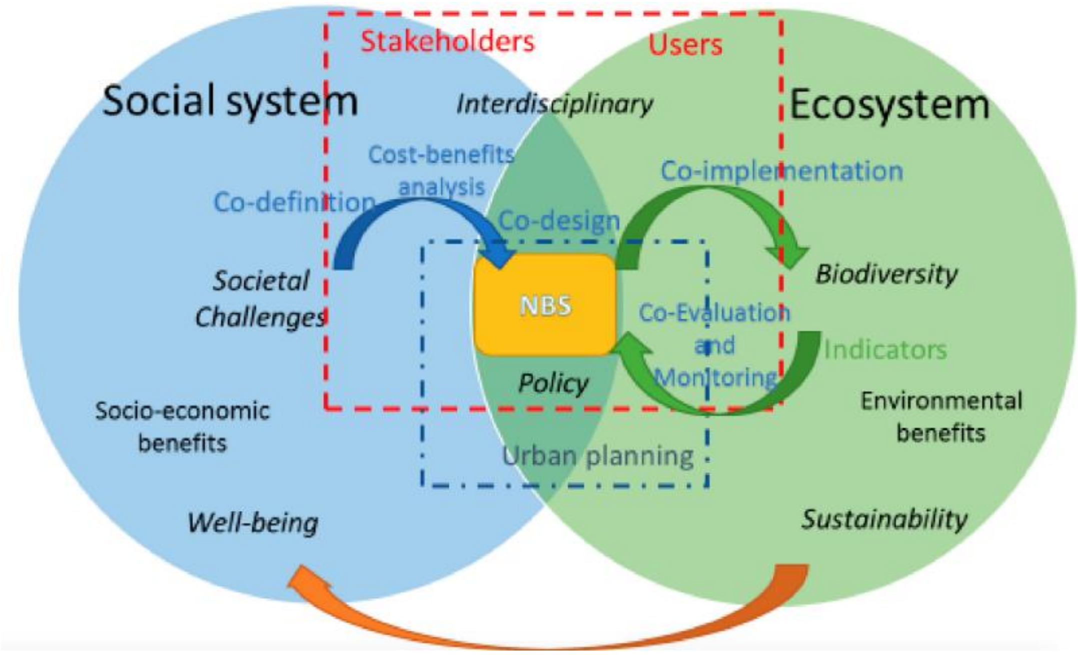


Figure 2.8 Conceptual understanding of nature-based solutions (Ferreira et al., 2020).

In the literature search there are many “green factors” which are considered as nature-based solutions particularly with regards to climate change adaptation and urban regeneration incorporating collaborative social ideas (Nature-Based Solutions Appendix 5). Those, which are listed below, in conjunction with non-intensive horticultural practices in the ornamental horticultural industry provide ideas for nature-based solutions in this study:

- Infiltration basin (NBS1)
- Retention pond (NBS2)
- Swale (NBS4)
- Construct wetlands (NBS5)
- Design and plant green wall and vertical gardens (NBS9)
- Build shelters and conserve areas for biodiversity (NBS14)
- Green corridors (NBS16)
- Private gardens (NBS21)
- Community garden (NBS22)
- Use of pre-existing vegetation (NBS24)
- Composting (NBS25)
- Soil improvement (NBS26)

- Systems for erosion control (NBS27),
- Riverbank engineering (NBS28),
- Rivers or streams (blue corridors) (NBS29),
- Diverting and deflecting elements (NBS31) (Castellar et al., 2021).

These “green factors” or nature-based solutions such as flood controls, carbon sequestration and storage can improve human health, alleviate poverty and increase biodiversity in urban areas. These are opportunities for ornamental horticulture to be part of the solution, as wholesale nurseries, retail garden centres and customer’s gardens can provide environmental protection, pollution reduction and increase natural capital if the above factors and principles are incorporated into their production methods, business strategies and design (Loiseau *et al.*, 2016).

These factors were not only used by the researcher investigating research question 8 and in developing the best practices manual (study objective 4) but also by numerous municipalities in South Africa in trying to ensure that a *“nature-based Green Economy is a reality”* (Sotyu, 2021).

In order to improve the green economy of a country, measurement tools such as the total productivity and more specifically the green productivity would have to be measured which not only includes the workforce and the capital and gross domestic product, but also the energy used from a variety of sources and the pollutants released into the environment (He *et al.*, 2022). These concepts and their relevance to this current study are explained below.

2.3.5 Environmental productivity and green productivity

In the face of resource depletion and human population increase, for the ornamental horticulture industry to remain viable in the future, various strategies of environmental productivity need to be developed to ensure the industry’s incorporation as part of the green economy of South Africa.

The use of environmental resources (“natural resources”) and the generation of by-products to manufacture goods (“output unit”) and / or provide services is known as environmental productivity (Repetto, 1990). During the 1990s, this term was popularised and often related to the competitive trade-offs in industry against environmental impacts and profitability which could be positive or negative (Jaffe *et al.*, 1995; Porter & Van Der Linde, 2017). To improve environmental productivity, either environmental innovation was involved and / or there was a change towards the development of green technology (Ghisetti and Quatraro, 2017). There was either an increased output using less than or the same amount of resources or the output remained the same but a reduced input with regards to natural resources usage and resulting pollution.

Furthermore, during this period when environmental productivity was being debated, the correlation between economic development and environmental degradation was also being researched, specifically the pollution-income relationship. These studies showed that at the beginning stages of industry expansion and progress, habitats are destroyed, and ecosystems damaged especially as a result of certain gaseous pollutants and water pollution (but excluding CO_2, diffusion costs and accumulated, long-term gaseous stocks). However, as the GDP and corresponding earnings increase, the environmental quality also improves. This is known as the “*Environmental Kuznets Curve” and* is shown as an inverted-U relationship. It was suggested in 2004 that maybe it was a “*N-shaped*” relationship between pollution and income, where when an income exceeds a certain amount there is a positive correlation between earnings and expansion which results in a deterioration of environmental concern and quality again (Dinda, 2004). This debate has continued for decades and is now known as the “*pollution-growth nexus”* but the concluding remarks are that developing and transitioning countries as well as developed economies should be creating policies, laws and practices which promote and reward “*green activities”* and improved environmental productivity (Purcel, 2020). This reiterates the importance of knowledge and skills development to improve environmental awareness and create a change of behaviour towards the environment independent of income. Study objective 3 and the associated research questions 5 and 7 highlight the obstacles and challenges faced by the OHISA working towards environmental productivity but this research will use the principles of the KAP (knowledge-attitude-practice) model to provide workable solutions to encourage *"green activities".*

Another term for environmental productivity is "green productivity" and these terms are often inter-changeable (Yu-Ying Lin, Chen and Chen, 2013). Green productivity is a strategy designed to increase outputs and improve environmental performance for complete socio-economic development (Srinivas, 2015). In addition to both terms being used to determine the efficiency with which companies use and impact natural resources, they include concepts such as good governance, informed decision-making and generate positive financial returns for businesses within a period of time (Terra Alpha Investments, 2015).

Since the promotion of environmental productivity, it was noted that positive change towards the environment has occurred both on a global and local level. In Europe, a continued fostering of green technologies through policy development and subsidies encouraged the true measurement of environmental impacts during the production process and the education of those involved via skills improvement and increased consumer awareness (Beltrán-Esteve, Giménez & Picazo-Tadeo, 2019). These ideas were introduced to sub–Saharan African countries with regards to agricultural productivity but more research, development and implementation is needed into alternative energy sources such as solar and hydro power, the correct use of fertilizers, improved irrigation techniques and companion cropping to improve environmental performance and mitigate detrimental long term effects (Salahuddin, Gow and Vink, 2020). As seen in Figure 2.9, the South African government is supporting initiatives to achieve better environmental productivity via green economic initiatives and training (Rosenberg, Jenkin and Lotz-Sisitka, 2017).

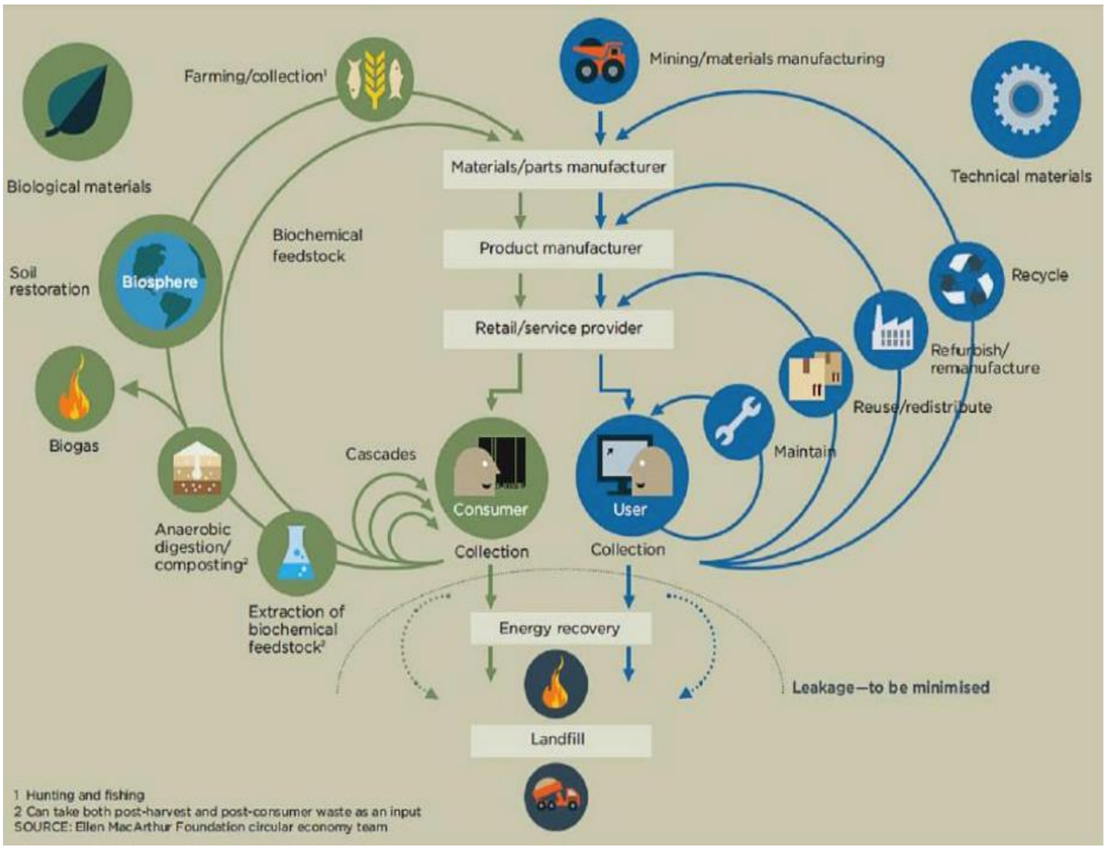


Figure 2.9 Envisioning an economy that is circular and green (Ellen MacArthur Foundation, 2013)

Figure 2.9 provides ideas and concepts using feedback loops which can be utilised to enhance green productivity and can thus be applied to the South African ornamental horticultural industry where the effects of global warming, an increasing population and water scarcity are comparable to other countries within sub-Saharan Africa. Thus, the current research will contribute to enabling green economic growth by using practical examples within the ornamental horticultural industry in South Africa to promote environmental productivity and not only sustainability reporting.

2.4 Ornamental horticulture as a problem and a solution

Ornamental horticulture is a contributing industry towards pollution and climate change, but it also can provide the means to achieve increased environmental productivity and hence green growth as explored by research questioned 8. The term “horticulture” is derived from the Latin hortus (garden) and cultural (cultivation) therefore garden cultivation (Acquaah, 2005) but this is rather limiting and it is better described as the integration of *“people”* and *“plants”* (Relf, 1992). *“Horticulture”* is an all-encompassing field of science, art, technology, and businesses that are involved in the cultivation of plants for human use. It is diverse and incorporates the production of fruits, vegetables, nuts and herbs as well as non-food crops known as ornamentals e.g., flowers, trees, shrubs, perennials and lawns - this is known as ornamental horticulture. The variety of food, health, pharmaceutical, lifestyle, environmental and social commodities and services that horticultural businesses contribute to results in the stimulation of minds and emotions of individuals and the enrichment and upliftment of communities which are all fundamental to human well-being (Relf and Lohr, 2003; Durner, 2013).

Horticultural crops also contribute to food security, mental well-being and a harmonious lifestyle (Jiang *et al.*, 2021). Generally, growing horticultural plants is more intensive than agronomic and forest plants, with higher returns on investment per unit area (Acquaah, 2005).

Within the agricultural sector of South Africa, the *“green industry”* includes ornamental horticulture, landscaping and organic nurseries and farming (AGRISETA and AGRISETA Subcommittee, 2015),. The *“green industry”*, describes those *“environmental”* businesses where plant material is produced and sold along with other allied trade products such as fertilizers, pots, organics etc. It incorporates other services such as landscaping, irrigation, garden, turf, tree and indoor plant care and maintenance on-sites such as estates, schools, golf courses, parks and nurseries (Hoy, 2009).

The purpose of the horticultural industry is to supply the necessary plants and related products that people require to enhance the environment in which they live. Within this *“green industry”* and other associated industries, is the opportunity to create *“green jobs”* e.g., in agriculture, manufacturing, research, developmental and administrative services. These *“green jobs”* will contribute to the conserving of biodiversity, rehabilitating environmental quality and ensuring the wise use of resources (Molewa, 2012).

The definitions of the green industry and ornamental horticulture at the start of this study and the discussion above show that they are very similar and in fact interchangeable but for the purpose of this study the researcher choose to focus on the growers and retailers within the ornamental horticulture or green industry which narrows the field of study to include those businesses involved in the production and sale of ornamental plants for gardening and landscaping purposes.

To ensure that the green industry remains “green”, proactive initiatives to design and implement sustainable practices, policies and manuals within South Africa must be initiated and continuously up-dated as has been done in other countries. This was the primary reason for this study, but a secondary objective was to highlight the importance that the South African ornamental horticultural industry plays in being part of the key to environmental productivity and positively contributing to the sustainable development goals through nature-based solutions.

2.4.1 Best management practices

As humans and in business, no one wants to settle for “good enough”. The way we live, the businesses we run, the products we sell or the services we provide are all meant to be “the best” (Bilderback & Bir, 1998). In the ornamental horticultural industry, this means finding the most environmentally friendly way to achieve success in the process of growing healthy, saleable plants and it begins with best practices manual. For the purposes of this study, the use of best practices manual and best management practices are interchangeable.

The BMPs can either be specific practices or a combination of procedures that, based on experimentation, nursery trials and / or field-testing and research, are determined to be the most productive and practical way for growers and garden centre retailers to increase their environmental efficiency using less natural capital and improve sustainability within a budget (Florida Department of Agriculture and Consumer Services, 2014).

These BMPs are designed to assist growers in recognizing extraordinary and sustainable production and management practices, methods, and procedures and prioritize them. The strategies or guidelines of BMPs should be applicable to nurseries of any size, at various locations, giving them the opportunity to improve plant production while minimising their environmental footprint (Southern Nurseryman Association Best Management Practise, 2013).

BMPs are usually voluntary guidelines, activities and maintenance procedures that involve management decisions to be made with regards to the business practices to prevent or reduce environmental degradation and depletion of natural resources (Maxime, Gauthier, Estrela, 2014).

The researcher selected best practices reports and / or sustainability studies and / or life cycle assessment papers which included the words, *"ornamental horticultural*" in addition the terminology aligned to key terms shown above e.g.,climate change, circular economy, green economy, natural resources, nature-based solutions, pollution, population growth and sustainable development.

In some instances, "sustainable practices" is a preferable term to "best practices" as each business model differs, and what works for one business may not always be as successful or even have the same positive effect in another. Sustainable practices can include any practices done on-site such as erosion control, hedging to reduce temperature variations and transpiration due to wind, and vehicle maintenance etc. The purpose of sustainable plant production is also to increase productivity while minimizing environmental impacts (Dennis *et al.*, 2010; Johnson, Mangiafico and Obropta, 2011b).

A few countries have investigated and implemented the best and / or sustainable practises in relation to their environment for the ornamental horticultural industry. These include Australia, Canada, Germany, Italy, Netherlands, New Zealand, South Africa, Spain, United Kingdom, and the USA.

South Africa and Australia are both positioned in the Southern Hemisphere (30.5595^{O}S and 25.2744^{O}S latitudes respectively) thus they have similar climates, weather patterns and growing conditions e.g., the Mediterranean areas of each even have similar soils (Cowling and Witkowski, 1994; Bennett, 2011). They also have similar flora as they were both part of the Southern Hemisphere supercontinent known as Gondwanaland (McLoughlin, 2001) Australia's ornamental horticulture industry has been very progressive and started to address best practices with regards to water management as early as 1997 and they published this manual in 2010 (Nursery & Garden Industry Australia, 2010). Their commitment to the environment was documented in their *"Environmental Sustainability Position"* in 2014 and this included aspects such as best management practice programmes for production farms which have an accreditation system for water and nutrient management; *"EcoHort*" which is an effective management strategy for natural resources and *"BioSecure HACCP"* which promotes biosecurity, invasive plant management and plant labelling within the industry (Nursery & Garden Industry Australia, 2014). This commitment contains other environmental issues too such as waste, best management practices for pesticide application and the consequences of climate change on urban forestry (Nursery & Garden Industry Australia, 2014). Horticulture Innovation Australia, (2021) published their latest commitment to the 17 sustainable development goals and the framework includes the ornamental horticulture as well as cut flower nurseries and turf. This report focuses on 4 pillars, namely *"nourish and nurture", "people and enterprise", "planet and resources"* and *"less waste"*. In Australia the nursery industry contributed $2.6 billion to the economy in 2021 and this grew by 8.84% from the previous year (Horticulture Innovation, 2021). Statistics like this are not available for South Africa apart to say that our ornamental horticultural industry is much smaller (pers comm, Paul Vonk, 2019). In this study, the researcher investigated how much of the above information has been implemented in South Africa as many of our growers and garden centre retailers travel oversees to international conferences such as the International Plant Fair - ESSEN (the world's leading horticultural trade fair) and IGCA (International Garden Centre Association) convention. They also hire international consultants to assist with their business practices and thus they gain new insights, solutions and innovations to industry related challenges.

Those States in the USA (Florida, Oregon, Massachusetts Virginia) which implemented industry related best practices also had original and practical ideas from which OHISA could learn. These include minimising water, fertilizer usage and energy utilisation as well as limiting non-renewable raw material inputs and reducing greenhouse gases production in 2010 and 2011 (Yeager *et al.*, 2010; Rideout *et al.*, 2011; Southern Nursery Association, 2013; Mack *et al.*, 2019). The best management practices of these regions differ between field grown crops and container plants and although the climatic conditions vary from those in South Africa e.g., winter conditions and the precipitation are different in these States, they tried and tested their recommendations for their climate.

The last focus area for best management practices which was relatable to South Africa was Canada. Again the climatic conditions differ and they focused on energy usage in tunnels and greenhouses more than is necessary but the research conducted was comprehensive with good questions and insights into the industry (Maxime *et al.*, 2014).

Using documents, publications and webinars from international horticultural associations or researchers, this researcher highlighted the frequency of environmental indicators or key resources that were mentioned per country in terms of best practices for sustainability in horticulture and tabulated it (Table 2.2). In some instances, the key indicators were grouped together in terms of the problems that they cause e.g., use of peat and energy sources such as fuel contribute to global warming and in some cases the terminology of the indicator varied but the implications were similar and hence were collaboratively grouped together e.g., single use plastic and product disposal which are both incorporated into waste which results in pollution.

Table 2:2 Synopsis of key resources of international best practise in horticulture

Country	**Key Resources**						
	Energy source	**Nutrients / Fertilizer**	**Pesticides**	**Soil/ Media**	**Waste**	**Water**	**Other environ-mental indicators**
Australia	Yes	Yes	Yes	Yes	Yes	Yes	Biosecurity Invasive species
Canada	Yes	Yes	Yes	Yes	Yes	Yes	No
Germany	Yes	Yes	Yes	Yes	Yes	Yes	No
Italy	Yes	Yes	Yes	Yes	Yes	Yes	
New Zealand	Yes	Yes	Yes	Yes	Yes	Yes	Habitat and wildlife protection
South Africa	No	No	Yes	No	Yes	No	Invasive species
United Kingdom	Yes	Yes	Yes	Yes	Yes	Yes	Biosecurity Ecosystem and Wildlife preservation Suppliers
USA	Yes	Yes	Yes	Yes	Yes	Yes	Crop protection Wetlands Invasive species Whole farm site (slope of land)

Applying the information shown in Table 2.2 as a guideline and with the aim of answering the research questions proposed in Chapter 1 it can be stated that these are key resources that need to be investigated for the environmental sustainability of the ornamental horticultural industry in South Africa namely: energy, fertilizer, pesticides, soil (growth media) water and waste. As can be seen, South Africa has documentation on chemical (pesticide) safety and a list of recycling companies, but this must be updated to include greater knowledge, understanding and skills development relating to sustainability and environmental productivity. One of the benefits of being a developing country is the opportunity to learn from developed countries, as infrastructure and development pathways are still being constructed (Luukkanen et al., 2019), as is the case of this research.

Coupled with the above key resources of best practices and articles are international standards e.g., Global Gap, which set certain food safety and sustainability criteria for agricultural farms. Some of the growers in South Africa use this because apart from growing ornamentals, they export fruit and plants throughout the world. In South Africa, there are local standards which again have their roots in agriculture but are now being adapted and used by some ornamental horticultural growers as certain box stores require them to do so to be able to supply into them e.g., Sustainability Initiative of South Africa (SIZA) (World Wildlife Fund, 2019) and Farming for the Future. These documents have also been studied to identify indicators and practices which are relevant for the compilation of the best practices manual.

2.4.2 Other ornamental horticultural industry practices that affect natural resources

Utilising the key indicators and themes discussed with regards to environmental indicators by Rahdari, & Rostamy, (2015) (Figure 2.4), sustainable development goals (United Nations) (Table 2.1 and Appendix 2), principles and standards highlighted by the circular and green economy, and the various methods suggested to measure and monitor environmental efficiency (e.g., Life Cycle Assessment (LCA) of a plant or product), the researcher will link these to the natural resources affected by OHISA. The effects on the natural resources have not been researched and documented although there are papers written with regards to agricultural practices thus the researcher looked at international practices within the OHI for guidelines, best practices, and policies (Table 2.2 and more detailed analysis in Chapter 6). Similarly, it was from these international examples that the researcher determined which natural resources to focus on namely water, land and air in relation to the production methods and sales structures used to grow and maintain a healthy plant for the consumer to buy i.e. using fertilizer and pesticides. Lastly the amount and variety of waste products produced in this process of growing was also investigated. In summary the six factors to be addressed are water, growth media (soil), fertilizer, pesticides, energy sources and waste creation and disposal.

2.4.2.1 Water

Ornamental Horticulture falls under agriculture in terms of water use and thus it is important to ensure that as an industry, water is used sustainably. It is also the responsibility of the industry to provide education to consumers as South African gardeners use 46% of their domestic water looking after their plants (Business Tech, 2015).

The impact of droughts on horticultural operations and business can be dire especially when they are associated with hot, dry, and / or windy weather that increases the plant's water needs. Furthermore, there is increased pressure on water sources during these periods when the water needs of non-agricultural users also increase, negatively affecting many business operations and their productivity (Meiring, 2018; Sheng and Xu, 2019). It is important for nurseries to have prepared plans for drought conditions since the perception of excessive water use can generate negative public and political pressure (Johnson, Mangiafico and Obropta, 2011b; Fulcher *et al.*, 2016; Olivier, 2022).

Irrigation systems and methods of watering are important. The ideal is delivering the correct amount of water needed for each plant at the most essential time for growth (Johnson, Mangiafico and Obropta, 2011b).

In the development of best practise manual, growers and garden centre owners were asked to evaluate their present irrigation system and if necessary take steps to improve it as was recommended by Bilderback and Bir (1998). The results from Australia and the USA showed that if they made some of the small, cost-effective changes they could increase irrigation efficiency. Depending on the type of irrigation systems available, their configuration, and the size of the nursery operation, the results will differ but these scenarios will produce options for both growers and garden centre owners to be able to use water more sustainably (Rideout *et al.*, 2011).

In addition to irrigation, the growing of crops and ornamental plants under protective structures helps growers, within reason, to control water issues specific to their region. The term "controlled environment" refers to a greenhouse structure which provides optimum growing conditions in terms of meeting the needs of the plants at their particular growth stage with regards moisture, humidity, temperature and light (Boodley and Newman, 2009). For example, in South Africa's semi-arid areas crop protection is needed to manage water use and transpiration of plants whereas in the semi tropical regions of the country, tunnels or greenhouses are used to prevent crop damage from flooding, water runoff and erosion (Sydow, 2010).

2.4.2.2 Soil

In this research soil is described as part of the ecosystem where fauna including microorganisms such as bacteria and fungi can live (refer to section 2.1.3). It is also an excellent catcher, filter and storage area for chemicals, polluted water, fertilizers, and other substances e.g., heavy metals. With these positive attributes of soil in mind, the degradation and erosion because of poor ornamental horticultural practices must be minimised. These practices are regulated by the norms and standards prescribed to ensure remediation of contaminated land either by metals and metalloids, petroleum organics, petroleum additives and anions such as chlorides, nitrates and sulphates in South Africa (South African Government, 2013b). This forms a link between the ornamental horticulture industry, and the fertilizers and chemicals that they use. The extent to which this Act is being enforced by the industry is unknown at this stage.

As already discussed, the ornamental horticultural industry not only uses soil to grow plants but also uses different growth media. A growth medium can be defined as a substrate in which roots develop and then these roots extract the water and nutrients (Landis et al., 1990). This process has been around for centuries as previously stated - as soon as people started to put plants into containers. The advancement of growth media came about when scientists investigated the nutritional needs of specific crops and started growing plants in inert silica sand for better disease control, and added nutrient solutions to meet the plant's needs (Raviv, Lieth & Bar-Tal, 2019). With the correct growing techniques, plants can be grown using a variety of substrates. The perfect growth medium minimizes management requirements to produce a healthy plant

(Ingram, Henley and Yeager, 1993). In addition to this, soil and growth media are not only being enhanced and enriched for agricultural crop production but also for ornamental horticultural crop production. In nurseries, an understanding of the properties contributing to soil quality is becoming paramount for good plant production. These include electrical conductivity (EC), pH, air-filled porosity (AFP), water infiltration and holding, as well as nutrient cycling (Johnson, Mangiafico and Obropta, 2011b). Within South Africa, the lack of standard growth media formulations which growers can depend on, affects the production of the plants (Sittig, 2020. pers comm).

With regards to sustainability and growing media, certain soil components such as peat are no longer readily available and many substitutes are being investigated (Alvarez *et al.*, 2017; Omidi *et al.*, 2019). As a result, some growers have evolved their growing media to include coir fibre which is an organic waste product derived from coconut which has been researched as a suitable replacement (Noguera *et al.*, 2000; Londra, Paraskevopoulou and Psychogiou, 2018). Coir has water-retaining properties, and it increases the air-filled porosity. This shows how growers are already adapting to become more sustainable, having less impact on their environment.

2.4.2.3 Fertilizers

To produce a saleable plant in the shortest space of time is one of the growers' greatest challenges. Ornamental horticulture, like agriculture, is a competitive market, and hence fertilizers are used to increase plant growth and improve the quality of the plant. It is important to find the balance per plant species and optimally apply the correct quantity of nutrients to prevent damage to the plant e.g., some plant tissues weaken and become more susceptible to disease, pests and breakages when over-fertilized with excess nitrogen and the leaching of this fertilizer into the environment can cause its degradation (Johnson, Mangiafico and Obropta, 2011b; Voogt *et al.*, 2017; Mack *et al.*, 2019).

Plant nutrition and the addition of minerals (e.g., ash) to improve plant development has been practised for thousands of years but it has become more specific and specialised through the ages to ensure food production for the growing population (Novotny, 1999; Raimondi *et al.*, 2021). Fertilizers are defined as substances used to stimulate plant growth and development with one or more essential plant nutrients being added thus increasing the nutritional value of the cultivated crop or improving the condition of the soil. According to the International Organization for Standardization (ISO), this definition only includes terms and not the elements related to plant nutrition (ISO, 1983). These elements are normally specified and monitored at a national level and can vary depending on the country. The increased productivity and yields from agriculture due to fertilizer usage contributed negatively to soil health, water quality and coastal biodiversity thus resulting in environmental degradation e.g., erosion and green-house gas emissions (Novotny, 1999; Balvanera & Pfaff, 2019; Raimondi *et al.*, 2021). Nitrates, phosphates, and potassium are elements which are most frequently found in fertilizers which benefit production. The pollution of soil, water and land is usually brought about by nitrate and phosphate leaching or their over utilisation so that flooding and soil erosion cause these elements to end up in dams, rivers and the sea which results in problems such as eutrophication (Lillywhite, 2014). On the other hand, certain naturally occurring elements such as rock phosphate is finite and it should be recycled back onto the land especially agricultural farms and not end up in water courses and the sea where it cannot be readily reused (Dawson & Hilton, 2011).

The ISO7851:1983 standard is under scrutiny to ensure that it adheres to SDG 2, 13, 15 and 9 (ISO, 2019). The debate initiated by Brown, Zhao and Dobermann (2021), in relation to what is plant nutrition, fertilizer and more specifically the elements essential for plant growth can then be clarified to allow for a wider variety of fertilizers to be made available for registration and use at country level.

Due to the adverse environmental impacts of conventional fertilizers, there has been much research done on slow-release fertilizers and controlled release fertilizers which have a coating such as a resin polymer or sulphur buffer surrounding the macro-, micro-, and trace elements e.g., nitrogen, phosphorus, potassium, copper, zinc, and selenium within the fertilizer. The use of these upgraded fertilizers such as Osmocote and Nutricote in agriculture have reduced nutrient use by plants resulting in a reduction in the frequency and amount of fertilizers being applied to plants, thus reducing nutrient loss and excessive leaching (Raimondi *et al.*, 2021). This was one of the best management practises stipulated to nurseries in Southern California during the 2000's (Dennis *et al.*, 2010; Mayer, 2010) and is still used today by growers throughout the world. Another suggestion which would have a less negative influence on the environment is the use of bio-fertilizers that contain fewer heavy metals (Salehpour, Khanali and Rajabipour, 2020).

Research in the agricultural industry with even more precision-based "smart fertilizers" such as nano-fertilizers, composite materials-based fertilizers, or bioformulation fertilizers is being done. These smart fertilizers optimise factors such as the application rate and duration of nutrient release into the soil and the time of uptake by the plant through the roots thus minimising the harmful effects to the environment (Raimondi *et al.*, 2021).

For the purposes of this study the 1983 ISO definition of fertilizer is utilised, and it is regulated by the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act 36 (South African Government, 1947) in South Africa. The Fertilizer Bill (South African Government, 2018) which is a proposed update to the Act ensures that good quality fertilizers for plant production are manufactured safely and do not negatively affect human or environmental health and is thus in keeping with the sustainable development goals. The use of fertilizers and the leaching of nutrients into the environment was investigated in this study.

2.4.2.4 Pesticides

Pesticides have similar detrimental effects to the environment as fertilizers. They can affect soil microbial activity and influence agricultural sustainability. If they enter the water, it can pose a serious threat to animal and human health. Agrochemicals which include "*herbicides, fungicides, insecticides, nematicides, molluscicides, rodenticides and chemical fertilizers"* have been used in agriculture to improve productivity of the land and feed the growing population and their changing dietary needs (Meena *et al.*, 2020; Srivastav, 2020). There has been and currently still is a need to move towards more sustainable horticultural practices and integrated pest management e.g., using natural or biological pesticides rather than indiscriminately applying agrochemicals which kill only 0.1% of the targeted pest and the rest contaminates the surrounding environment, be it air, water, land or soil (Meena *et al.*, 2020).

Natural products for the control of pests have been a source of research for many years. Plant based insecticides and herbicides make up a large percentage of those natural products used to combat pests (Sparks, Hahn & Garizi, 2017) including pyrethroids, which originally were plant-sourced and now many are made synthetically. Biopesticides are used to control pests such as weeds, invasive species, insects, fungi, bacteria, viruses and nematodes in a manner that reduces pollution and harmful exposure to the surrounding environment, humans and animals (Johnson, Mangiafico & Obropta, 2011; Lorenzetti *et al.*, 2019; Meena *et al.*, 2020).

An International Code of Conduct on Pesticide Management stipulated by the World Health Organization provides a framework for the manufacturing, distribution, application, and management of pesticides. Past guidelines and more updated standards have been used by many governments to write their own legislation, which can vary from country to country. These are continually revised and updated to ensure human safety and reduce environmental risks (Skevas, Oude Lansink & Stefanou, 2013; World Health Organization (WHO) and Food and Agriculture Organization (FAO), 2014). In developing countries, the lack of resources, education and training as well as enforcement of legislation can be problematic and has been for decades (Ecobichon, 2001; Handford, Elliott & Campbell, 2015). There is also legislation to ensure that remediation of the land by those responsible for the contamination occurs, but this too, is not always enforced (Lorenzetti *et al.*, 2019).

In South Africa, the Agricultural Pests Act (Act No. 36 of 1983) gives guidelines for methods to deter and eradicate pests (South African Government, 1983a) and in 2010 the government adopted a pesticide management policy which was in line with that of the World Health Organization which ensures that all pesticide usage must have little to no detrimental effects on human health nor the environment (Department of Agriculture, 2010).

The control of unwanted pests within the ornamental horticultural environment plays a large role. The laws and guidelines of pest control are not only applicable to agriculture but also to ornamental horticulture. In ornamental horticulture many growers produce a wide variety of plants, each with associated pests which can result in several different pesticides being used compared to agriculture. Another variation from agriculture but relating to edible horticultural crops is that there is an emphasis placed on growing and selling a blemish-free, aesthetically pleasing plant, especially annuals and perennials with little or no leaf, flower or fruit damage (Brand & Leonard, 2001; Bethke & Cloyd, 2009; O'Connor, 2018). Research has shown that many of the international garden centre associations and growers, including South Africa, recognize the importance of safe pesticide handling and usage to protect individuals and the environment (Virginia Tech & Virgina State University, 2013; SANA, 2017; White *et al.*, 2019; Salehpour, Khanali & Rajabipour, 2020).

Preventing pest damage by not using pesticides may reduce environmental damage by pesticides and reduce the harm done to plants, but these measures are not always practiced. They include:

- Horticultural covers e.g., greenhouses or insect control mesh for tunnels (Legarrea *et al.*, 2010; Kitta, Bartzanas & Katsoulas, 2017; Gruda *et al.*, 2021)
- Climate control within greenhouses (Tantau & Lange, 2003)
- Soil solarization (Barzman, Bàrberi, Birch, *et al.*, 2015)
- Biological control / biopesticides (Barzman *et al.*, 2015; Warra & Prasad, 2020; Stenberg *et al.*, 2021).

Integrated pest management (IPM) combines the surveillance of pests and climatic conditions with the meticulous use of "cultural, biological, physical and chemical" measures to manage pest infestations (Johnson, Mangiafico & Obropta, 2011; Barzman *et al.*, 2015). There are 8 principles of integrated pest management recommended by Barzman *et al.* (2015) to effectively manage pests as shown in Figure 2.10. These principles will be discussed in the manual as an option to improve the environmental sustainability of the ornamental horticultural industry.

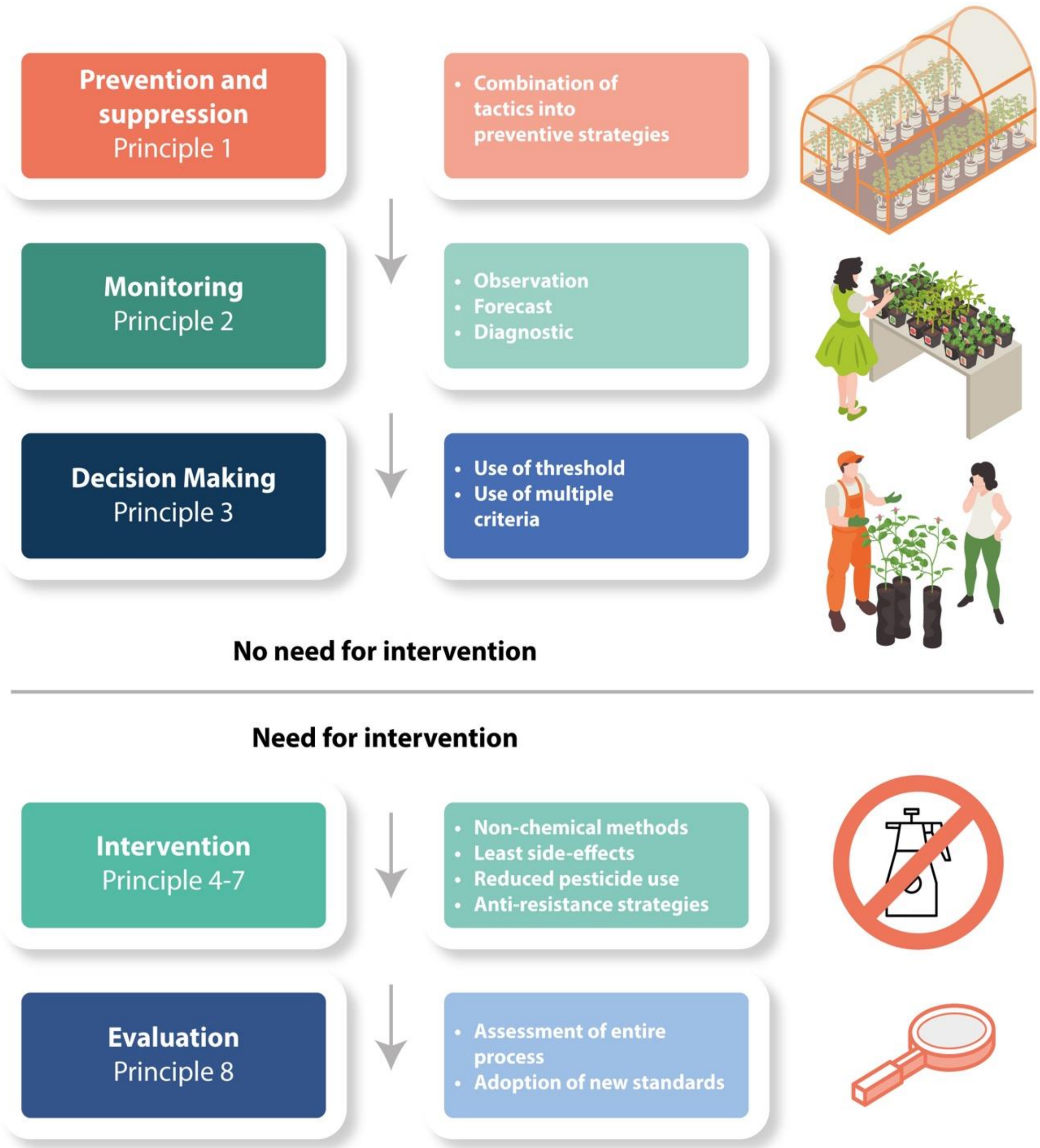


Figure 2.10 The sequential rationale behind the eight principles of IPM (P1-P8). (Draft Guidance document for establishing IPM principles, 2008) adapted by author.

In addition to the eight principles indicated in Figure 2.10, there is the need for increased awareness about pesticide pollution and training on pests, pesticides, and the use of beneficial organisms in ornamental horticultural businesses to control pests and improve pollination. These educational strategies have the potential to mitigate costs associated with eco-friendly pesticides, improve applications and make integrated pest management a better solution for all (Skevas, Oude Lansink & Stefanou, 2013; Wei & Khachatryan, 2021).

2.4.2.5 Energy sources and usage.

When addressing the best management practises with regards to energy, it is imperative to understand why the conservation of natural sources is necessary to facilitate their future provision especially with regards to non-renewable fossil fuels. Since 1974 the International Energy Agency has been collecting, evaluating, and sharing information to ensure energy security. More recently the data gathered include energy sources other than oil, natural gas, and electricity. This also assists emerging markets in developing energy-related policies and provides information about clean energy technology and energy efficiency (International Energy Agency, 2020a). According to the information provided for the World Energy Outlook (International Energy Agency, 2021), 75% of global emissions are as a result of energy consumption due to commerce, manufacturing and society. The recent ramifications of this is global warming increasing by an average of 1.0^{o}C and if this continues *"the climate change-induced temperature will reach the level of 1.5^{o}C between 2030 and 2052"* (Chaudhry *et al.*, 2021). Furthermore the growing population is increasing the demand for energy-related services causing greater concern for the environment (Saidur *et al.*, 2011; Maurya *et al.*, 2021) and human well-being (Inglesi-Lotz & Dogan, 2018).

Figure 2.11 is a graphic description of renewable energy resources and natural resources having a negative effect on the ecological footprint thus reducing environmental damage whereas population growth, non-renewable resources and biocapacity increase (+) CO_2 emissions and thus the ecological footprint. Although this information is used by Khan, Hou and Le (2021) to provide a background for the United States, it can be typical of many others countries.

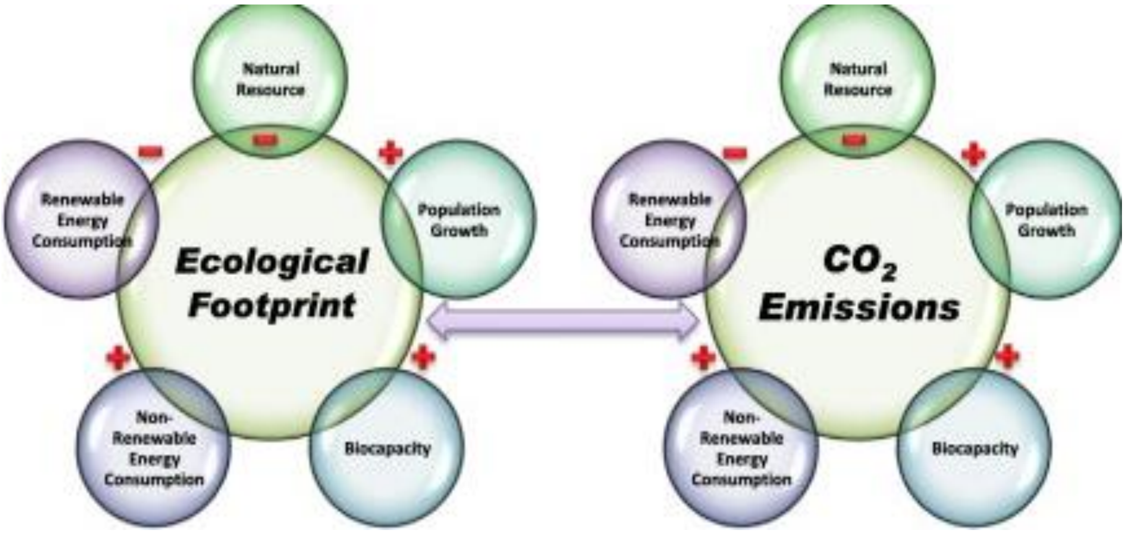


Figure 2.11: Impact of natural resources, energy consumption and population growth on environmental quality (Khan, Hou & Le, 2021).

Natural resources are used to produce energy either as non-renewable fossil fuels such as coal, oil and natural gas, or renewable resources such as wind energy, water, solar power, geothermal and biofuels. Due to the environmental degradation from greenhouse gas emissions and climate change caused by fossils fuels (Apergis & Payne, 2012) as well as their escalating prices and the uncertainty of availability, there is a rise in the use of sustainable energy using renewable resources for future growth (Chu & Majumdar, 2012; Yihdego, Salem & Pudza, 2017). The need to slow down the exploitation of fossil fuels and convert energy production to renewable sources is crucial. Energy technology and research in this sector is the way to achieve sustainable development (Bilgen, 2014; Destek & Avik, 2020) and more specifically SDG 7, which states that consistent, affordable and clean energy be made available to everyone by 2030 (United Nations Department of Economic and Social Affairs, 2015).

Africa has many sources of energy, both renewable such as solar power, wind energy and water and non-renewable such as coal, diesel and natural gas but is lacking in infrastructure and funding to provide sufficient energy (Yihdego, Salem & Pudza, 2017). As the economies in sub-Saharan countries grow, so will the use of renewable energy sources through intergovernmental partnerships, networking with local energy experts and sharing of skills and resources (Inglesi-Lotz & Dogan, 2018). This pooling of expertise and assisting those countries that are not striving towards sustainable development goals is not isolated to sub-Saharan Africa but also Europe where some countries are very advanced at using renewable resources e.g., Germany, while others need assistance to reduce emissions and improve air quality (Alola, Bekun & Sarkodie, 2019).

In South Africa energy is extensively used for mining and industrialization and as it was cheap there weren't incentives to conserve it (Department of Energy, 2011). A decade later, the price of electricity has increased by 173% and petrol by 70% (Lindeque, 2021), and now this energy is expensive and less reliable (Goldberg, 2015). The predominant sources of energy in South Africa are coal, oil and gas and their usage causes high CO_2 emissions (pollution) (Danish, Baloch, *et al.*, 2019) (Figure 2.11). In 2008, 2015, and now again in this new decade there have been electricity shortages known as load-shedding which has affected businesses, development, and the economy (Goldberg, 2015; Mabugu & Inglesi-Lotz, 2022).

A cost- effective way for a business to approach sustainability is improved energy efficiency. The National Energy Act 34 (South African Government, 2008a) provides opportunities for a variety of energy sources to be researched and utilised to promote energy conservation especially with regards to solar power, photovoltaic, wind energy and biomass energy. These clean energy sources can reduce carbon and SO_2 emissions (Department of Minerals and Energy, 2009). Apart from this there is also the Carbon Tax Act 15, with a polluter pays strategy (South African Government, 2019). This discourages the combustion of fuels such as anthracite, bio-diesel, bio-gasoline, diesel, charcoal, peat, petrol and others where emissions affect the environment.

In 2011, the South African Government and social partners signed "The Green Economy Accord". This information resource was created to empower South Africans to address climate change, and through partnerships implement processes to green the economy. The goal was to promote energy efficiency by building renewable energy plants and locally manufacturing the equipment needed, such as solar panels, solar water heaters, wind-turbine blades, towers, turbines and turbine components and electricity inverters (Economic

Development Department, 2011). This goal was broadened by the mission statement of the Department of Mineral Resources and Energy (2015) wanting to promote energy conservation, reduce energy costs and the detrimental effect that the use of non-renewables has on the environment, by developing a national energy policy using renewable energy sources with a sustainable energy future in mind. Further research has shown that these steps taken by South African policy makers is vitally important and action is needed and funding set aside (Danish, Baloch, *et al.*, 2019).

To work towards SDG 7 in South Africa, the latest sources of energy being harnessed are solar power, regional hydropower and wind energy which, similar to coal in the energy mix, are necessary to create jobs, uplift communities and provide investment opportunity (Radebe, 2019). As can be seen from Figure 2.12, there has been an increase in coal usage in South Africa, and this has also been a global trend in 2020 particularly in China and India which is cause for concern with respect to the achievement of zero net emissions by 2050 (International Energy Agency, 2021).

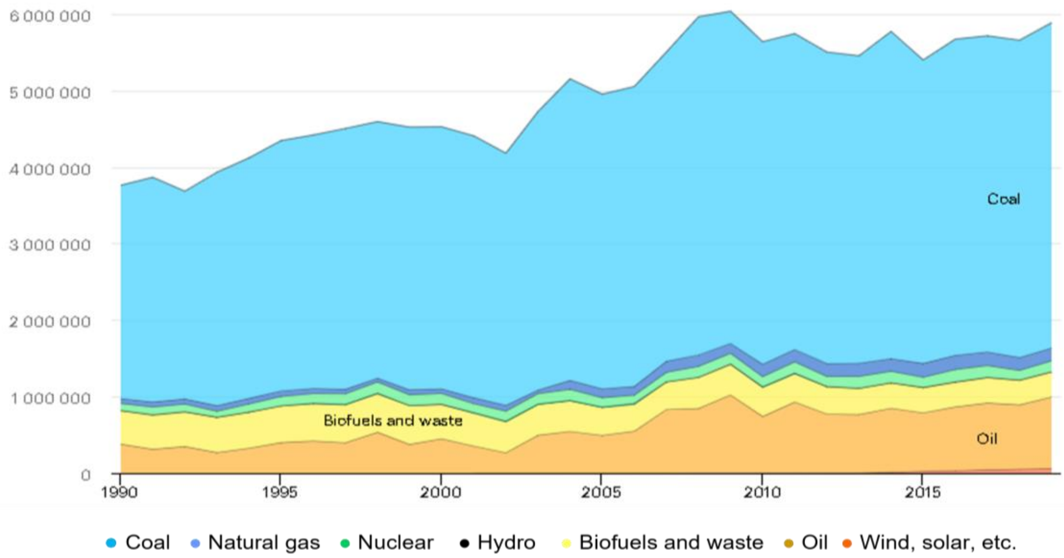


Figure 2.12 Total energy supply (TES) by source, South Africa, 1990-2019 (International Energy Agency, 2020b).

With the increasing energy costs and the depletion of oil and coal reserves, both of which are non-renewable, industries needed to look towards alternative sources. The international ornamental horticultural industry did likewise (Serra, 1994; De Cock and Van Lierde, 2000; Griffin, 2010; Christopher Marble *et al.*, 2011; Rideout *et al.*, 2011; Maxime *et al.*, 2014; Hadley, 2017) as greenhouse production and nursery equipment both use large amounts of energy (Vox *et al.*, 2010; Darras, 2020b).

The South African Ornamental Horticultural Industry can learn from those countries which experienced similar challenges. In the United States, areas with inconsistent electricity have adapted to more economical growing processes which are powered using a mix of diesel and propane generators, wind energy or solar power generation, biomass-powered genets and micro-hydro power (United States Agency for International Development, 2014). In South Africa some of the growers have resorted to alternative energy sources e.g., solar but there are many other sources of energy available such as petroleum, natural gas, renewable fuels such as biofuel and hydropower, the potential of which still must be explored in the field.

The use of energy in the South African ornamental horticultural industry is different from that in the northern hemisphere, due to the favourable climatic conditions for growing south of the equator (De Visser & Dijkxhoorn, 2012), thus making the energy use for plant production and sales lower. Lighting also plays an important role in energy use (Maxime *et al.*, 2014) and in the United States there could be a saving of 34% in energy costs if all the horticultural lighting in greenhouses was converted to LED lighting (US Department of Energy *et al.*, 2020). This saving is not only in terms of operating costs and reduction in CO_2 emissions but it was established that the use of LED technology stimulates plant growth, increases nutrient absorption by plant cells and maintains plant structure (morphology) without the use of hormones (Stutte, 2015). In the southern hemisphere the climate is favourable for propagating a variety of plants under natural lighting conditions. It is for this reason that the Nursery & Garden Industry of Australia did not include energy use as a factor in their sustainability report at the time (Nursery and Garden Industry Australia Ltd., 2009). However more lately, concepts of it are included in the Australian-grown Horticulture Sustainability Framework (Horticulture Innovation Australia, 2021). South Africa is one of the highest emitters of greenhouse gases in the world which not only affects the environment but also the health of much of the population (Department of Energy, 2011). This is due to the use of finite resources for energy, lack of reliable power, cost of energy, climatic change, and pollution and, accordingly, this warrants investigation in this current South African study.

2.4.2.6 Waste and recycling

Another factor that this research focused on with regards to environmental productivity is that of solid waste and waste management. Waste is defined as *"any substance or object the holder discards, intends to discard or is required to discard"* (European Commission, 2013). Population growth increases consumption not only of food but of other products and as a result there is the generation of solid waste (Aniekan & Ikechuku, 2016). Waste results in societal problems such as pollution and / or environmental problems as follows:

- Greenhouse gases through the burning of solid waste
- Methane gas released from food and organic waste decomposition
- Poor quality water from pollution which either must be treated to be used or is wasted
- Potable water wasted from leaking taps and pipes which decreases the amount available for human consumption and usage
- Land deterioration and contamination by the use of landfills for waste disposal (Aniekan & Ikechuku, 2016; Wulandari, Sugeng Hadi & Bagus Shandy, 2017).

Solid waste disposal and the related environmental impacts vary from region to region but increased waste generation, the use of landfills, and indiscriminate burning of solid waste occurs more in developing countries with lower to middle income groups (Aniekan & Ikechuku, 2016; Yang *et al.*, 2018; World Bank, 2019). Countries, particularly those in sub-Saharan Africa where increased waste accumulates due to growing populations, (Hoornweg, Bhada-Tata & Kennedy, 2015) can contribute to global problems. Another challenge from this region is the improper disposal and management of agricultural biodegradable waste e.g., coconut husks. These can provide coir fibres for horticultural growth media, which then have the potential to improve their economic prospects (Baiyeri *et al.*, 2020). Sustainable development goal 12 highlights the importance of changing the way in which products are manufactured, food may be cultivated and how both are consumed and used. One of its targets is reducing waste generation by prevention, reduction, recycling and reuse by 2030 (United Nations Department of Economic and Social Affairs, 2015).

In South Africa, waste is governed by the National Environmental Management Waste Act (South African Government, 2008b, 2013b) as well as various other legislation such as the South African Constitution (Act 108) (Republic of South Africa, 1996), the Hazardous Substances Act 5 (South African Government, 1973), and the Municipal Structures Act 117 (South African Government, 1998a). These regulations provide reasonable measures to protect the health of the population as well as the environment from damage by waste and pollution. In 2011, the Green Economy Accord Commitment Five (Economic Development Department, 2011), focussed on waste recycling, reuse and recovery and the government committed to promote reduced waste generation during production processes and highlight the reuse of waste where the waste products from one process or product manufactured are a source of energy or a starting component another industry or product. Waste research is continually being conducted to try to reduce the amount of waste ending up in landfills and promote sustainable waste management within South Africa (Figure 2.13).

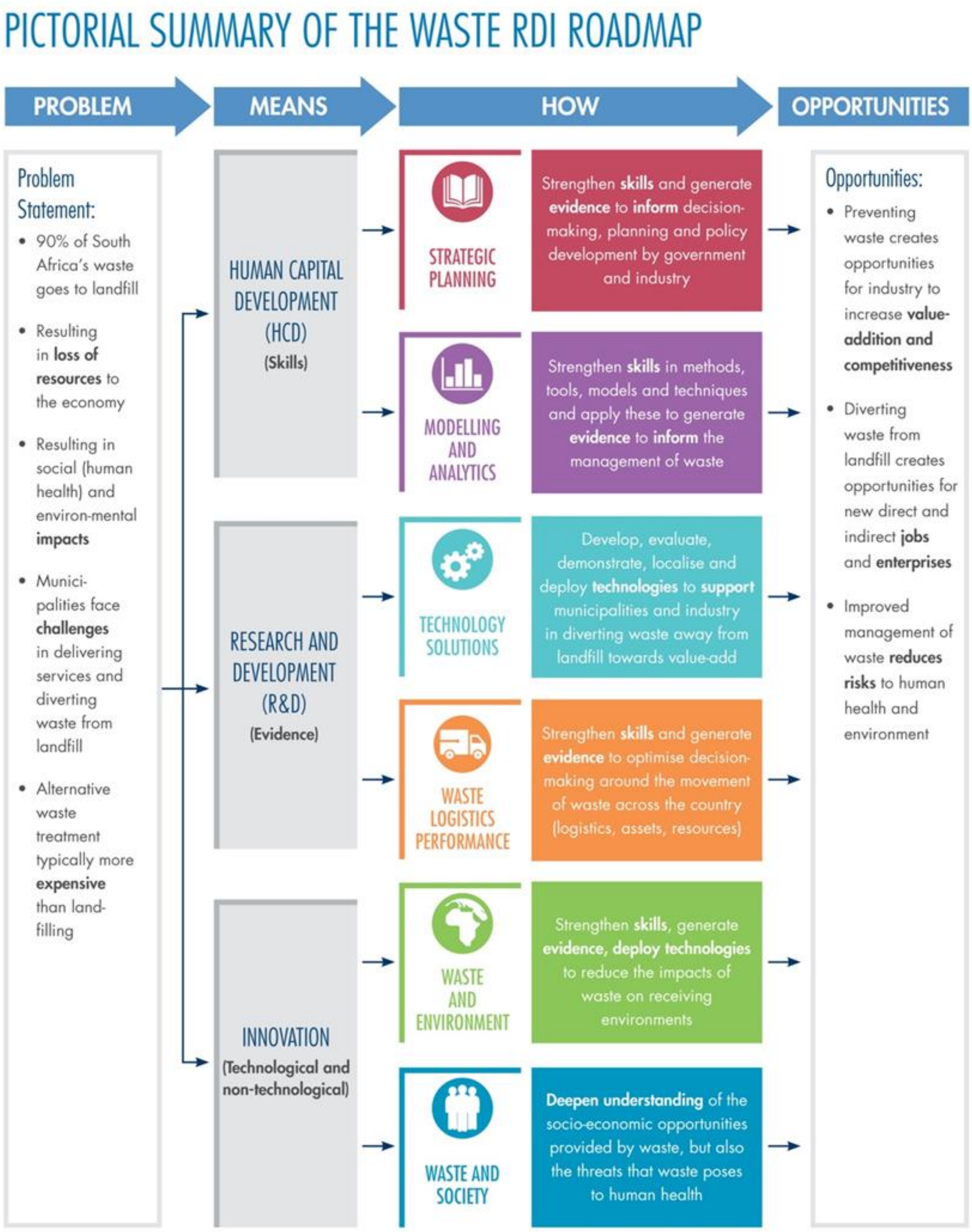


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Figure 2.13: Summary of the waste RDI roadmap. (Department of Science and Innovation and Council for Scientific and Industrial Research, 2021).

As can be seen, waste affects all sectors such as industry, agriculture and urban areas etc., (Lemaire & Limbourg, 2019) and the roadmap (Figure 2.13) provides pathways for these sectors to target their development of waste management strategies and policies to improve their environmental productivity. Many governments including South Africa are affirming the importance of post-consumer waste management which will involve extended producer responsibility. This will encourage manufacturers to improve product design to be more eco-friendly and promote better methods for the treatment and disposal of waste (OECD, 2001; Economic Development Department, 2011).

The ornamental horticultural industry generates various waste products such as organic material, plastics, polystyrene trays, leachates and empty containers from pesticides and fertilizers and run-off from wastewater. Organic material is often recycled and reused within the nurseries, the leachates have been discussed previously but the use and disposal of the solid waste products such as plastics used for containers, greenhouse structures, polystyrene trays, fertilizer bags, irrigation piping and shade-netting is an environmental problem (Briassoulis *et al.*, 2013; Maxime *et al.*, 2014; Meng *et al.*, 2016). Wholesale nurseries, field nurseries, greenhouse growers and retail garden centres have different inputs and outputs in terms of substrates and plastics therefore they produce varying amounts of waste from these products, which results in numerous different focus areas in terms of sustainability and their environmental considerations and productivity (Nicese & Lazzerini, 2013).

As in other industries, waste creation is a normal and inevitable business practice in the ornamental horticultural industry. Using the strategy of reduce, reuse and recycle advocated by governments and researchers, this industry could minimise its effect on the environment whether it be solid waste such as soil and plastic pots or liquid waste e.g., water wastage and leachates (Rideout *et al.*, 2011; Meng *et al.*, 2016). In the development of the BMP manual in the current study, the researcher explored different avenues recommended by international best practices and industry specific articles and practices for example:

- Reduce purchases
- Reuse of materials decreases the business' environmental footprint and reduces operational costs (Rideout *et al.*, 2011) e.g., one ton of organic waste can produce 80m^3 of biogas and 474kWh of energy (Pujara *et al.*, 2019)
- Recycling of materials.

Recycling of plastics by the industry has been tried for decades with varying degrees of success due to the fact that there are additional costs of labour and the sterilization of trays as well as it not being a priority of the business (Cameron, 2009; Rideout *et al.*, 2011). The international ornamental horticultural industry has conducted research into the use of bioplastics (Michael, 2017), such as the production of a plastic pot made from 50% degradable plastic polymers (Lazzerini, Lucchetti & Nicese, 2014). Alternative sources of containers for plants, such as processed manure pots, coir fibre pots, wood pulp fibre pots and recycled paper pots to reduce the environmental impact have also been researched (Pollock, 2012; Harris, Florkowski & Pennisi, 2020). Although the properties of some of these alternatives such as watering distribution and use of water by the plant in the pot, pot integrity and the aesthetic value of the plant and pot combination when compared to plastics were found to be similar or more favourable, especially by consumers, there was still a relatively low adoption rate by the growers (Harris, Florkowski & Pennisi, 2020). This could be due to costs of the alternatives and the need for change not necessitated yet.

Research has shown that in the ornamental horticultural industry a change in behaviour towards the environment through education and training is one of the most effective approaches to improve the environmental productivity and promote a positive attitude and resultant change for the better (Meng *et al.*, 2016; Pujara *et al.*, 2019).

Chapter 3 explains the methodology used to obtain the information that substantiated the aims and objectives of this study and shows that all data collected are reliable, valid, and beneficial for this research, thus enabling the improvement of environmental sustainability of the South African ornamental horticultural industry.

Chapter 3: Conceptual framework of the study

When an outline of ideas and concepts are interconnected (Jabareen, 2008) graphically or as a narrative, this describes the basis of a conceptual framework (Miles et al., 2014). This chapter aims to provide an insight into the knowledge-attitude-practice (KAP) model that will be used to explore the understanding, awareness, perceptions, behaviours, and activities of environmental sustainability within the South African ornamental horticultural industry.

Antonenko's (2015) definition of a conceptual framework states that it is a theory based on an individual's knowledge, beliefs, experience, and assumptions combined with peer-reviewed evidence and literature. Once the literature review is completed and the parameters of the study are established then the key variables are extracted and the connections between them illustrated via a conceptual framework (Regoniel, 2020). This framework is then used to validate the importance of the research problems, explain ideas, "establish theoretical and empirical rationale" and guide the data analysis selection methods. This is illustrated in Figure 3.1.

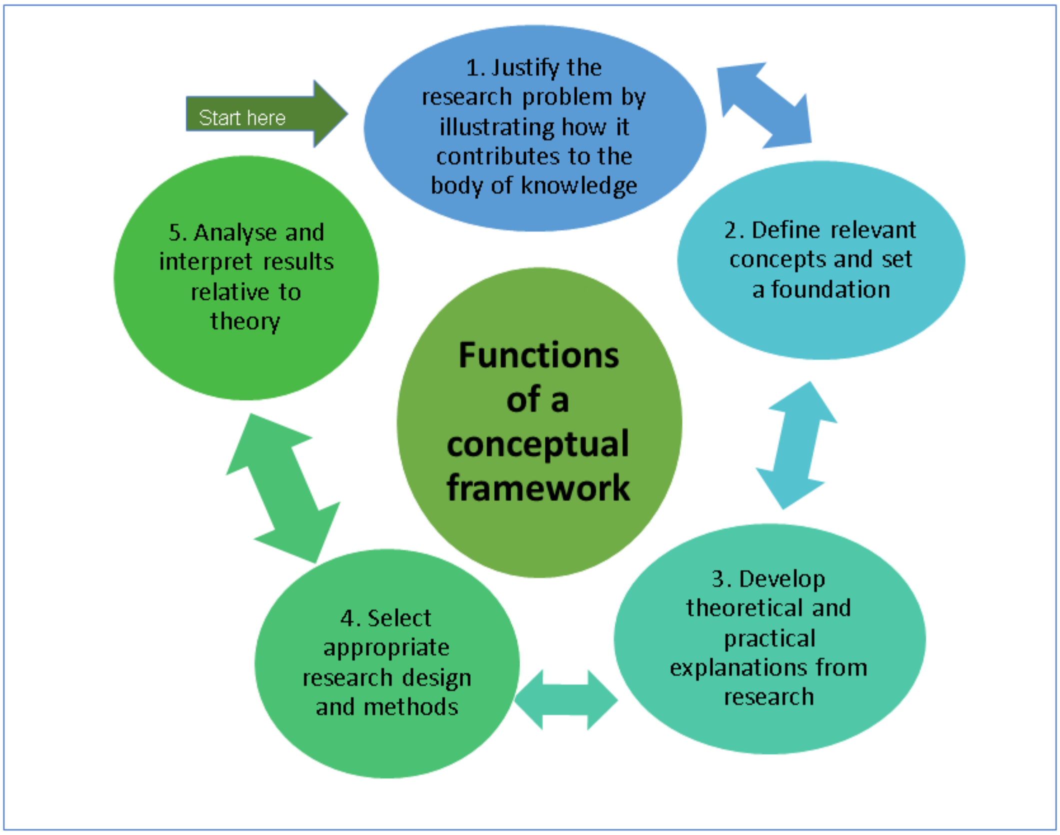

Figure 3.1: Functions of a conceptual framework. Adapted from Antoneko (2015) and Rocco and Plakhotnik (2009).

The multidisciplinary nature of sustainable development (Jabareen, 2008) and the interpretation of environmental productivity via an index (Oh, 2010) make concise definitions challenging. It is for this reason that broader themes and their relationship to the topic are described via frameworks. A conceptual framework maps out the variables or key terms within a study determined by the literature review and displays the researcher's understanding of the themes and the relationship between them (Figure 3.2) (Regoniel, 2020; Orkin *et al.*, 2021). Another benefit of conceptual frameworks is that they provide guidelines for the design of materials from the linkages between the emerging themes e.g., "factors influencing environmental resources" in Figure 3.2, which link to the "resources affected by the ornamental horticultural industry" (Arah *et al.*, 2003).

Figure 3.2: Conceptual framework of this research project

Environmental, sustainable development and agricultural papers often use a conceptual framework to provide an understanding and integration of ideas (Von

Braun, Bouis & Kennedy, 1994; Jabareen, 2008; Anjaneyulu & Manickam, 2011). Using this philosophy, the researcher developed a basic framework to highlight the key characteristics of environmental sustainability with regards to natural capital which provides a “source” of resources for human survival. Apart from providing goods and services, nature-based solutions and the green economy can neutralise the detrimental effects to ecosystems, and this is known as a “sink function” (Ekins et al., 2003) such as pollution, land degradation and over-utilisation (see Appendix 6). Barbier (2019), further emphasised that comparable to human and manufactured (“reproducible”) capital contributions, the environment can boost its capital e.g., rehabilitation. The difference is that the constant burden on natural resources can cause an irregular functioning thus destroying the baseline limit, resulting in irreparable damage and the breakdown of the ecosystem.

A similar conceptual framework was proposed by Olewiler, (2006) (Appendix 7) which focused on drivers such as industry, urban development and government that cause pressure on natural resources e.g., pollution, population increase and loss of habitat as described in Chapter 2. The resultant impact causes biodiversity loss, human welfare problems and economic challenges. The responses to these impacts e.g., food production, manufacturing opportunities to increase jobs, taxes, transport networks and human needs, also have a causal effect on the pressures and natural capital. These were replicated and adopted in the current qualitative research study to determine which indicators (air, water, land / soil, energy sources) the ornamental horticultural industry in South Africa should focus on with respect to sustainability and environmental productivity.

The use of a conceptual framework diagrammatically highlights the pathway for the research design and methods to be used as it shows interlinking of the concepts in this mixed methods study. According to Jabareen, (2009) conceptual frameworks are made up of three assumptions:

- Ontological assumptions – “knowledge of the way things are” e.g., research questions 1, 3 and 7)

- Epistemological assumptions – “how things really are in an assumed reality” (research question 2) and
- Methodological assumptions – “relate to the process of building the network and assessing the framework and what it can tell us about the real world (research questions 4, 5, 6, 7 and 8).”

This relates to the principles of the KAP model described below (Section 3.1) and using these as background, a questionnaire was designed to survey the member’s knowledge, attitudes and practices (Kibue *et al.*, 2015) of environmental sustainability within their businesses. The framework (Figure 3.2) was used by the researcher to critically analyse the scientific knowledge and application thereof on the topic and draw parallels between this literature and this research which provided a clear motive and significance for this study. This combined process of sequencing logical arguments adds rigor to the research (Ravitch and Riggan, 2017).

In summary, the description and relevance of each key term as well as their significance to the topic as shown in Figure 3.2 is described in this chapter. The combination of these concepts is highlighted during the research process and aligned to the exploration research questions in Chapter 1. The conceptual framework is used to create the best practices to improve South African’s ornamental horticulture industry’s natural resources usage and reduce its environmental impacts where possible.

3.1 KAP Model

The knowledge (K), attitude (A) and practice / perception (P) (KAP) model is used to give an explanation of what a specific population understands, believes and how they behaviour, or the practices they conduct in relation to a certain subject or set of circumstances (World Health Organization (WHO), 2008; Rav-Marathe, Wan and Marathe, 2016; Kruger, 2022). Practice / perception can also be referred to as “behave” (Kaliyaperuma, 2004; Lownik *et al.*, 2012), as shown above. The model aims to ascertain the knowledge that a population has on a certain topic, their attitude towards it and their practices or behaviours related to it e.g., in this research, the KAP model was used to determine the knowledge, attitudes and practices carried out by a select number of ornamental horticultural industry participants in South Africa with regards to environmental sustainability.

The KAP model was first used in the 1950's when conducting family planning research related to population studies (Launiala, 2009). Due to its flexible and effective nature is has since been used in numerous other fields of study regarding people e.g., nutrition (Bano *et al.*, 2013; Kigaru *et al.*, 2015; Angeles-Agdeppa *et al.*, 2019) , health (Lownik *et al.*, 2012; Muleme *et al.*, 2017; Bierhoff *et al.*, 2021) and environmental studies (Kibue *et al.*, 2015; Domínguez-Valerio *et al.*, 2019; Abdelaal and Guo, 2021) to name a few.

It is a simple, cost effective model and the quantitative data obtained is easily interpreted and thus often used in developing countries although the contextual understanding of the questions can result in an inaccurate measurement of the knowledge and practices (Stone and Campbell, 1984; Launiala, 2009). It was recommended to use additional qualitative methods to compare and confirm data collected is an accurate representation, improve validity and minimise sampling errors (Stone and Campbell, 1984). In this research, the boundaries of the businesses within OHISA provide the context limiting discrepancies of using KAP and as recommended other qualitative research methods were also used e.g., semi-formal interviews and observation to provide a comprehensive picture of the environmental sustainability knowledge, practices, and attitudes of the participants.

The use of the KAP model for this research focuses on those authors who agree that it forms "*an interlinked triangle*" whereas one element changes so this affects the other two as seen in Figure 3.3 (Bano *et al.*, 2013; Siltrakool, 2017; Domínguez-Valerio *et al.*, 2019) e.g., a gaining of knowledge will motivate a change in practice (Muleme *et al.*, 2017) or an attitude affects practice more than knowledge (Kigaru *et al.*, 2015).

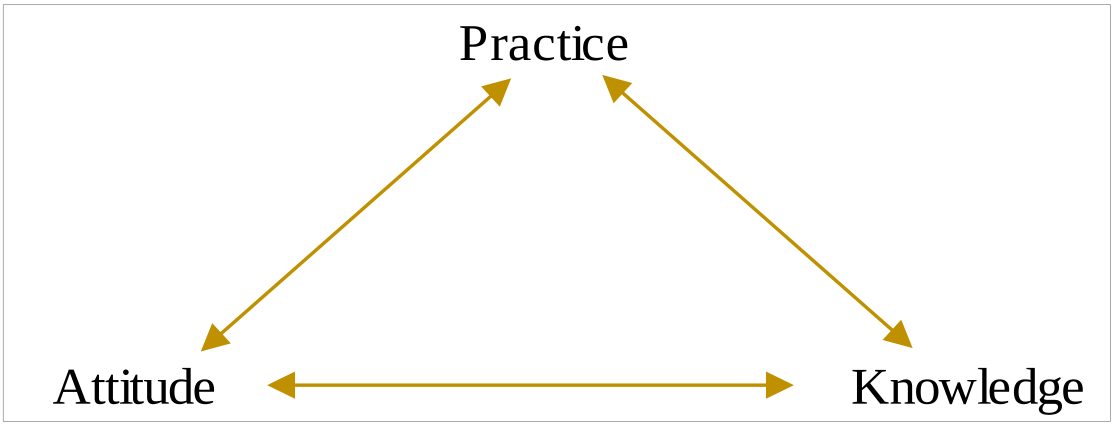

Figure 3.3: Triangular relationship of KAP. Adapted from Bano et al. (2013); Siltrakool (2017); Arumugam (2019); Domínguez-Valerio et al. (2019); Zeng et al. (2019).

- Knowledge: the manner in which information and understanding is acquired and being able to apply it (Lee and Lee, 2020)
- Attitude: an opinion towards a person, situation or subject is developed over a period of time from numerous experiences. Once an attitude has been developed, to change it takes time and knowledge and is often met with resistance (Eagly and Chaiken, 2007). The sequencing of the KAP indicates that as knowledge increases so attitudes are formed and practices are changed (Baranowski *et al.*, 2003).
- Practice / perception: the way in which people react or behave in certain situations or in the case of this research, their practices (Schrader and Lawless, 2004).

Using the above definitions, it is a progressive learning process which is applied (using the KAP model) in the compilation of the best practices manual to encourage positive practices towards environmental sustainability to be achieved.

Following on from this, the section below discusses the linking of the elements into a conceptual framework which was used to explore environmental sustainability within the South African ornamental horticultural industry.

In conclusion, the adapted KAP model (Valente, Paredes and Poppe, 1998) was used to determine the knowledge, practices and where possible attitude of the participants towards the concepts portrayed by the relationships of the indicators shown in conceptual framework which provided the basis for this study.

Chapter 4: Research Design and Methodology

In Chapter 2, the literature review provided a background to this study explaining the current environmental crisis due to population growth, climate change and pollution. It explained the history of these global problems and explored the studies of universal solutions suggested such as sustainable development, green productivity, circular economy, and nature-based solutions as well as other related key terms. These proposals, goals, strategies and ideas guide policy, laws, and projects at a country or national level. The implementation of the various solutions means moving from national to local e.g., provinces or state to businesses and industries, which can make the necessary changes and see the long-term benefits of stewardship of the natural resources and caring for the environment. Chapter 3 showed the linking of the concepts, problems, solutions, theory, and practices as well as the relationships between the key terms and factors via a conceptual framework. This, Chapter 4, discusses the research design, data collection methods used investigate, understand, and gain the evidence most relevant to answer the research questions and objectives presented in Chapter 1. It explains how the researcher, who has worked in the ornamental horticultural industry in South Africa for many years, saw a problem which needed investigating. The problem being that although members of OHISA are known as the “green industry,” are they really that environmentally productive or sustainable?

This problem is not isolated to the South African ornamental horticultural industry. It has been explored by various other horticultural industries internationally as well as agricultural industries which all have an ecological footprint. This backdrop furnished the researcher with the knowledge to further investigate the South African situation and see what is currently being done and if it is possible to improve on it. How the research questions (listed in Chapter 1) were investigated and answered is detailed in this chapter. Also included is:

- How the inquiry was undertaken (research design)?
- Who was involved (sample)?
- When did it take place?

- What was explored and more?

4.1 Research paradigm

Chapter 2 and the use of interlinking assumptions (namely ontological, epistemological and methodological in Chapter 3) which guided the design of the conceptual framework, form the foundation of the research paradigm (Patel, 2015) in this chapter. This pattern provided a culture for the research with which other researchers are familiar, based on similar beliefs, values and assumptions (Kasim and Antwi, 2015). The different paradigms, their associated philosophies, and the recommended methodologies as well as the suggested data collection methods are shown in Table 4.1. Over time the paradigms have changed as different methods of research were conducted, initially using either the positivist or interpretivist approach, and later the pragmatic paradigms (Onwuegbuzie, 2002). To this day the finer details related to paradigms and their related methodologies is much debated as to which provides the most relevant and reliable data for assumptions to be made with regards to knowledge accumulation and testing (Shan, 2021).

Table 4.1: Table adapted from various sources including Mackenzie and Knipe (2006); Patel (2015) and Kasim and Antwi (2015).

Paradigm	**Ontology**	**Episte-mology**	**Methodology**	**Methods**
	(What is reality or what is the nature of how knowledge is made up in the world?)	**(How to discover real knowledge about the world?)**	**(Strategy for research – how can you find out, guiding research methods?)**	**(How do you go about finding out something? Data collection tools)**
Positivist / Postpositivist	Single reality / truth	Reality can be measured therefore use reliable and valid tools	Experimental research or survey research e.g., experiments, quasi-experiments,	Quantitative generally used e.g., sampling, measurement, scales, statistical tests, randomization, formal protocol

Paradigm	Ontology	Episte-mology	Methodology	Methods
			tests and scales	testing questionnaire, focus group or interview
Interpretivist / Constructivist	The reality is created by individuals	Reality is explained and used to discover the reasons why things happen	Ethnography (study of cultural groups). Grounded Theory (describes phenomenon). Phenological research (study of individual's Heuristic inquiry). Action research. Discourse analysis. Feminist standpoint research etc.	Qualitative methods mostly used: Interviews, observations, document reviews, visual data analysis, participant study, life history, theme identification and case study
Transform-ative			Various tools which examine justice.	Qualitative with quantitative, thus mixed-methods – more specifically in relation to social science, providing a situational narrative of the past
Pragmatic	Reality is constantly changing and interpreted depending on the application thereof in new	Problem solving. Finding solutions through change	Mixed methods. Action research or design-based investigation.	Qualitative or quantitative depending on research goals and objectives. Can contain instruments from positivist and interpretivist paradigm e.g., interviews,

Paradigm	Ontology	Episte-mology	Methodology	Methods
	unpredictable situations			observation, testing and experiments.
Subjectivism	Reality is what we perceive it to be	Knowledge is in the eye of the beholder – perception	Discourse theory, archaeology, genealogy, deconstructivism.	*"Autoethnography. Semiotics. Literary analysis. Pastiche. Intertextuality".*
Critical	*"Realities are socially constructed entities that are under constant internal influence".*	Reality and knowledge "*influenced by power relations from within society*".	*"Critical discourse analysis, critical ethnography, action research, ideology critique"*.	*"Ideological review. Civil actions, open-ended interviews, focus groups, open-ended observations and questionnaires, journals".*

In Table 4.1 six paradigms are described but with regards to this research only the positivist, constructivist and the pragmatic paradigms are discussed in more detail. In a broad sense this study investigates the relationships between people and their environment within the context of the South African ornamental horticultural industry. Using Table 4.1 as a guide these three paradigms were explored relative to the study:

- The positivist approach is where the environment and humans are separate and the researcher studies events by looking at them from an outside perspective without any interference to determine the causal link. From this laws are created which can be used in any similar situations to forecast the future (Rehman & Alharthi, 2016). This paradigm is not ideal for this investigation as the researcher is actively striving to achieve change in human behaviour towards the environment by using various methods, and the outcome is uncertain e.g., the history of sustainable development discussed in Chapter 2 shows that the positivist approach would be ideal if people applied the regulations designed to save the planet, but this has not happened.

- The interpretivist paradigm seeks to interpret the connection between humans, each other and the environment as each individual sees it usually within a social setting (Rehman & Alharthi, 2016). There are numerous realities, and knowledge is created through a collection of individual ideas combined through experience and insight from situations which can be subjective. This approach has the potential to complement this research but due to lack of standards for knowledge analysis and assessment (Turyahikayo, 2021) within the South African ornamental horticultural industry, it too is not the ideal choice.
- The pragmatistic paradigm is most suited to this study as it suggests that knowledge will lead to an attitude change that, in turn, will lead to action which will result in a change (Goldkuhl, 2017). As members of society, it is people's responsibility to assist in balancing the evolutionary changes, whether they are caused by humans or natural processes within the ecosystem thus ensuring a future (Brinkmann, 2017). The knowledge provided by this framework gives beneficial understandings of academic as well as practical examples which can be applied, although whether this is actually done can be a downfall of this approach (Turyahikayo, 2021). When using this approach with regards to an organisation, it is imperative to ensure that the goals of the organisation are achieved through the creation of systems and strategies which foster knowledge sharing and application at all levels (Turyahikayo, 2021).

The choice of the pragmatic paradigm for this research allows the researcher to use the mixed method strategy for the research design. This includes using both qualitative and quantitative methods for data collection.

4.2 Research design

The broad objectives of scientific research is to contribute towards solving a problem using specific procedures to collect and analyse data which can then be used to describe phenomena or predict future events or understand situations (Marczyk, DeMatteo & Festinger, 2005; Creswell & Guetterman, 2019). From the starting point of the research problem to the culmination of the research outcomes via study analysis, the researcher must make many decisions. The productive use of resources such as time, people, experiments, documents, funding and fuel, is best done by creating a research design plan or map (LeCompte and Schensul, 1999; Leavy, 2017). The format of good research design is a description of the problem which leads to questions, then a search for existing literature theories and concepts related to solving the problem and answering the questions. This usually highlights the absence of information related to the specific questions e.g., context, applicable solutions etc., giving significance and relevance for the research. Then data must be collected which relates to the problem and is organised into themes and patterns which is later interpreted within the research context. This either produces positive or negative results in relation to the research questions which either solves the research problem/s and / or requires further investigation to contribute to the existing knowledge base (Leedy & Ormrod, 2013). The philosophy of the research described above (research approach) forms the framework for the literature review, conceptual framework and guides the research design procedures and data collection processes (Leavy, 2017; Turyahikayo, 2021). The research design for this study is summarised in Figure 4.1 and then explained in more detail later.

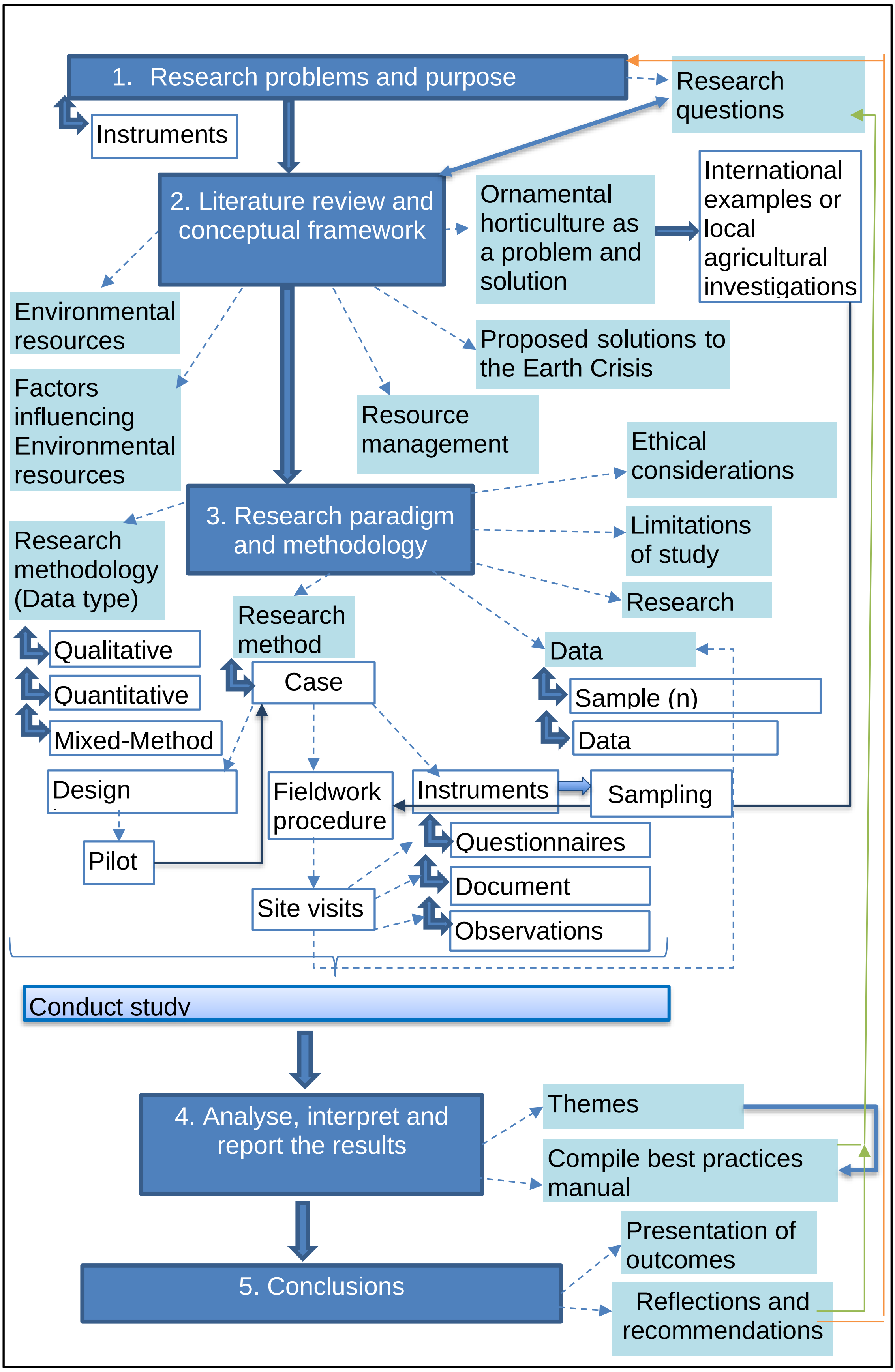

Figure 4.1: Research design

The research design is not meant to be restrictive with boxes to complete but rather direct the researcher along a path where much relevant knowledge can be collected. This is particularly important when it is qualitative research, where people and situations can cause complications and misdirection which can either complement or detract from the specific research problems or questions (Leedy & Ormrod, 2013).

4.2.1 Research problems and questions

The research problems of this study are generic environmental problems that are found globally as well as in South Africa. There are many suggested solutions, some theoretical and others practical to guide legislation and policy development which is meant to motivate attitude and behavioural change towards the environment. The literature related to the ornamental horticultural industry with regards to these problems tends to be more functional with practical examples related to businesses rather than prompt positive changes of individuals in the sector towards the environment as mentioned in Chapter 2.

The research questions of this study were prompted as the researcher works in this sector and has personal experience and local knowledge. In Chapter 1 there were 9 research questions which exceeds the recommended 3-4 (Leavy, 2017), but a broader selection of initial research questions is recommended when using qualitative methods as they are revisited, amended and sometimes added to or rejected during the investigation (Mertens, 2010).

The type of questions asked to fulfill the research objectives depends on the research approach and the associated methods as shown in Table 4.2.

Table 4.2: Categories of research questions. Adapted from Tashakkori and Creswell, (2007); Rockinson-Szapkiw (2012); Patton (2017) and Schoonenboom and Johnson (2017).

Research methods	Question types	Examples
Quantitative	Monitoring and measuring	How much…? What percentage…? How often…?
	Comparative	What is the difference?
	Relationship / Causal	What is the relationship between?
Qualitative	Exploratory	What are? What do you do?
	Predictive	Are more people...? How often would you…?
	Interpretive	How do you feel…? How do you attribute value?
Mixed methods		How do the qualitative accounts substantiate the quantitative findings?
	Concurrent design or parallel design	How and why do the qualitative and quantitative outcomes relate to each other?
		How do the results from group A and B differ due to the variables X and Y and what observations can be made with regards the group A and B's behaviour due to their experiences?
	Phase questions in study (sequential studies)	Phase 1: qualitative questions Phase 2: quantitative questions

A mixed method approach was used by the researcher for this study which includes both qualitative and quantitative data types. These are discussed below to describe and explain the reason for using mixed methods.

4.3 Research methodology (Data type)

The means of collecting, organizing and understanding data are known as the research methodology (Leedy & Ormrod, 2013). The information collected in this research will use both quantitative and qualitative methods. To be able to benchmark the current South African situation the changes that might have been made with respect to environmental productivity were discussed during the site visits and semi-structured interviews, and a questionnaire with both qualitative and quantitative properties was compiled. Most of the information collected from the case studies was of a qualitative nature. All data collected using these various approaches falls under the umbrella of participatory action research using a mixed method approach.

This use of mixed methods with regards to sustainability is due to its complex nature (Luukkanen *et al.*, 2019) and the various assessments, indicators, models and methods which can be applied to measure it. It is also necessary due to the all-encompassing nature of sustainability as a multi-level discipline.

4.3.1 Qualitative

Qualitative research involves processes such as observing, journaling, documenting, writing, recording, analysing and understanding the characteristics, customs, features and significance of human behaviour in relation to situations (Gillis, A., & Jackson, 2002). It is often used when there is minimal knowledge and scientific research related to a phenomenon (Kasim & Antwi, 2015) and it allows for the reciprocal sharing and learning of participants in their own environment (MacDonald, 2012; Taylor, Bogdan & DeVault, 2016) which was favoured by this research as a method to obtain realistic results.

The following considerations define qualitative research:

- A descriptive comprehension of participant's insights towards events
- Data collection, investigation and evaluation that is conducted by the researcher
- Research creates a theory rather than testing an existing hypothesis
- Data are highly descriptive (Butina, Campbell & Miller, 2015).

These characteristics are conducive to this study as the researcher conducted the interviews with the participants in their environment, asked them to complete a questionnaire and then, in the majority of instances, did a site visit to correlate their answers to their business practises. The objective was to create concepts and postulate ideas from the investigations via the development of a best practices manual which can be shared with the participants to help them improve their businesses' environmental productivity.

4.3.2 Quantitative

The numerical testing of a theory or hypothesis which compares the relationships between two or more variables where the research purpose is to assess, clarify or confirm theories usually using large amounts of data are known as the quantitative approach (Leedy & Ormrod, 2013; Leavy, 2017). As mentioned in Figure 4.1, sampling, scales, randomization and questionnaires are some the of the research instruments used to objectively collect data which may then be measured using statistical tests to produce accurate results (Leedy & Ormrod, 2013; Butina, Campbell & Miller, 2015). The research design is predictable as the hypothesis is stated at the start and the researcher works towards proving or disproving the theory, unlike qualitative research where the research questions and design change as the process unfolds (Kasim & Antwi, 2015). This project lends itself to qualitative research but due to its limitations certain quantitative questions and aspects are needed and, hence, the use of a mixed method methodology. This double outlook approach where the weaknesses and strengths of the different methods complement each other produces beneficial results (Abowitz & Toole, 2009).

4.3.3 Mixed method design

To provide a comprehensive portrayal of the South African ornamental horticultural industry's impact on the environment, both positive and negative, the project combined concepts from both qualitative and quantitative approaches which resulted is using a mixed method design. This is also in accordance with the research paradigm of pragmatism chosen by the researcher. This paradigm and methodology provided the framework for the study but it was important to reflect on these during the process to ensure that they did not limit the research or provide inaccurate conclusions because of sampling and bias (Hesse-Biber, 2015). This design allowed for flexibility and creativity to enhance the body of knowledge in the field through all aspects of the process, data collection, investigation, analysis and synthesis of results and recommendations (Leedy & Ormrod, 2013).

The use of a mixed mode method can be contentious (Bergman, 2011) e.g., the equality of the instruments used in relation to combining the above two methods and using the same instrument to obtain different data types e.g., focus groups where numerical and descriptive data were obtained (Bryman, 2006). To ensure that this method was the best for the study, the researcher followed the approach of Schoonenboom and Johnson (2017), on constructing a mixed methods design. They suggested using different dimensions to create a strong mixed method design namely:

1. *"Purpose*
2. *Theoretical drive*
3. *Timing*
4. *Integration at point*
5. *Typological versus interactive*
6. *Planned versus emergent designs*
7. *Complexity".*

These "dimensions" and the background of each, as well as their relevance to this study is detailed below.

1. "*Purpose*"

To successfully answer the research questions of the study, the researcher felt that the benefits of using the mixed method design outweighed the negative aspects such as the extra time and resources it might take (Leedy & Ormrod, 2013).

The points below provide reasons why the researcher and others have chosen to use mixed methods:

- "*Complementarity"* – it includes the merging of data and gaining co-operative outcomes

- “*Triangulation”* – assessing results from a variety of methods and comparing for synthesis and discrepancies
- “*Development”* – where one data type leads to the improvement of another data type
- “*Initiation”* – one data type provides opportunity for the re-evaluation of questions, frameworks, and views
- “*Expansion”* – increase the scope of the research using different methods (Greene, Caracelli and Graham, 1989).

During the research design these five purposes formed the basis for the type of instruments used to answer the questions as well as the procedures needed to complete the research.

With this background Bryman (2006), after much investigation into multi-strategy research combinations, categorized the purposes further and included new concepts. The ones most relevant to this project have been highlighted such as:

- “*Offset”* - the limitations of one, complements the positive contributions of the other enhancing research
- “*Process”* - qualitative research assists in describing the logical constructs of quantitative research thus improving understanding
- “*Explanation”* - one method clarifies issues found in the data and results of the other method
- “*Instrument development”* - e.g., a questionnaire can be used in both approaches and during the study the questions evolve to improve the data collected both in wording and scale or yes-no questions
- “*Credibility”* - one methodology strengthens the other
- “*Utility”* - the combination increases the value of the study
- “*Diversity”* - allows for the varying opinions to be quantified and explained by qualitative accounts
- “*Sampling”* - the manner sampling is done is refined when the methods are combined to get the most relevant data from the most reliable participants.

Again, the way the sampling for this study was planned, used the reasoning proposed by Bryman (2006) for mixed method design, a large initial sample concentrated into a smaller number of experts in the field. Likewise, these experts are all involved in the horticultural industry but have specialties within and thus their varying views make the study richer in value. The list of constructive attributes for mixed method design is continually growing but the last few the researcher felt most applicable to this study were:

- *“Learning from different perspectives on teams and in the field and literature”*
- *“Determining what works for whom and the relevance / importance of context”*
- *“Juxtaposition-dialogue / comparison-synthesis”*
- *“Explaining interaction between / among natural and human systems”* (Schoonenboom and Johnson, 2017)

The attributes described by Schoonenboom and Johnson (2017) contributed positively to the research during the fieldwork and literature studies on the topic as well as learning from other best practices and participants in the study. The participants and observations helped the researcher refine the data to ensure that that which could practically be achieved in South Africa was stressed. Using Bereday's, (1964) comparative theory (which is described later in the chapter) the third rationale namely “juxtaposition” is the context of this study. The last attribute is the ultimate purpose of the study which is the impact that the people involved in the ornamental horticultural industry in South Africa have on the environment.

2. “Theoretical drive”

Further classification of the type of mixed method design is necessary to ensure there are no misconceptions about the theoretical drive of this project. It is qualitative dominant and not equal-status as primary mixed method research suggests (Burke Johnson and Onwuegbuzie, 2004; Schoonenboom and Johnson, 2017). The researcher believes that using the above criteria indicates why the mixed method approach was chosen and not only a qualitative approach to which majority of the instruments used and data collected lean towards. This qualitative core due to the nature of the study being “exploration and descriptive” (Morse and Niehaus, 2016) is not favoured by all researchers due to the lack of equal rigor application (Burke Johnson and Onwuegbuzie, 2004) and not advisable for the project as a whole but rather applied to individual research questions (Schoonenboom and Johnson, 2017) which is what the researcher did.

3. “Timing”

Another aspect of mixed method design is the timing of the procedures. Initially the research design of this study was to be sequential-dependent lending itself towards an explanatory design (Schoonenboom and Johnson, 2017; McCrudden and Sparks, 2018) ideal for mixed method design where a brief quantitative study would be followed by a comprehensive, more in-depth qualitative investigation (Greene, Caracelli and Graham, 1989; Leedy and Ormrod, 2013) e.g., an initial questionnaire was randomly handed out at an industry related trade day to identify those attendees who showed interest in responding. This approach was unsuccessful due to lack of feedback.

A “convergent design” (Fetters, Curry and Creswell, 2013) using a different questionnaire was later used to obtain and analyse data for both the quantitative and qualitative aspects. Parallel to this being done, the fieldwork and document analysis was conducted, thus the different data sets collected at different stages of the study were analysed independently and collated into themes.

Another feature related to the timing is whether the variables within the data collection and analysis are “dependent” or “independent” of each other. In this study, the elements are independent of each other particularly with regards to the data collection (Schoonenboom and Johnson, 2017). The merit of this with regards to validity will be discussed later in the chapter.

4. “Integration point”

The joining of the qualitative and quantitative approaches in the mixed method approach is imperative for the purpose and value of using it (Onwuegbuzie and Combs, 2011). According to Fetters, Curry and Creswell, (2013) the amalgamation can take place:

- During the design of the study e.g., questionnaire or

- Via the data development, connections, and combinations e.g., case study analysis or
- Lastly in the results, understanding and feedback e.g., the best practices manual development, “data transformation” and “joint display”.

Other authors suggested only two points, on joining results or analysis (Morse and Niehaus, 2016) while others four points, the additional two to Morse and Niehaus (2016) being the initiation of the project and the data collection (Tashakkori and Teddlie, 2014).

To strengthen the research and take it to the next level the incorporation of simple designs into more comprehensive ones is an advantage of this mixed method approach. These include case study schemes, participatory plans, multi-stage methods and intervention or nested designs (Fetters, Curry and Creswell, 2013; Leavy, 2017). This project uses comparative cases to emphasize the benefits of the mixed method approach and incorporates the positive attributes of the other approaches and negate their limitations.

5. “Typology utilization”

The classification of various designs in the mixed method approach can assist in adding structure and value. It also helps other researchers know the development pathway of the study, justifies the context, initiates new ideas for further research and implies how the study can be a teaching tool (Tashakkori and Teddlie, 2014). At first the researcher believed the typology of this project was “convergent parallel” (Creswell and Plano Clark, 2007; Doyle, Brady and Bryne, 2019) as described above but after more research, noted that it is a hybrid design (Schoonenboom and Johnson, 2017) which also incorporates the strategies “fully integrated mixed-design” proposed by Tashakkori and Teddlie (2009). The study combines the qualitative and quantitative research at each stage to try and seek answers to the individual research questions.

6. “Planned versus emergent designs”

The designs of this study were planned but the researcher was ready should the data outcomes reveal unexpected results as warned by Schoonenboom and Johnson (2017), which could happen due to the numerous variables in the study. For example different business types and sizes as well as different provinces within South Africa which have very different weather patterns which will affect the growing conditions of the plants such as one grower mentioned that he could grow a wider variety of colourful perennials throughout the summer months in Cape Town but now he is growing in Natal and certain perennial plants like fuchsias and calibrachoa do not perform well due to the higher humidity (pers comm, 2022- Peter van Rooyen).

7. “Complexity”

In this project an in-depth investigation has been done on numerous garden centre retailers and growers within the country providing intricate and valuable information from a variety of sources over a period of time - this indicates the complexity of the research. It is the researcher’s responsibility to weave the methods, data and results together in terms of component dependency and outcomes on each other to present a fully integrated mixed method design (Schoonenboom and Johnson, 2017).

A mixed method design was used to ensure that the gaps in the investigation were minimised, and discrepancies understood and explainable. It was also used by the researcher due to the nature of the topic and related key terms which Antonini and Argilés-Bosch (2017) mentioned as having:

- A shortage of true measurement tools to accurately calculate the impacts of businesses, industries, and people on their environment. In global, continental, country and even business base studies of this nature, the financial reports are used but this doesn’t always give a clear indication of either contribution or damage to the environment by the businesses, industries, or countries.
- A lack of consistency with tools used to measure environmental performance which too results in differences and often the surveys and

the voluntary disclosure of information can result in bias. The use of International Standards for Performance (as mentioned in Chapter 2) results in compliance but does not always show the real situation on-site.

- The potential to miss local nuances and regional or industry specific variations which do have an environmental impact.

Some of these challenges were briefly stated in Chapter 2 when trying to define and describe sustainability and environmental productivity and the everchanging related terms e.g., initially global thinking was a food-energy-water nexus now more lately it is a soil-food-energy-water nexus which also influenced the research approach and associated methods.

The fieldwork of this study is local (South Africa), and data are collected “on the ground”. By using suggested indicators to make it valid, although it is qualitative in nature rather than quantitative and so could have bias, the values of those involved in the research will always be there. This is inherent in human nature and provides a perspective to what is studied as well as influencing the outlook from which outcomes are presented (Taylor, Bogdan and DeVault, 2016). To minimise this and increase reliability and validity of the study mixed methods aspects of quantitative methodology were used.

Lastly this multi-strategy (mixed method) approach has numerous benefits as described above but as a complete solution it must be evaluated when used to improve the outcomes. There is the potential to accumulate and assimilate surplus data in trying to achieve integration between the qualitative and quantitative approaches thus resulting in a waste of resources both on the part of the researcher and the participants (Bryman, 2006; O’Cathain, 2015) and the researcher has kept this in mind during the process.

In conclusion, the research methodology provides the framework from which the research questions were answered. The design of the framework and paradigms underlying it provide the foundations for the research to work on. These are also relatable for other researchers to understand the perspectives and why certain decisions, methods and instruments were selected. It sets the scope of the research project which is then more finely tuned by the methods used to source and analyse the answers. From the research methodology and variety of options provided, the use of a mixed method design for this project is appropriate as many of the proposed purposes are a match for the requirements of this research. Although the theoretical drive lends itself towards a qualitative approach, the points of integration by using multiple case studies (sub-cases) simultaneously link the quantitative and qualitative designs together. This is done in each phase of the research - the initiation of the research i.e., the development of the research questions, the choice of methodology, the actual fieldwork and study, as well as the analysis of data and the interpretation of the final outcomes. Thus, a comprehensive, complex mixed method approach was chosen.

4.4 Research method – A case study

To undertake a thorough investigation and obtain a clear picture of the true practises and patterns of the environmental impacts of the ornamental horticultural industry in South Africa and its needs with regards to sustainable green growth, the researcher believed that a comprehensive study was needed of both the growers and retail garden centres from different sectors in the different provinces and this pointed toward using a case study. There are many definitions of a case study but the most relevant to this project is:

- *"A research strategy that can be qualified as holistic in nature and following an iterative-parallel way of proceeding, looking at only a few strategically selected cases, observed in their natural context in an open-ended way, explicitly avoiding tunnel vision and using analytical comparisons of cases or sub-cases and aimed at description and explanation of complex and entangled group attitudes, patterns, structures or processes"* (Verschuren, 2003).

This study provides an integrated approach of looking at the ornamental horticultural industry, selecting a number of growers or wholesalers as well as nurseries or retail garden centres as representative of the whole. At these sites (on-site), a questionnaire was completed, a walkabout was done where direct observations took place with regards to the six factors which illustrated if, when, why and how these businesses were having an impact on the environment. During the investigation, interviews were conducted with the participants and any relevant documentation that they had regarding their environmental footprint was included as evidence. This plan broadened the opportunity for the researcher to see, understand and clarify the verbal and written reports and document a more accurate approach of what was happening in the businesses.

- *"Case studies are an analysis of persons, events, decisions, periods, projects, policies, institutions, or other systems which are studied holistically by one or more method. The case that is the subject of the inquiry will be an instance of a class of phenomena that provides an analytical frame – an object – within which the study is conducted and which the case illuminates and explicates"* (Thomas, 2011).

A case study is also one of the advanced designs suggested by Fetters, Curry and Creswell (2013), in the mixed method approach particularly if it involved multiple cases increasing the complexity and widening the scope to build an effective case to add to the body of knowledge for the industry.

For the purposes of this study a single case study was used (the ornamental horticultural industry) but embedded in this were the numerous sub-cases which were the individual participant's businesses (Yin, 2003), thus multiple cases within a single study. These sub-cases made logical sense to explain specific details related to the environmental productivity. The methods used in each sub-case were repeated to search for patterns and practices within the smaller units which if true, then these sub-cases could be used to represent the whole and increase the rigour of the study (Zainal, 2007). Due to the number of sub-cases investigated there was the necessity for triangulation (Yin, 2003).

The other option for a single case study was a holistic one whereby a comprehensive investigation into the environmental footprint of the entire industry is studied. This might have had insufficient credible data, due to the lack of statistics and research done within the industry on the related topic thus leading to unsubstantiated conclusions. To ensure that the researcher did not focus entirely on the sub-cases and a comparison between them, the cyclic nature of the study was considered and once the data collection from the individuals is analysed, it was collated to be representative of the industry and used to design the manual which will be shared (Yin, 2003) (12).

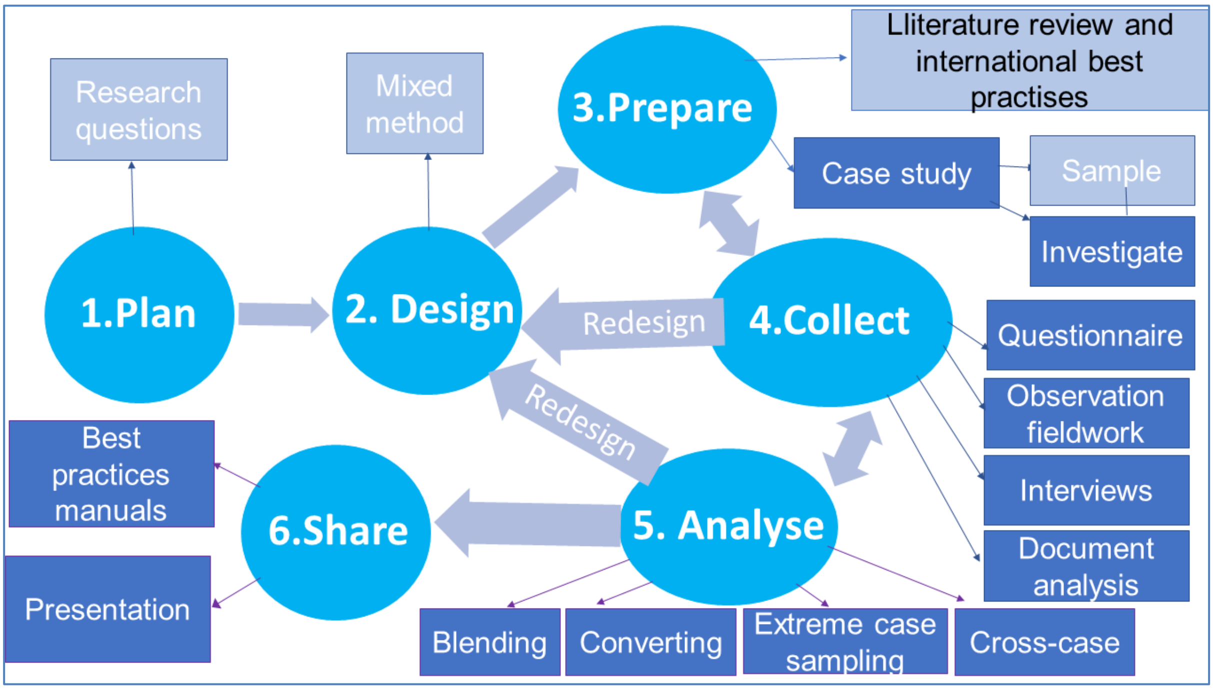

Figure 4.2: Adapted from Doing Case Study Research: A linear but iterative process (Yin, 2003; Creamer, 2019)

The flexible nature of a case study is both a positive and a negative, and in the case of an all-inclusive study of the industry this flexible nature could result in a change of pattern, different from that which is required to answer the research questions. This was seen as a negative attribute to case studies as a whole, and even more specifically to the holistic, single case study design (Yin, 2003) particularly when some members of the allied trade in the industry, who procure and produce chemicals and fertilizers, might have a greater environmental impact than those growers and retail garden centres researched due to the nature of their products but they were not included in the study.

A constraint of the case study is its generalization and hence numerous case studies have to be conducted to obtain more reliable conclusions (Basturkmen, 2012). Sub-case studies provide unique and in-depth insights (Thomas, 2021) and the researcher used these to investigate the environmental productivity of each business, which when analysed assisted in ascertaining the complex nature of sustainability practices within the industry (Figure 4.3). The information gathered from the sub-case studies was scrutinized (Marczyk, DeMatteo & Festinger, 2005) to ensure it either correlated with, or challenges that which was sourced from the literature review and other research instruments.

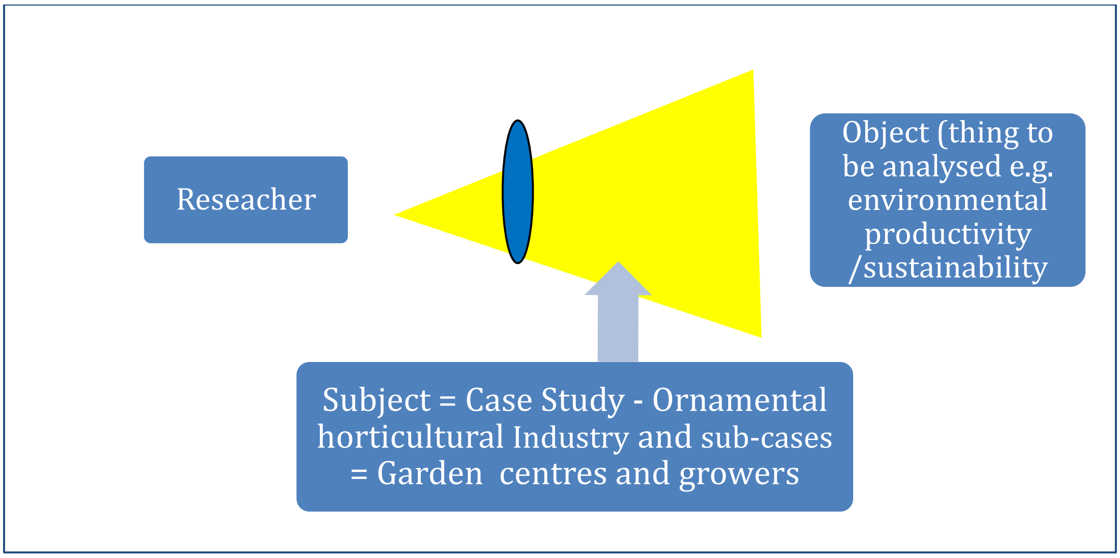

Figure 4.3: Lens analogy. Adapted from Thomas (2021).

The nature of case study research allows for the participatory exploration and explanatory understanding (Stake, 2006; Merriam, 2009; Simons, 2014) thus the key factors within the individual businesses were investigated, broadening the scope of research to reflect practices in ornamental horticultural businesses in South Africa and this was used to answer the research questions. Those businesses which participated were looked at as individual entities and used to determine the current environmental productivity awareness and practises currently being done on-site. Time was taken to ensure that aspects of the key factors - energy, nutrients / fertilizer, pesticides, soil / media, waste / recycling, and water were observed and discussed and personalized comments and photographic evidence used to enrich the research.

The use of numerous instruments to complete the case study in terms of collection, analysis and interpretation provided a cooperative and thorough picture of real-life happenings (Yin, 2003; Stake, 2006; Merriam, 2009; Flyvbjerg, 2011). The strategy to combine the instruments such as interviews, focus groups (during pilot study), observations and others is used for triangulation which enhances the study (Harrison *et al.*, 2017).

4.5 Research instruments

4.5.1 Questionnaires

Questionnaires are a well-used data collection instrument as they provided a wealth of in-depth knowledge and the potential to source valuable, written data about situations and human behaviour towards these situations, however planning and design are important (Marshall, 2005). Questionnaire design has a few integrated layers such as purpose, content of questions, wording and language and lastly sequencing and layout - together this is what makes a useful questionnaire (Gendall, 1998; Roopa & Rani, 2012). A questionnaire was designed to investigate the present overall level of environmental productivity awareness, understanding and implementation within the ornamental horticultural industry in South Africa.

The researcher first investigated the option of using an existing validated questionnaire but found no validated questionnaire existed at the time of questionnaire design. A few partial or fully validated questionnaires that focus on an individual's sustainability choices in terms of consumerism and citizenship or conscientiousness were located in the literature search (Micheletti, Stolle & Berlin, 2012; Gericke *et al.*, 2018). However, these were not suitable for this project as the questionnaire needed to focus on using the most appropriate legislation related to the key indicators to determine a baseline of environmental sustainability knowledge and practice within the business. Furthermore, the questionnaire should test the study participant's knowledge as well as how, if, and when, that knowledge was applied to business practices to improve sustainability, and if this was even a factor in determining environmental awareness.

Pilot study

A questionnaire was provided to a mix of landscapers, retailers and growers within a focus group setting where the participants were informed about the study and asked to complete a section of the sample questionnaire. It was an incomplete questionnaire as it focussed only on environmental perceptions and water related issues. From this questionnaire it was noted which questions were answered easily and those which challenged the participants. In discussion with a statistician and advisors, the questionnaire was then adapted to try to get the most valuable information without taking up too much of the respondent's time.

In the design of a questionnaire each section should have a similar structure to make it easier for the respondent complete as well as including a combination of structured questions and open-ended questions - this combination provides insightful information (Driscoll, Salib & Rupert, 2007). The questionnaire design for this research followed a similar pattern:

After the business background demographic section, each of the sustainability sections, namely environmental awareness, and environmental sustainability factors (water, growth media, energy, fertilizers, pesticides, and waste / recycling) included structured questions such as those including a Likert scale together with at least one open-ended question.

Apart from careful planning, design and circulation (Leedy & Ormrod, 2013), other aspects to ensure that the questionnaire achieved the objectives of study were sample choice, ease of readability and understanding of the questions and that there was a numerical (quantitative) aspect included (Marshall, 2005).

Thus, the final questionnaire had three sections (Appendix 9):

1. Business background (5 questions)
2. Environmental awareness with regards the business (13+1)
3. Environmental sustainability factors – Water (9), Soil (8), Energy (7), Fertilizers (10), Pesticides (8) and Recycling / Waste (6).

The first section included information about the participant's business. This was followed by questions about general environmental terminology and legislation which sets the tone for the research. This then logically led into questions relating to environmental productivity factors, which provided an indication of the study participant business practices. This process of questionnaire design was proposed by Gendall (1998) where the first "general principle" questions are those that the participant can answer honestly and easily as they relate to their situation, awareness and conduct. The following "specific principles" questions are more targeted as they include closed questions for context and comparisons with a few open-ended questions which allow for explanations.

The questionnaire design allowed for easy reading and answering for the respondents and at the same time provided reliable data for the researcher. The researcher tried to ensure that the questions were direct, explicit, relevant, and lacked ambiguity. They also had a code ascribed to them for analytical purposes (Leedy & Ormrod, 2013).

In designing the questionnaire, steps were taken to minimise bias as similar questions were asked for each of the key indicators. This pattern was to make it easier for the participant to understand the questioning process and to complete it. There was a mix of qualitative and quantitative questions and although the researcher was looking for information about the business practices, the questions were not intrusive or of a sensitive nature. One company did ask the researcher to sign a non-disclosure form.

The layout of the open-ended questions, scale questions, tables to complete and other questions was structured to ease the participant's completion of them. The length of the questionnaire was an important consideration. If it is too long, the respondent could experience questionnaire fatigue to eventually compromise some of their later answers (Choi & Pak, 2005). This was a concern as it took most participants 35-45 minutes to complete but only one of the respondents had a problem with it and yet their final answers were still comprehensive and relevant. Thus, the researcher believed that questionnaire fatigue was not a problem.

On the return of the questionnaires, each participant was allocated a respondent number. The data from the questionnaire were captured into MS Excel which can be used for basic numerical, analytical purposes (Scala and Howard, 2020)

The researcher then decided to increase the number of sub-units of the case study and apart from only using the questionnaire as described above, interacted with 41 growers and retail garden centres in eight of the provinces in South Africa (Appendix 10). In each case, the study participant was asked to complete the questionnaire, then a site visit was conducted and a semi-structured interview as well as participatory observations followed. In both KwaZulu Natal Province and Cape Province, the site visits were hampered by travel restrictions due to COVID-19 and so, in these regions, the questionnaires were e-mailed, and discussions were held telephonically between each participant and the researcher.

4.5.2 Fieldwork procedures

On-site fieldwork is best for exploring the various variables to better understand the situation as it complements the questionnaire and thus enriches the study (Marshall & Rossman, 2016; Tight, 2020). The researcher felt that fieldwork was best for exploring the use of the key factors and other elements related to the study on-site to gain a picture of what is actually happening with regards to sustainability and help compile a comprehensive description of the environmental productivity within the industry.

Using Google Earth, the researcher prepared for each visit by gaining an overview of the site and infrastructure. For this purpose, the researcher went into the field and did on-site audits of the practices and procedures of the growers and retail garden centres. In the two provinces not visited by the researcher, members in these regions were asked to complete a questionnaire using a semi-structured telephonic interview. The Northern Cape was not investigated as they only had one SANA branch member at the time of the study.

During each field visit, field notes were taken to record the on-site environmental sustainability practices at each site. Thus, dams or reservoirs were visited, the area where the growth media was kept and mixed was noted, chemical and fertilizers rooms were inspected, fertigation systems were investigated and dumping, and waste disposal areas were reviewed. In addition, during these site visits, participant observation methods for the qualitative research parts of the study were conducted such as while walking around the site, watering practices were recorded or photographed as well as spraying pesticides and delivering fertilizer. With regards to energy usage, the storage of diesel was noted as well as other fuel sources. Offices and tunnels were inspected for electricity or other energy sources.

This type of inquiry revealed rich and reliable data with regards to the actual behaviours of those within the business context (MacDonald, 2012). During the fieldwork, the researcher had the opportunity to be part of the experience, using all her senses (seeing what is happening, hearing the different instructions given and machines used, touching the different growing media etc.) to be immersed in the businesses' practices, and to engage in the activities with the participants and their fellow workers. The active involvement of the researcher during the fieldwork can result in bias and had to be circumvented by the triangulation of this method with field notes, photographs, videos and recordings which ensured the data collected was objective (Marshall & Rossman, 2016). The researcher was aware of this pitfall and followed the advice of Marshall and Rossman (2016) and after each visit transcribed, checked, and collated the collected data.

4.5.3 Semi-structured Interviews

An interview is a conversational exchange of information, that is guided by the interviewer using questions related to the topic (Gillis & Jackson, 2002; Adams, 2015). In a formal or structured interview, the questions are predetermined, making the assessment of the answers unbiased and comparable. During a semi-structured interview, the interviewer prompts the direction of the discussion with a few prepared questions. By diligently listening to the answers of the participants, s/he is prompted to ask the next question and thus guides the interaction. In both cases the interviewer should listen intently to the words spoken as well as their tone, respect the participant's answers and watch their mannerisms to fully gain insight into the participant's knowledge, attitude and behaviour (Marshall, 2005; Doody & Noonan, 2013).

In the current study, the researcher had chosen semi-structured interviews which were conducted in the manner of an informal discussion where the interviewer was someone the researcher knew and trusted.

The majority of the interviews were conducted at the business site being studied. This gave the researcher the opportunity to not only use them to gather answers to questions but also take note of the physical characteristics of property and structures as well as the interactions between the team members doing the various tasks involved in growing and selling plants. The advantages of on-site interviews were that the respondents felt comfortable, and it was convenient for them. These positive attributes, particularly of participant observation in situ by the researcher, were suggested by Elwood and Martin, (2000). The dialogue that took place during the semi-structured interviews is one of the research tools of "participatory action research" (MacDonald, 2012; Burns, Howard and Ospina, 2021). A "participatory action research" interaction between the interviewer and interviewee involves the interviewees sharing their experiences, ideas, knowledge, and memories of the situations e.g., interactions between team members and their individual feelings in terms of their interaction with the key factors. Participatory research provides a gateway for positive change for mankind and the environment based on the combination of theoretical knowledge and experiences (Burns, Howard & Ospina, 2021). Apart from participant observation, the researcher learnt how certain things took place e.g., filling the potting machine, why different soil mixes are necessary and feeling the growth media to better understand the recipe make-up. Two growers mentioned that they changed their growing media once they "got their hands dirty", did the experiments and soil tests and realised what they were expecting their plants to grow in. This information was not divulged in the answering the questionnaire nor during the site exploration which involved current practices, not past. Hence the use of multiple methods of data collection was beneficial.

Results from the interviews helped determine to what level businesses within the ornamental horticultural industry had already taken steps to implement change and decrease their dependency on non-renewable resources and impact on the environment.

4.5.4 Document analysis

Some of the growers were already expected to meet certain sustainability criteria due to requirements by the chain stores or corporates that they supply. This required the preparation of auditable documentation that was available when the researcher asked permission to study it - Global Gap (GLOBALG.A.P., no date) and Farming for the Future (King and Thobela, 2014). The researcher also asked permission to study other documents that were relevant for the study if they were available. A summary of these was described in the questionnaire or covered in the interview. It also became apparent that many retail garden centres and growers did not have written policies or documents e.g., integrated pest management plans, watering practices, recycling policy etc.

The use of mixed methods for business and management is valuable as it provides insights and understanding of the related challenges and questions which foster growth and development (Molina-Azorin, 2018). This underscores the need for use of mixed method research for this study as the researcher was investigating local businesses and their management of natural resources. A combination of data collection methods was used from several different sites to enrich, support, and validate the findings ensuring that a true reflection of the situation was represented in the results.

As mentioned in the introduction, international best practices and associated information was collected and analysed to look for similarities and differences between the OHISA and international growers and garden centres in the search for answers to Research Question 9. The researcher selected 32 best practices reports, journal articles or similar studies from numerous countries as discussed in Chapter 2.4.1.

4.6 Sampling

The sample for this study has been briefly mentioned above. From the population that was selected with individual businesses having one characteristic that sets them apart which is then refined to the sample frame which includes the list of potential participants and finally is narrowed down to that actual sample which is those participants that participated in the study (Appendix 11) (Creswell and Guetterman, 2019) . When referring to the topic, the researcher wanted to study the ornamental horticultural industry of South Africa (the population) which for this study is represented primarily by the members of the South African Nursery Association (the sample frame or target population). The researcher identified this population to be of interest where all the members have a similar goal of growing and selling a healthy plant. To investigate the entire population is challenging and thus the researcher selected a few businesses (the sample) to positively represent the whole and from the results of the data collected make generalisations about the industry - this is known as sampling (Leedy & Ormrod, 2013).

4.6.1 Sampling procedures

When choosing a sample there are three factors to take into consideration: sampling method, number of participants (sample) and willingness of participants to be involved (respond) (Acharya *et al.*, 2013; Saunders & Lewis, 2016).

4.6.2 Sampling methods and design

Probability sampling is where a random group of people within a population are represented in the research. As any member in the population has the opportunity to be part of the study, this type of sampling is ideal for generalisation as the results are truly representative of the whole (McMillan & Schumacher, 2010; Leedy & Ormrod, 2013; Creswell & Guetterman, 2019). The researcher did test this method initially by submitting the questionnaire as part of the trade day package to random people within the industry, but the response was poor. Apart from the lack of response with regards to this sampling type is the practicality of it regarding the population size and distribution throughout the country causing time, financial and manpower constraints (Acharya *et al.*, 2013; Creswell and Guetterman, 2019).

Non-probability sampling is the other method where the participants are chosen by the researcher i.e. they are available and willing to participate in the study (Setia, 2016) but it may result in selection bias as some members have no possibility of participation (Acharya *et al.*, 2013; Leedy & Ormrod, 2013). There are a few derivatives of non-probability sampling including convenience, purposive, snowball, expert selection and network sampling (Vehovar, Toepoel & Steinmetz, 2016). Using the guide provided by Saunders and Lewis (2016) involving "choosing a non-probability sample technique" the best method of sampling for this research was purposive sampling, as the participants were chosen as a group who represented the diversity of the industry according to business size, plant selection and geographical location in the country, all factors that would contribute to answering the research questions. Due to the nature of this type of sampling, the researcher can confidently generalise with regard to the whole OHISA growers and retailers population, as the sample was representative of it (Creswell and Guetterman, 2019). Thus, the use of purposive sampling was not considered a weakness with regards the project as the researcher was searching for in-depth information from the smaller sub-case studies which would produce valuable data (Rai and Thapa, 2015; Saunders, Lewis and Thornhill, 2016).

The researcher's intention was to describe the practices and strategies of the businesses within the ornamental horticultural industry and if these are re-occurring in a high percentage of the sample then generalisations could be made if other criteria were similar. Conversely, anomalies which the participants experience are important to be noted to ensure a holistic research project. If the sample has similar characteristics, problems and solutions within the framework of the study and these meet the clear criteria chosen with regards to sample selection, then the results can be compared to other corresponding samples (Rai & Thapa, 2015) and the bias can be reduced (El-Masri, Maher, 2017). An example of this is if 90% of the participants do not know how the sustainable development goals apply to their business and do not have an environmental management plan then a generalisation could be made that this research is a necessity for the industry to become more environmentally sustainable. On the other hand, if only one business mentions using chickens as means of pest control, this business is an exception, but it could be a natural way to control insects and should also be mentioned.

4.6.3 Sample size

When using non-probability sampling it is vital that sample selection, size and criteria are carefully explained, evaluated and transparently written, acknowledging potential bias situations and risks (Vehovar, Toepoel & Steinmetz, 2016). Sample size is an important consideration for researchers - the greater the number of samples collected, the more confidently generalisations can be made (McMillan & Schumacher, 2010; Leedy & Ormrod, 2013). Each research project is different but the ideal sample size is one that meets the requirements of the study, answering the research questions with a truthful portrayal of the practices and procedures while still being flexible and allowing for a realistic variance level that certifies consistency and repeatability (Kothari, 2004). The use of a case study with sub-cases within this research allows for a smaller sample size as statistical measures are not as important as the exploratory nature of the study even though conventions imply that the sample size should include a pilot study and best between 20-150 participants (Daniel, 2014). This number of samples was further refined to “4-12” for a homogenous population which involved a very comprehensive study of specific businesses similar in size, production and sales methods and business strategies. This did not describe the sample for this study which was more of a heterogenous population which did have similar characteristics such as growing and selling plants but the businesses themselves varied as to the number of staff members, business size and the way in which they operated and the resources that they used. Using heterogenous populations when doing non-probability sampling, the suggested sample size was between “15-60” participants to ensure that the data collected is representative and the study worth-while (Saunders & Lewis, 2016).

The South African Nursery Association (SANA) was used as the sampling frame to represent the ornamental horticultural industry in South Africa, as in those countries where other best practices have been written such as Canada (although in Canada they also included landscaping and turf management sectors) and Australia.

The current study could potentially sample 318 SANA members divided into four sectors, namely allied trade, growers, bedding plant growers and retail garden centres. The researcher amalgamated the bedding plant growers and growers into a single growers' sector for the purpose of this research. Principal members of SANA were investigated as branch members are aligned to them in characteristics, principles, and business strategies but in three cases, the branch members were part of a different sector to the principal member and so they were included in the study. Therefore, with no allied trade participation, the population of the SANA ornamental horticultural industry with the potential to contribute to the study was 130 participants. Due to the constraints of COVID-19, time, and finances, only 40 members received the questionnaire and of those 38 participated as a sub-case study due to their willingness and proximity to the researcher. The region in which no participants were part of the sub-case studies was the Northern Cape Province. Three additional non-SANA members, but still growers, were sampled to increase rigour and see if the SANA sampling was representative and comparable to those non-SANA members of the industry (Figure 4.4). This meant that a total of 41 growers and garden centre retailers were ultimately sampled.

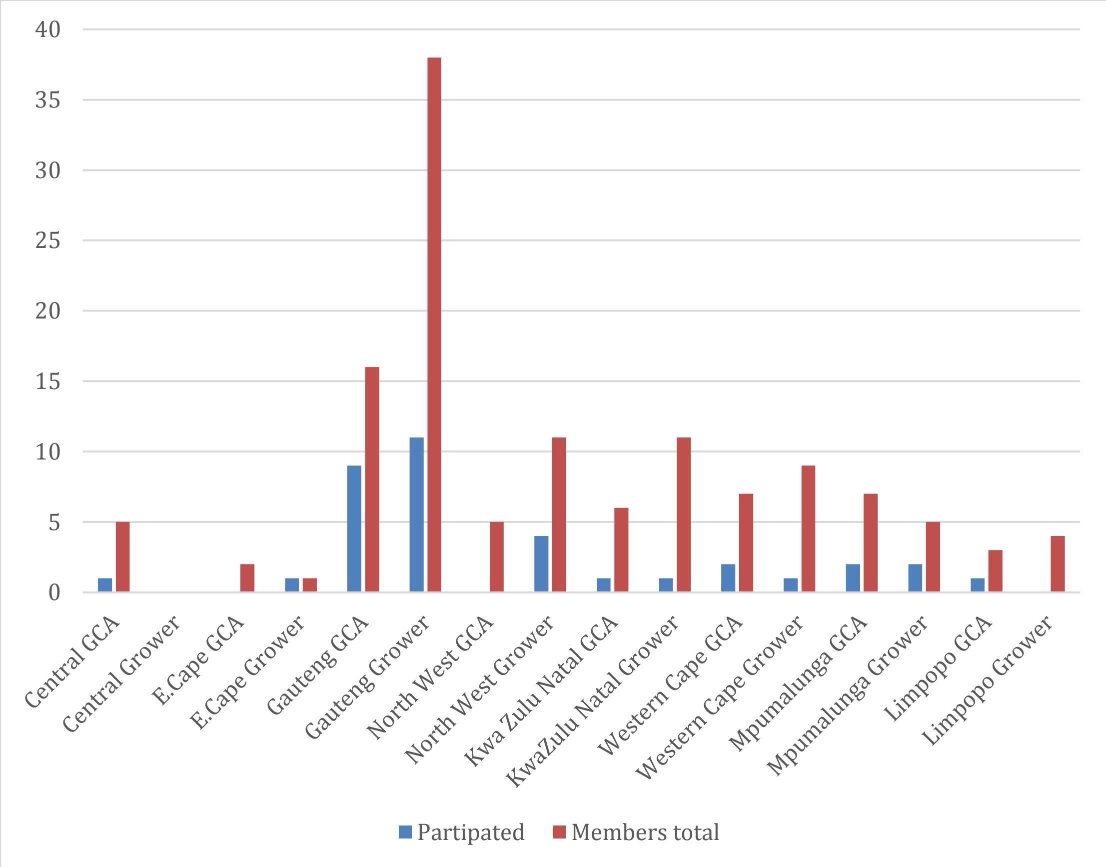

Figure 4.4: Summary of participation of Grower and GCA's per region

Summary of sample selection:

SANA potential sample size (n) = 130 (bedding plant growers, growers, and retail garden centres);

Number of SANA member questionnaires answered (n) = 38 (29%).

Comparable non-SANA members but growers or retail garden centres (n) = 3.

Number of participants visited = 33.

Figure 4.5 show the 9 provinces of South Africa and these are linked to the different regions discussed in the study, particularly Figure 4.4 (above).

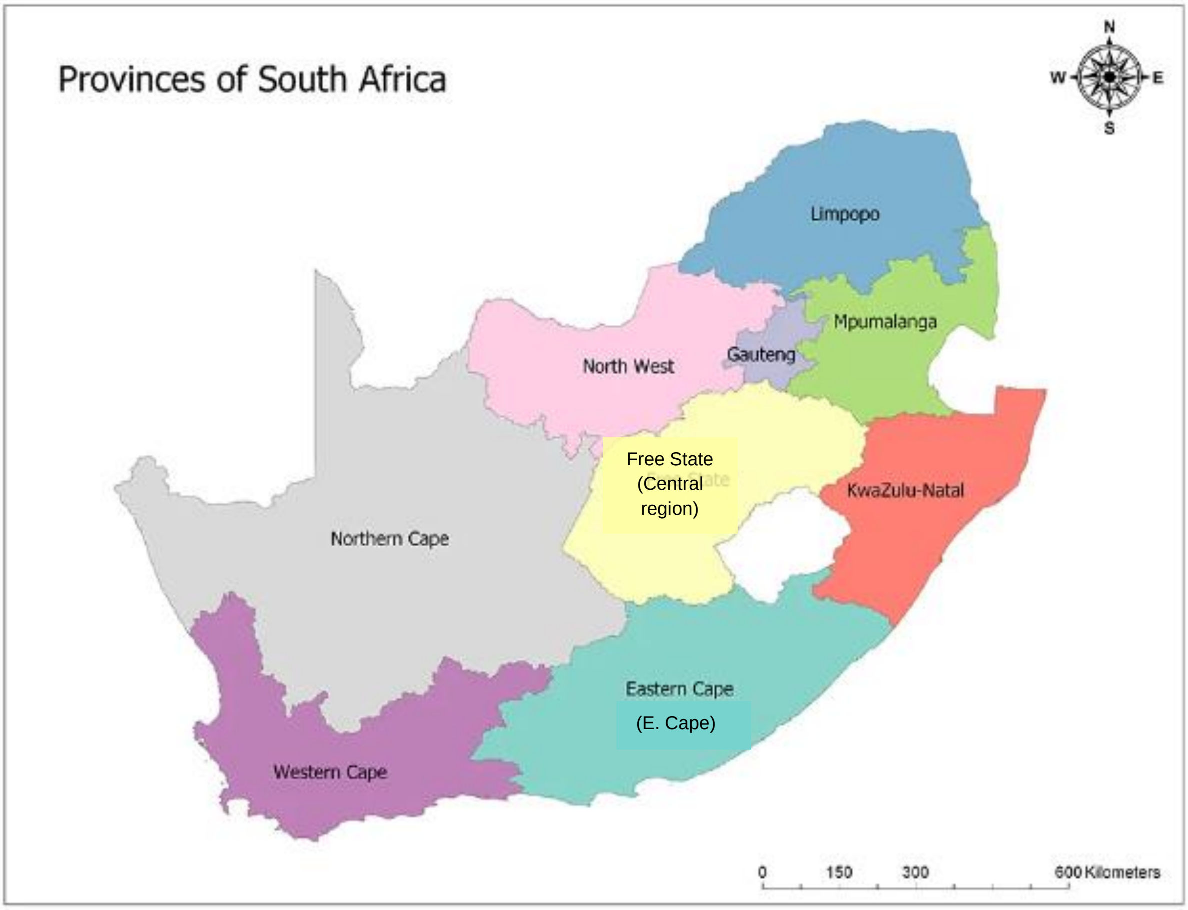

Figure 4.5: Map of South Africa showing the nine provinces and linked region if different to Provinical name. Adpated from (Mappr, 2023)

4.6.4 Sample response and criteria

Sampling errors can increase bias within a study and various methods can be taken to minimise them, these include:

1. Ensuring the questionnaire is user-friendly and well designed
2. Ensuring that all methods possible were taken to get the chosen participants to respond, thus ensuring a desired number of samples for research to be valid and reliable
3. The third challenge is the “indeterminacy principle” where the behaviour of participants changes as they know they are being studied
4. Lastly is the ineligibility or incidence rate where some members which were included in the sample might not be eligible (Kothari, 2004; Daniel, 2014).

In the research project, the following steps were taken to reduce bias and sampling errors which could occur, as mentioned above:

1. The researcher spent time investigating and studying other similar questionnaires to produce a questionnaire that was easy to read, understand and obtain data to answer the research questions as a poorly designed questionnaire results in common errors. The researcher also piloted part of the questionnaire to confirm that it was indeed a valid and reliable data collection tool.
2. There was an initial lack of response from chosen participants in those provinces where the researcher could not visit to do sub-case studies and the questionnaires were sent after an emailed or telephonic introduction letter or conversation to the project was conducted. Thereafter if the response was still poor further communication methods were employed to confirm willingness to participate. In most cases the questionnaires were then sent back completed. It was only in KwaZulu Natal where growers failed to return questionnaires.
3. A change in behaviour and / or attitudes of the participants was offset by the researcher spending a longer time at each site, and looking in-depth at the key factor's use within the businesses and by the participants, and using mixed methods for measurement
4. Using a heterogeneous purposive sampling method in this study ensured that all participants were chosen and their contribution to the study was validated.

In conclusion, the importance of sampling procedures and selection is highlighted by the following factors: sampling design, gaining access to data, choosing suitable participants and sample size. The researcher has been part of this industry for many years and the participants were generous in opening their doors and sharing information. The researcher chose a non-probability, purposive type of sampling which allows for a smaller sample size which is consistent with the objectives of a case study. It does however reveal a wealth of descriptive data and a way to understand situations, but it also has the potential for greater partiality from the researcher in participant choice and sampling errors. These have been discussed but will be highlighted later in the chapter with reference to bias and limitations. The data collected from the various participants over a period of 15 months was captured, organised analysed and then interpreted. These steps are described below.

4.6.5 Storage and management

Once a site visit had been conducted and the questionnaire completed, the data gained were transcribed, notes were made which were filed and photos and videos put into folders on a computer and uploaded to the cloud, each site having its own folder and business number to ensure anonymity and protection of information. The early organisation and correct storage of data was necessary to avoid confusion and inaccuracy at a later stage of the study (Creswell & Guetterman, 2019). The continuous organisation of information during the process was not only important to capture the reality of what was happening in the field (Tight, 2020) but also included the decision-making process of capturing data e.g., photographs and videos that was most relevant to the key themes of the study (Marshall & Rossman, 2016). This process was the start of the data analysis, and the data was saved twice into two different places – by business and by key factors.

4.7 Data analysis

As mentioned above several methods were used for data collection in this study: observations on-site, in-depth, personal interviews, photographic evidence, google earth mapping, studying related documents and questionnaires. The information obtained from these methods was processed and analysed. A strategy was developed to examine the information collected from the various sources and sites separately. Part of this strategy was to sort the data collected into various indicator groups e.g., climate change, emissions, pollution and waste, energy efficiency, and water corresponding to the environmental indicators mentioned in Chapter 2 (Rahdari and Anvary Rostamy, 2015). This information was filtered into smaller, more manageable and related groups (Tight, 2020). When designing the questionnaire, Kothari (2004) recommended assigning codes to the different options of answers which would save money and time and add clarity when analysing the data. In the current study, these procedures were followed, and data collected was inputted into an Excel spreadsheet as it was collected. Microsoft Excel has the capability of using macros to perform basic statistical tests and produce quantitative results from the data which has been captured and organised. The open-ended questions were grouped into themes according to the answers given and which were allied to those indicators discussed in the literature review. To prevent bias with regards to grouping of open-ended answers, they were first grouped independently by two separate researchers and then the results from these were compared and collated. The information from the semi-structured interviews was transcribed together with the video footage - often it was easier to video the conversation and practices concurrently than only having a verbal recording. The verbal transcriptions from the interviews as well as the photographic and video evidence were also grouped into related themes which helped with the assessment. It was important for the researcher not to get caught in the cycle of collecting more and more descriptive data and lose sight of the fact that the data had to be interpreted to answer the study research questions (Leedy and Ormrod, 2013) which was to help solve the environmental productivity challenges of the industry.

A use of comparative sub-cases studies was the design used in the current study to answer the “how” and “why” research questions. This type of approach generates valuable exploratory data by using the empirical data from the theory and collating it with the practices and procedures happening on-site (Goodrick, 2019). The sub-cases studied were further compared to each other to produce patterns and explain if modifications and development within the business context had made a difference to the environmental productivity within that structure. This framework allows for meaningful comparisons to be made between the indicators, key factors and themes from the current information obtained from the sub-case studies to establish a picture of the environmental productivity of the ornamental horticultural industry in South Africa. This was then compared to the respective international best practises and from these results a South African best practise manual for sustainability was developed.

This framework is described as:

1. "Description of the process" - methods and methodology written about above
2. "Interpretation of data" – evaluation, analysing and sorting data into themes and key factors and indicators
3. "Juxtaposition of data" – establishing similarities and differences between the sub case studies
4. "Comparison" – comparison between the South African and international practices (Bereday, 1964 cited in Bray and Koo, 2005).

This design process should produce rich data that can be used effectively to draw reliable and valid conclusions with the use of coding and thematic analysis of information.

4.7.1 Coding

The development of a coding scheme ensures that all information is scored using the same standards and processes to maintain objectivity and minimise misguided results (Fraenkel & Wallen, 2009). Coding involves separating the data into individual sections that are understandable entities (McMillan and Schumacher, 2010). If needed another researcher can use the same code to obtain or achieve similar results. A code can be an activity, phrase, word, quote or process (McMillan & Schumacher, 2010) and in this case an indicator.

Coding can be:

- Inductive – where the codes are developed from the information investigation during collection and examination
- Deductive – the codes are pre-determined from existing information usually from the research questions or conceptual framework, from which patterns are formed which enable data assessment (Miles, Huberman & Saldana, 2018)
- Blended – a combination of inductive and deductive where the coding methods complement each other and the data obtained (Graebner, Martin & Roundy, 2012). This is also known as a hybrid method where ideas or

information are seen and recorded (inductive approach) and later matched to the themes from the deductive codes (Fereday *et al.*, 2006).

The researcher used a blended approach to coding, thus using both inductive and deductive coding methods. The indicators for sustainability in Chapter 2 provided guidelines for the deductive coding and the development of the conceptual framework explained in Chapter 3 highlights the similarities in the sub-case studies. Inductive coding entails using codes which are representative of the exploratory data which are observed and noted during the fieldwork, interviews, and open-ended questions of the questionnaire. These “lightbulb moments”, differences and nuances at each site were not accounted for in the deductive coding. These inductive codes allow for observation transparency by recording the actual findings which improve the credibility of the data collected (Skjott Linneberg & Korsgaard, 2019). There are often many more codes created using an inductive method that are later grouped into categories.

Using this blended approach allowed the researcher to indicate which codes were inductive and separate them from the deductive codes but, at the same time, show the relationship between the codes which evolved during the research process (Graebner, Martin & Roundy, 2012).

Creswell’s data analysis spiral (Cresswell, 2007, cited in Leedy and Ormrod, 2013) suggests a cyclic nature to coding (Figure 4.6). Skjott Linneberg and Korsgaard (2019) suggested using two or more cycles. The first cycle is descriptive and seeks the inductive codes derived from observation, interview, and document analysis data. This is followed by “attribute coding” - searching for those characteristics or elements from the data that are comparable. The second cycle looks at refining the codes from the first cycle and collating them into usable categories, parallel themes or contrasting patterns which are scrutinized, conceptualised, and interpreted as to whether they were able to answer the research questions. The development of a coding scheme includes the grouping of codes into categories and linking codes that are in relationship to each other, into existing theories and concepts - this is known as triangulation (Gibson, 2017). These were the steps that the researcher followed during the cyclic nature of data analysis to process the codes found in the existing literature and those which appeared during data collection. The redundant and duplicate codes were deleted as was suggested by Creswell (2013).

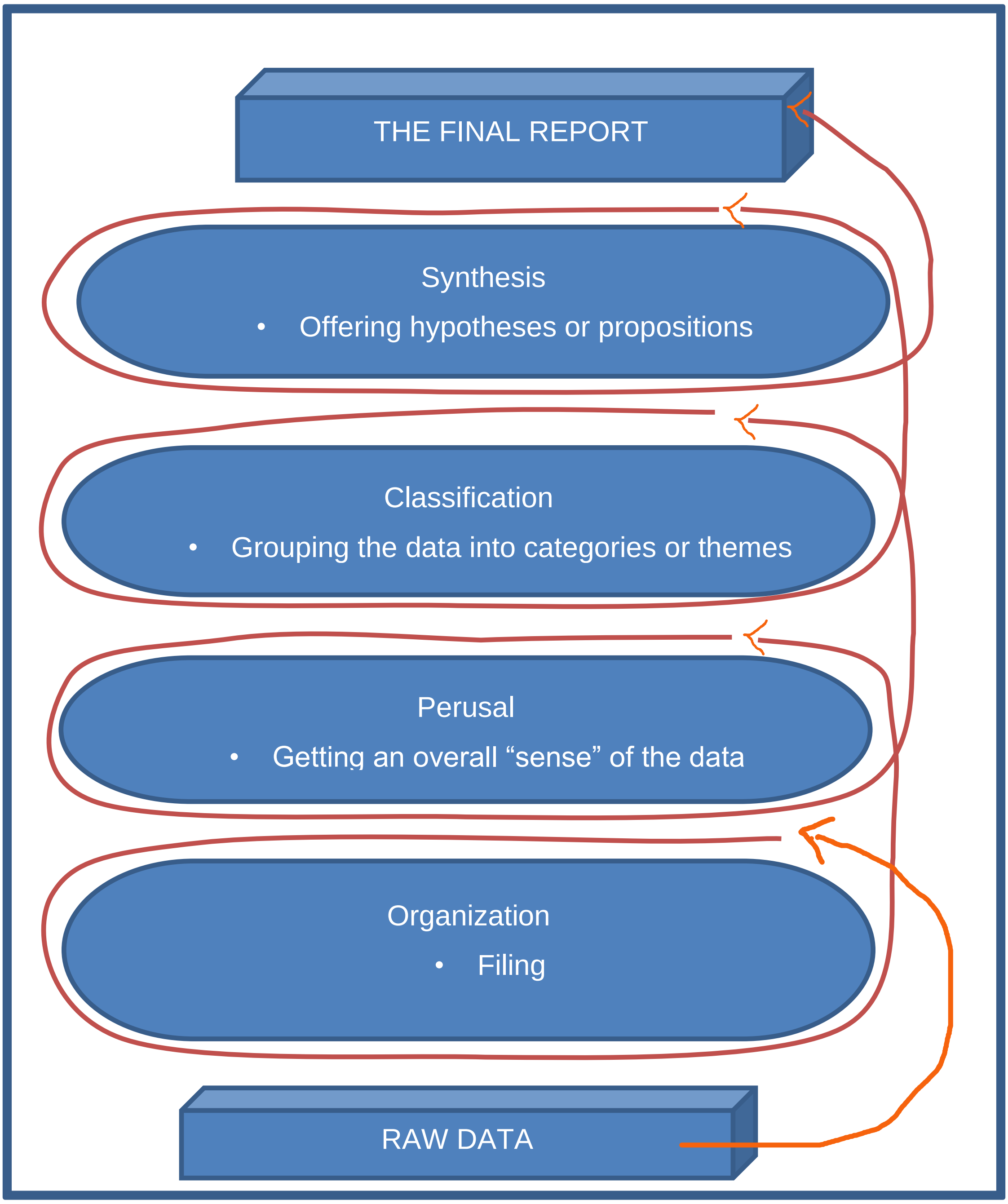

Figure 4.6: Data analysis spiral (Creswell, 2007, cited in Leedy and Ormrod, 2013).

4.7.2 Thematic analysis

Introducing thematic analysis as part of the current study adds rigour and an opportunity to further provide beneficial insights for the investigation from different perspectives of the participants by grouping together the differences and similarities between them and then noting the unexpected observations. This highlights the realities of the data and increases the trustworthiness of the research (Nowell *et al.*, 2017). This process can be challenging and time-consuming and it requires dedication and focus (Campbell, 2020) but is made easier if broken down into steps as described below:

1. Acquainting oneself with the data collected
2. Producing codes and providing procedures on how this was done
3. Establishing themes – using mind maps or infographics to show thematic relationships
4. Reviewing themes (see also Figure 5.1) – triangulation and creating team discussions related to theme choices
5. Defining and categorising themes - triangulation, peer review, detailed procedures of data development from codes into themes
6. Compiling a document (Nowell *et al.*, 2017).

The thematic analysis was also undertaken of the international best practices, life cycle assessments, journal articles and related documentation to examine the commonalities and differences.

In addition to coding and creating patterns, frequency counts of responses were also undertaken. The patterns most often linked to the indicators for the study and number of times the concept codes and themes were repeated in the open-ended questions, document analysis (both local and international) and site visits was recorded. This was done to indicate prevalence of concepts, beliefs and actions of participants (Fraenkel & Wallen, 2009) with the environmental productivity of certain aspects within the industry. These frequency counts were then used for statistical analyses and created quantitative data to triangulate with the qualitative information.

4.7.3 Statistical analysis

The statistical analysis of data in this study was to further validate the findings of the qualitative study and depended on the information gathered from the questionnaire. The frequency counts of indicators assisted in providing data for constructive or inferential statistics. The way the statistical data were collected and analysed was done according to the needs of the study:

- Descriptive statistics: whereby numerical values or graphics are used to explain the attributes of the sample in using statistical terminology such as mean (average), median (middle rank) and standard deviation (average of difference) (Fisher & Marshall, 2009)
- Inferential statistics was used to make deductions and draw conclusions from the sample to apply to the greater population. This measures the "significance" of the differences in the data (if they exist) and is used to determine if they are real or random in the test and this is given a "*p"* value (Marshall & Jonker, 2011).

The current study used descriptive analysis in the assessment of the data collected.

Following on from this, both descriptive and inferential statistics use the same basic scale of measurement types, namely:

- Nominal: these are groups or categories which have to have an opinion for each participant in the study to be included (Fisher & Marshall, 2009). These categories are equal in value so that locations such as Gauteng Province are not given a greater value than Limpopo Province
- Ordinal: these are groups that are ordered with a hierarchy and these groups are not a reflection of a direct measurement but rather a scale e.g., from smallest to greatest, Likert scale (Fisher & Marshall, 2009)
- Continuous: these are *"direct measurements using infinite scales where the increments on the scale are of equal distance, such as weight in grams"*. This can further be divided into intervals, such as grouping within categories including age (10-15) (McCrum-Gardner, 2008) or temperature, height (a person can't have zero height, then they do not exist) (Fisher & Marshall, 2009).

4.7.4 Method used to develop best practices manual

Using the information from the literature review, the data from the quantitative and qualitative questionnaire and interviews, fieldwork, document analysis including that of international best practices provided a comprehensive background of information and practical advice for the manual. The information was arranged into six main themes in alignment with the key terms highlighted in the thematic analysis of data. These themes correspond to the appropriate sustainable development goals showing how the OHISA is able to positively contribute to the green economy.

4.8 Improving research rigour

During the research process, rigour describes the careful and detailed manner in which the study was conducted to ensure that all influences were identified and acknowledged and that the research methods selected provide an honest depiction of the research which will result in quality driven, reliable and trustworthy conclusions (Allen, 2017). Often, qualitative studies are picked apart as they appear to lack scientific rigour, namely clarity of procedures followed, credibility of data collection and findings interpreted by the researcher with bias whereas validity and reliability are terms synonymous with quantitative research and they provide a rationale for the methods and justification of findings (Noble & Smith, 2015). Although reliability and validity are measured independently during the research process, the one can influence the other so that if the scores from the research instrument are not reliable then the conclusions will not be valid (Creswall, 2013). It is for this reason that the researcher used mixed methods to improve the research rigour (Tight, 2020) by conducting on-site fieldwork and engaging with the growers and garden centre managers, experiencing their real-life situations and investigating their environmental productivity practices and procedures in the ornamental horticultural industry.

4.8.1 Validity

Validity is referred to as the “truth value”. In quantitative studies it is the accuracy of how close the measurement tool represents what is being measured. In qualitative studies, it refers to the participant experiences and whether the findings are an honest representation of these (Montello & Sutton, 2006; Frey, 2018). To achieve complete validity is impossible, but during the research process the researcher must acknowledge the following two components to enhance validity: sound measurements from research instruments and validity of conclusions made by the researcher (Fraenkel & Wallen, 2009). A few potential threats to the validity of a study, apart from the researcher, are technological mishaps and participant sharing false information (Frey, 2018) but these should be minimised by the combination of research instruments used.

To improve validity of a study the researcher should consider the following concepts related to validity:

- "Credibility" – does the researcher's interpretation match the participant's opinions and experiences (Nowell *et al.*, 2017)
- "Transferability or applicability " - the researcher is to provide the context of the study and detailed explanations within this setting so that the information can be shared with others and implemented easily in similar confines (Noble & Smith, 2015; Nowell *et al.*, 2017; Frey, 2018)
- "Dependability" – the way the data are collected must be clear, systematic and well documented (Nowell *et al.*, 2017; Frey, 2018)
- "Confirmability" – were the intentions of the research met using the data collected, and was the understanding of the data interpreted correctly to give a concise pathway to the conclusions - was bias investigated whether intentional or not (Nowell *et al.*, 2017; Frey, 2018)
- "Audit trail" – the paperwork is not only used as part of the data collection process but also used to make decisions during the research process and for cross referencing and collating information (Nowell *et al.*, 2017)
- "Reflexivity" – the researcher should maintain a journal and account reflectively on the experiences undertaken, how they were challenged or confirmed, their values and insights about self, and record how decisions were made (Noble & Smith, 2015; Nowell *et al.*, 2017).

4.8.2 Reliability

The stability, consistency and replicability of research over time is referred to as reliability (Cohen, Manion & Morrison, 2005). When a research instrument is repeatedly used over a short period of time, the scores from the data collected should be stable (Creswall, 2013). Thus, reliability ensures the accuracy and precision of the research presented (Cohen, Manion & Morrison, 2005; Leedy & Ormrod, 2013).

The following steps were taken to improve reliability during the research process:

1. The site visits were randomly conducted over a period of 15 months although appointments were made with all participants.
2. The same instrument - the questionnaire - was given to numerous industry role-players to provide a good representation of the ornamental horticultural industry of South African to improve the reliability of the results. These questionnaires were answered independently of the researcher although she was present when some of them were completed. The instructions on how to answer the questions were clear and understandable.
3. The collected data were consistently captured from the research instruments and entered into an Excel spreadsheet. A second person checked the accuracy of the data captured from the questionnaires, semi-structured interviews, and site visits by watching the videos and listening to recording and checking this against the written transcriptions.
4. To improve the inter-coder reliability, data were coded by two people separately and then they conferred. High levels of agreement (at least 80%) between the two coders were acceptable to improve reliability (Fraenkel & Wallen, 2009). However, for this research, if 100% agreement was not achieved then the codes were discussed until both coders agreed fully.
5. The researcher has worked and been part of the industry for many years which enabled her to gain access to many sites. Having a respectful, business rapport with the participants ensured that they felt comfortable in their surroundings and were happy to share in-depth insights into their business practices. This advantage in reliability had the potential to be a

disadvantage as well, as the researcher was close to the subject matter and could have had difficulty remaining objective and interpreting the interview data from her perspective and not that of the participants (Graebner, Martin & Roundy, 2012) and, hence, and a mixed method approach was used to reduce this bias.

In conclusion, methodological rigour is of vital importance, not only with regards to the validity and reliability of the study but also from an ethical viewpoint out of respect for the participants (Cohen, Manion & Morrison, 2005). Using the above mentioned methods, the researcher tried to reduce bias and enhance the quality of the study by showing due diligence with regards to the sampling, reliability and validity of the research, thus ensuring that the research questions were answered truthfully and that the research added value to the present body of knowledge (Cohen, Manion & Morrison, 2005).

4.9 Limitations, delimitations, assumptions, and scope of study

During this research project there were certain aspects which the researcher had no control over which may have limited the study. This mainly involved COVID-19 restrictions on the researcher travelling and performing site visits in every province within South Africa.

While investigating the topic and the literature review in terms of the key words searched and articles obtained, the researcher felt that focussing on the key environmental resources of the study, namely water, soil, pesticides, fertilizer, energy, and waste was restricting and provided limiting boundaries of the environmental sustainability aspects that were addressed, especially those pertaining to South Africa. Other key indicators e.g., invasive species and biodiversity were noted as a theme (Table 2.2) and are an integral part of South African environmental legislation, National Environmental Biodiversity Management Act (Government Gazette of South Africa, 2004), when investigated it was determined that research related to these key terms and their impact on and from the OHISA has been investigated in previous research projects (Le Maitre *et al.*, 2020; van Wilgen, Measey, David M Richardson, *et al.*, 2020) and hence they were not used in this study as an indicator. The key indicators identified and investigated in this study, mentioned above, had limited scope relative to the ornamental horticultural industry and the production and selling of quality plants in this country.

Other limiting factors of the study were in the methodology and methods e.g., participation was voluntary, and it was difficult getting participants, whether they were members or non-members of the South African Nursery Association, involved in the semi-structured interviews and case studies. However, once committed to participating in the study, those participants that the researcher visited were very welcoming. The questionnaires which were emailed and followed up with telephone calls were not as forthcoming in results. Other restrictions such as potential researcher bias and misinterpretation are inherent in studies of this nature although the researcher focussed on reducing their impact.

The delimitations were those restrictions which the researcher set in place. These included area of study, namely ornamental horticulture and specifically those members who were involved in only growing and selling plants which excluded landscaping, turf management and allied trade as well as other SAGIC members.

The scope of the study was also a limiting factor as it only represented a sample of members of the ornamental horticultural industry within South Africa which was drawn mainly from the South African Nursery Association members.

Lastly, another assumption related to this research was that:

- Those who participated in the study were aware of the real or potential environmental impacts of their businesses
- They were qualified, whether it be by practical experience or knowledge, to be able to complete the questionnaire and participate in the case study

- These participants answered truthfully and clearly ensuring that the researcher was able to understand their meanings as mentioned above.

The limitations framed the research within a context and where their impact could potentially negatively affect the study, every opportunity and resource was used to try and minimise this to ensure that valuable conclusions could be made. The findings are not only relevant for the ornamental horticultural industry of South Africa but could also add to the greater body of knowledge regarding other industry's environmental impacts, but this would only be valid if all the research was done under the most ethical conditions.

4.10 Ethical considerations

Each university has a code of ethics that must be adhered to, before even starting a research study. The intention, purpose and way the study is conducted is described within a research proposal that has to be approved by the university's ethics committee. It is the responsibility of the researcher to conduct their study in a manner that respects the rights of those being asked to participate (Cohen, Manion & Morrison, 2005; McMillan & Schumacher, 2010).

This case study was thoroughly planned from inception to implementation ensuring that the methods used supported an ethically robust process. During the research proposal and each year thereafter, the SANA president was asked for permission to conduct the study within the industry. (Appendix 10). The current SANA president in turn asked the SANA Executive Committee to approve the researcher. Each of the participants was also contacted telephonically to set up an appointment and their permission was sought if they agreed to participate. Before the questionnaire was provided and the semi-structured interview began, the participants were fully briefed about the intention, purpose, and guiding principles of the study. Their commitment, and voluntary involvement was emphasised. Their permission as to recording the interviews, taking photographs and videos, and reviewing relevant documents that they wished to share was requested at the start. Lastly, the researcher assured the participants of their confidentiality throughout the research process by assigning numerical values to each business as part of the record taking (MacDonald, 2012).

All data recorded during the sub-case studies was logically and methodically documented to ensure its integrity (Harrison *et al.*, 2017). In addition, the researcher was ethically responsible and understood the experiences and words of the participants accurately to enable her to provide honest, valid, and reliable feedback from the study.

4.11 Summary

In this chapter, the methods used to conduct the research were outlined and the means to best achieve the objectives of the study were discussed. To fully understand what the impacts of the ornamental horticultural industry of South Africa has on the environment, the researcher had to visit relevant businesses within the industry and investigate their practises and procedures with regards to growing a healthy plant. How this was done, and the different methods used to achieve this provided a true reflection of what was happening in the industry, the extent of OHI business knowledge and commitment, and how decisions were made with regards to the environment particularly pertaining to its sustainability.

The pitfalls and the potential challenges of the research were also described and the way in which they could influence the outcomes of the study was explained. It is with this background that the study was conducted, and the findings and results are revealed and explained in Chapter 5. The researcher has the same belief as Reilly, Prinn and Reilly, (2012) who stated that: *"The challenge is to make the environmental connection explicit so as to provide a guide to where changes in policies could provide benefit"*. This is highlighted in the next chapter.

Chapter 5: Results and discussion related to the South African Ornamental Horticultural Industry

5.1 Introduction

This Chapter introduces results focusing on the demographics followed by aspects of awareness and influences of the KAP model followed by results linked to energy, water, growth media, fertilizer, pesticides and finally waste and recycling. This is culminated in results linked to the need for a best practices manual for the OHISA.

This study provides an integrated approach to investigating selected natural resources which are used, affected, or altered by the ornamental horticultural industry of South Africa (OHISA). The actions in turn affect the resources' sustainability which will have a knock-on effect for the industry e.g., water pollution caused by the leaching of chemicals and fertilizers during the production, selling or processing of plants will result in less "clean" water for growers to use which can result in it being difficult to produce healthy plants. The research aimed to identify the nature and extent of current environmental knowledge, awareness, and practices being implemented within the industry, including environmental and / or resource management legislation and its application. As previously mentioned in Chapter 3, this was done with an adaptation of the KAP model (Figure 3.3) providing a framework for analysis and interpretation of results (Figure 5.1).

Several growers and retail garden centres were selected as being representative of the growers and garden centres within the ornamental horticultural industry of South Africa as per the sampling methods described in Chapter 4.6. Site visits and interviews were conducted at 80% of the participant's businesses. Direct observation, relevant documentation and photographic evidence was collected and used to assess their environmental footprint and use of natural resources. This gave the researcher an opportunity to observe, understand and clarify the verbal and written reports and thereby document a more accurate approach to what was happening in each business.

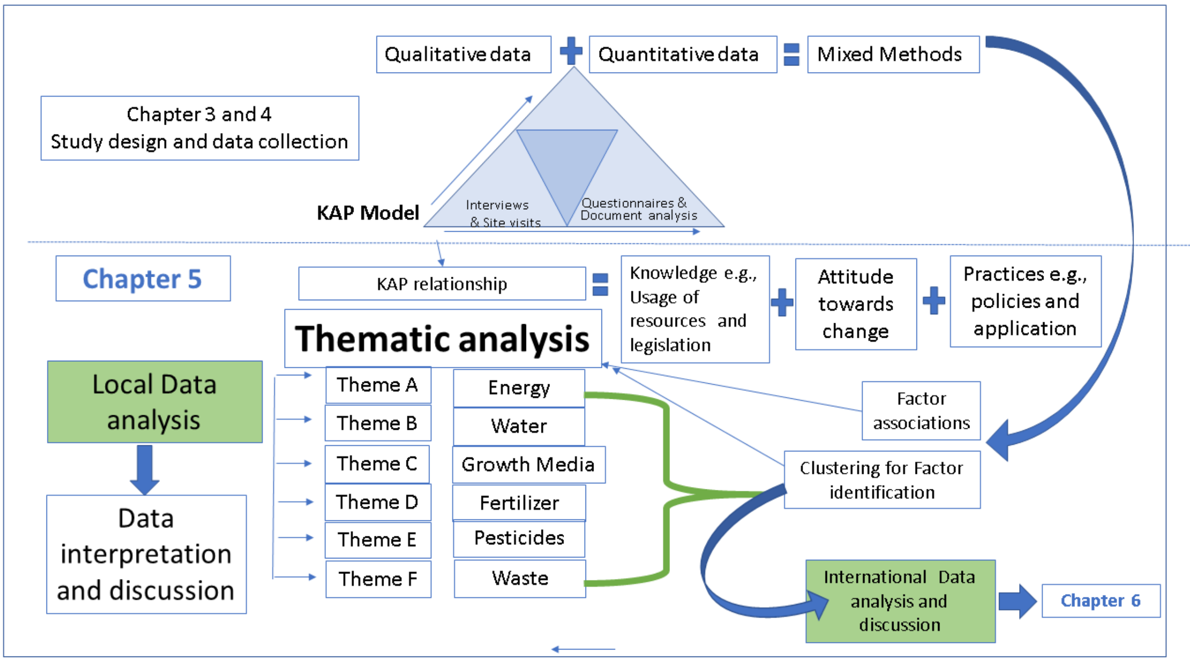

Figure 5.1: Adapted framework used to map qualitative data onto trends and associations identified by quantitative data (Muleme et al., 2017)

These data collection methods provided qualitative data for analysis as shown in the diagram above (Figure 5.1). Quantitative data was obtained from some of the questions within the questionnaire and were used to complement or verify the qualitative results.

As per Diamontopoulos and Schlegelmilch (2006), *"data description provided an insight into the responses received, contributed to the identification of errors in the sampling process, and provided a compact method for presenting the research results*".

5.2 Profile of the participants

5.2.1 Results from demographic sampling

This research study was conducted in cooperation with the ornamental horticultural industry of South Africa and focused specifically on growers and retail garden centres throughout the country.

The research questionnaire was sent to 40 SANA members and three non-SANA members of these, 41 participated as a sub-case study, two members chose not to complete the questionnaire or participate in a site visit or interview. The three non-SANA members were included in the study to increase rigour and to determine if the SANA sampling was representative and comparable to those non-SANA members of the industry.

Of these study participants, most (n=33) were sited close to the researcher and were willing to authorise a site visit by the researcher at their places of business. The number of site visits carried out are provided in Table 5.1.

Table 5.1: Summary of participants and research instruments used.

	Questionnaires	Site Visits
Growers	24	20
Garden centre retailers	17	13
Total completed	41	33

5.2.2 Results showing the participants plant range.

The sampling for this research was purposive and apart from a fair representation of growers and garden centre retailers in South Africa as discussed in the previous chapter, the selection of plants (categories) that are grown and sold within the ornamental horticultural industry is also well represented. The variety of plants grown and sold by the participants is in depicted Figure 5.2.

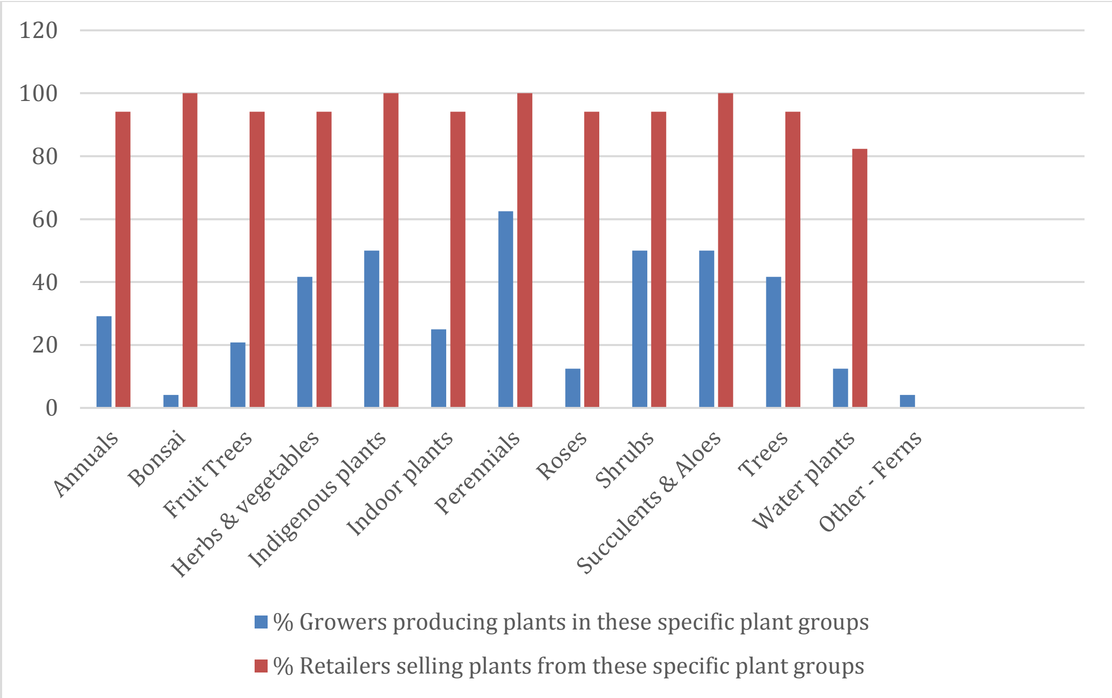

Figure 5.2: Plant groups grown and sold by study participants

In the study, the majority (83%) of the growers were generalists that produce and sell a variety of plants however, others tend to specialise in specific plant categories:

- Business 11 sells only roses
- Business 18 grows and sells only succulents
- Business 25 specialises in ferns
- Business 21 specialises in water plants.

It was seen from the site visits and semi-structured interviews that when a grower chooses to be a specialist it is usually due to their passion for a particular plant group or their location and the climatic conditions which would enhance what they grow naturally. Business 18 is situated on the drier side of Tshwane with very sandy soils and little access to water and so succulents thrive in this location. Business 25, on the other hand, is based in a warm and humid environment in Mpumalanga where ferns do exceptionally well. In both these situations the businesses are working with the local climatic conditions to grow their plants.

The results from the garden centre participants show that they sell a wide variety of different plant species within certain plant categories e.g., from annuals to water plants and from the sample, there were no specialists.

5.2.3 Results showing OHISA support of the Green Economy

To get an overall picture of OHISA and the businesses it comprises of the researcher not only asked about the plants that they sold but also who their customers were. In Chapter 1, the researcher asked the question as to which factors would result in business practice changes towards the environment e.g., was it weather patterns, legislation / SDGs, pressure from their customers or resource depletion. One of the study objectives (Study Objective 2) from Chapter 1 was how does OHISA contribute towards the green economy? Apart from the plants that are produced and sold, do the people who support the industry, the customers influence the businesses and their environmental attitudes or policies? The researcher had to determine, from each business, who their customers were to be able to show how OHISA is or is not working towards the green economy as reflected in Table 7.1. The following five figures (Figures 5.3 to 5.7) show graphically the different customer groups of OHISA participants. Different customers have different objectives according to their own policies, beliefs, attitudes towards the environment and business strategies and it is how these criteria affect their purchasing power of plants. The customers can be seen as advocates or obstacles for the OHISA (Research question 5).

5.2.3.1 Consumers or general public

The first customer group investigated was consumers which form part of the general public who buy plants for their garden and home to beautify it, or to encourage wildlife such as birds and butterflies into their garden, thus promoting biodiversity or to grow their own edible vegetables and fruit. They usually would describe gardening as a hobby.

Figure 5.3 shows that the growers have very few consumers as customers compared to the garden centre retailers where most of their customers are consumers.

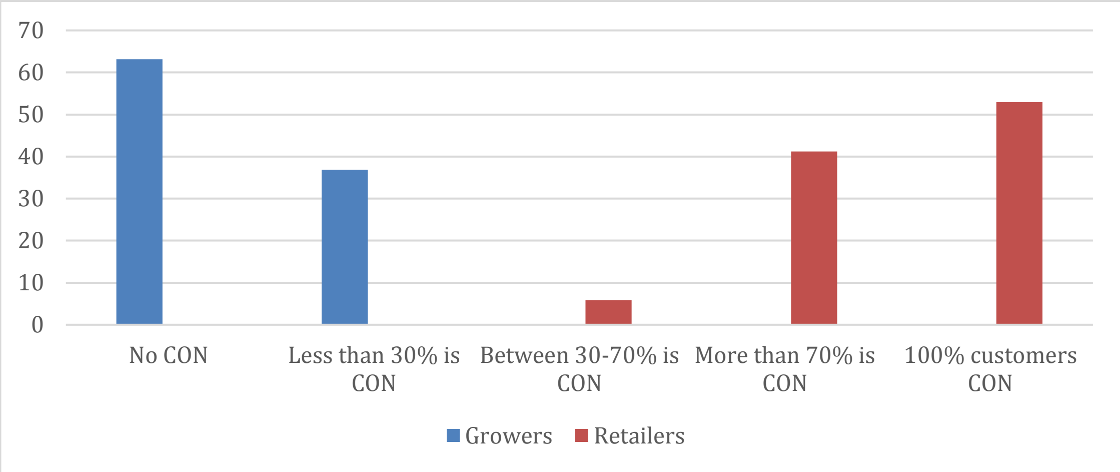

Figure 5.3: Percentage consumers (CON) as part of the customer base

Following on from the question in the questionnaire related to categories describing customers which is shown in the graphs (Figure 5.3 to 5.8) was the following question which relates to Research Questions 5 and 8 :

Have you ever been pressurised by a customer to be environmentally sustainable?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, give the details:

Some of the relevant answers in response to this question, are documented below:

- Business 3: “To stop supply of overly dangerous pesticides.”
- Business 34: “Customers asking for more environmentally friendly fertilizer and pesticides” and “watering saving systems”
- Business 7: “A few years ago we had quite a bit of pressure on “Roundup”, which we subsequently took off our shelves.”
- Business 19: Customers complained about the sale of “Roundup” and “Ridder.”
- Business 35: “Pressure from customers to stock more indigenous plants and less chemical insecticides and fungicides.”

From the interviews and the questionnaire, it was noted that consumers are most concerned about the harmful chemical pesticides that they have heard about in the media such as “Roundup” and yet the active ingredient which is in other products is not targeted as frequently (Business 27 and 13). This pesticide was removed from the shelves of two garden centre retailers due to pressure from consumers (pers comm, Business 7 and Business 27).

Two other garden centre retailers removed certain chemical fertilizers e.g., superphosphate from their shelves, not at the request of customers but because they believed environmentally it was the right thing to do, again referring back to Research question 8 and the positive contribution industry role-players make. Corresponding to this, the customers show their shopping preferences by increasing their purchase of organic rather than chemical pesticides and fertilizers.

During the drought periods and the implementation of water restrictions, especially in the Western Cape, both the growers and garden centre retailers had to get exemptions from local Government with regards being able to water their plants.

- Business 26: “During the water restrictions there was a big focus in the Cape on water and we would have pressure put on us to use very little water, which is obviously not possible. If a staff member was irresponsible with their water use it was highlighted very quickly.” “We were also asked, “How do we look after our water sources?”
- Business 29: “Customers very aware of water use and conservation”

At this time, it was the consumers who encouraged the garden centre retailers to change their product mix to include more water saving products for their gardens and household (pers comm, Business 41).

- Business 12: The use of plastic planting bags and plastic pots was also of concern to the consumers, thinking that they might fall into the “*single use plastic*” category
- Business 16: “Do you recycle black planting pots and thankfully we do.” “Also, we are sometimes criticised for importing products”
- Business 27: “Main focus of customers is around plastic pots and recycling them”.

Many other garden centre retailers and growers have a return and reuse policy for the pots and even the plastic bags if they haven’t been damaged. Even the sale of plants in polystyrene trays has decreased over the years but sometimes the growers still use them to grow their smaller plants e.g., 595, 200 or 128 trays.

- Business 19: “Customers did not like buying their seedlings in Styrofoam trays and we made a Business decision in January 2021 not to sell seedling in these containers due to the challenges of trying to recycle them”.
- Whereas Business 25: “sterilizes and reuses polystyrene trays.”

The details of this will be elaborated upon later in this chapter where the results of the waste category of the questionnaire and informal interviews are discussed.

Another pressure that the consumers place on garden centre retailers and even growers is the composting (disposal) of non-saleable plants whether it be because they are at the end of their season, or they were a poor plant - customers ask why they can’t be donated to charities or planted in places that need greening.

- Business: 13, 16, 35 reuse the soil from non-saleable plants in garden beds.

Some of the garden centre retailers commented that there was a request from their customers for them to stock a wider variety of indigenous plants (Business 35) and rather support local suppliers (Business 7 and 16).

As recorded, the general public (consumers) are aware of sustainability issues and do ask the retail garden centres questions about the plants and products that they sell and the packaging thereof.

- Business 11: “there is a big move towards environmental sustainability, and many people take this very seriously.”

5.2.3.2 Government

Another group of purchasers of plants from growers and garden centre retailers was the government, which included municipalities and government departments.

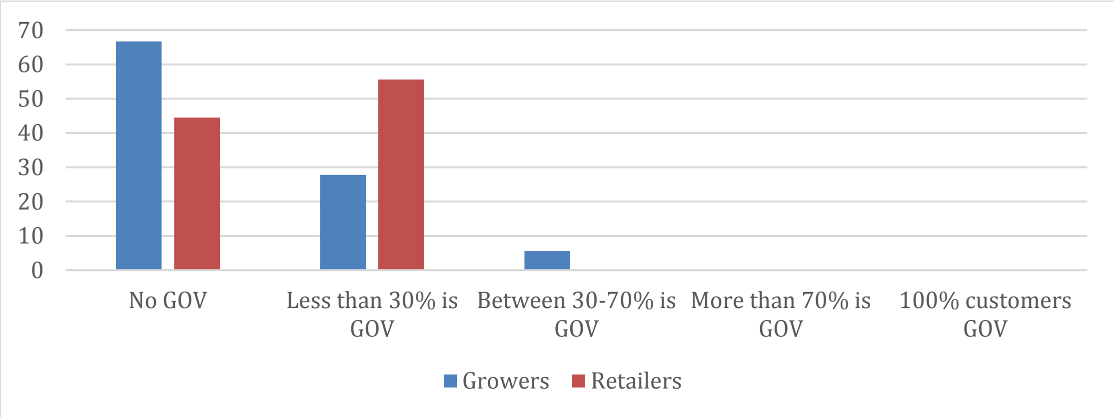

Figure 5.4: Percentage government (GOV) departments as part of their customer base

Figure 5.4 shows that very few government departments are customers of either the wholesalers or the garden centre retailers. When asked why during the informal interviews, the growers said there is often a third-party involved and government department have their own nurseries and growing operations e.g., Johannesburg City Parks nurseries and the Botanical Gardens nurseries.

5.2.3.3 Landscapers

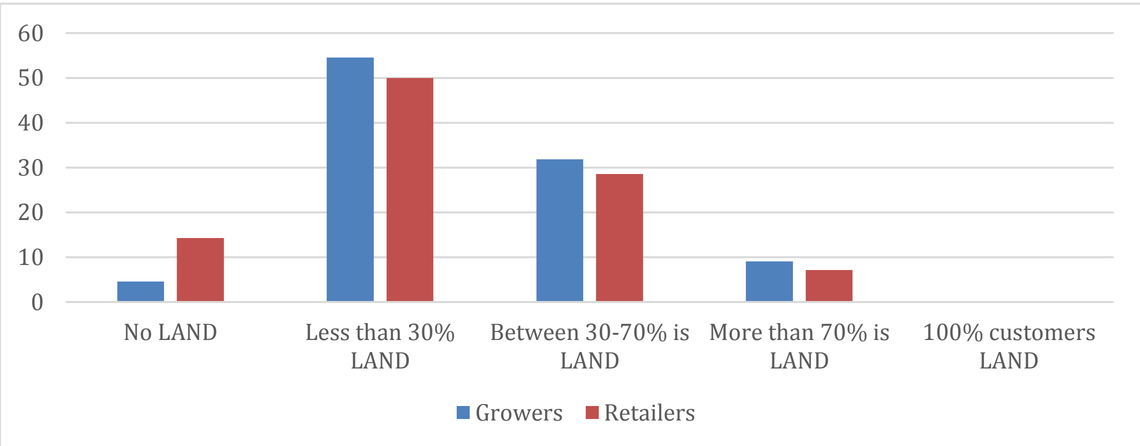

Figure 5.5: Description of the growers and garden centre retailers' customers – landscapers (LAND)

The number of landscapers frequenting both growers and garden centre retailers is very similar. Neither growers nor garden centre retailers supplied exclusively to landscapers (Figure 5.5). During discussions with garden centre retailers and growers, landscapers seldom placed any environmental-related pressure on them as they asked more specifically for certain plants of specific sizes and prices. During the drier periods it was noted that there was a move towards more grasses, succulents, and low maintenance plant varieties.

5.2.3.4 Box or chain stores

The next customer category to be investigated was box or chain stores (Figure 5.6). These stores usually have plant sections within their retail store, but they also have many other sections e.g., food, hardware, paint etc. Many of these stores form part of larger conglomerates or businesses with many interests and often they have international investors which encourage them to conform to global norms and standards.

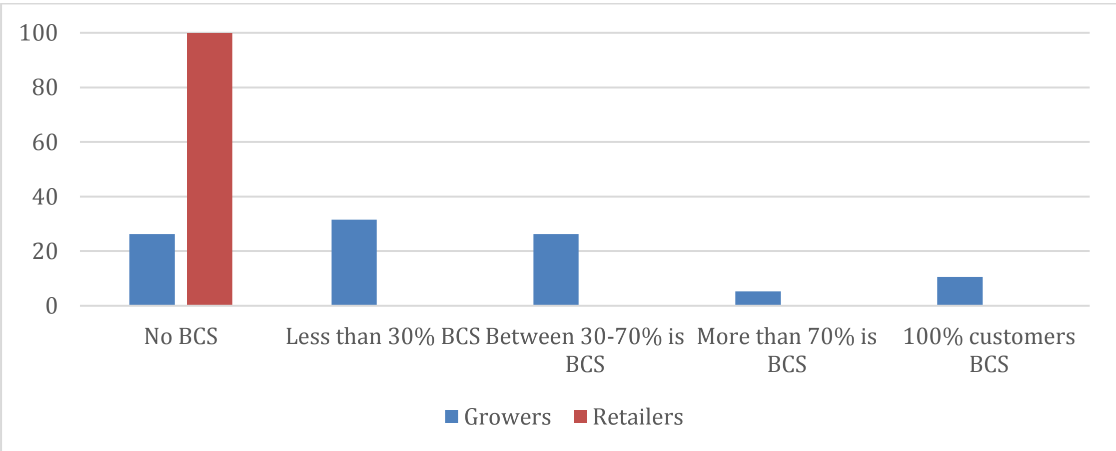

Figure 5.6: Percentage box or chain stores (BCS) as part of your customer base

One of the reasons that this question was asked to growers and garden centre retailers is that the researcher was trying to determine what might have motivated the change towards environmental awareness and documentation or adoption of certain strategies towards sustainability. During the informal interviews, it was noted that the box and chain stores with a more corporate identity tended to stipulate the terms and conditions of supply with regard to environmental and social sustainability (Business 14, 15 and 34).

- Business 14 stated that “chain stores have all been pressurised to reduce their carbon footprint, get rid of plastic and work towards the GAP / Farming for the Future principles.”

These supply regulations would have to be adhered to and thus strategies such as Global Gap (see section 2.4.1 and 6.1) and Farming for the Future (see xx – Definitions of terms) were promoted. Figure 5.6 indicates that no garden centre retailers have box stores as customers while growers do.

5.2.3.5 Wholesalers or other growers

Do growers, supply plants to other growers? As can be seen from Figure 5.7, there is not a high percentage that do, but it does happen. During the interviews, the growers mentioned that often if they are specialised growers or their farms are not close to many garden centre retailers, then they sell their plants to other growers for better distribution and sales opportunities. Even a few garden centre retailers supply plants to growers, but this is usually when the retailer has found a few speciality plants that they would ask the grower to propagate for them.

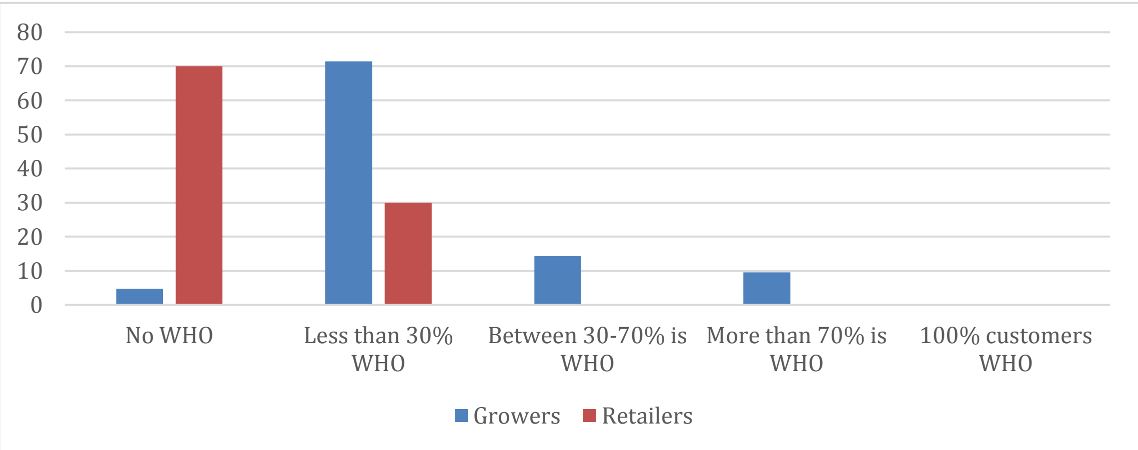

Figure 5.7: Percentage wholesalers (WHO) as part of the customer base

Examples of growers buying plants from other growers are shown in Figure 5.7 are:

- one grower will buy from another grower a product they can resell to retail garden centres which the first grower doesn’t supply e.g.,

- Business 23, 25 and 37 have ideal growing conditions for particular plants and they grow them and then sell them to Business 14,15 and 36 who are also growers in different regions but have greater distribution opportunities in different provinces or
- or grower X buys from grower Y, smaller plants (4l or trays) or plants on special and *"rebags"* them into larger containers, grows them on and then when the plant is larger, they sell them for a profit to retail garden centres
- Business 33 buys from Business 26 who grows on and sells to retail garden centres

Figure 5.8 shows that more garden centre retailers have been pressurised to become more environmentally sustainable than growers, and this the researcher believes is reflected in the study participants' customers.

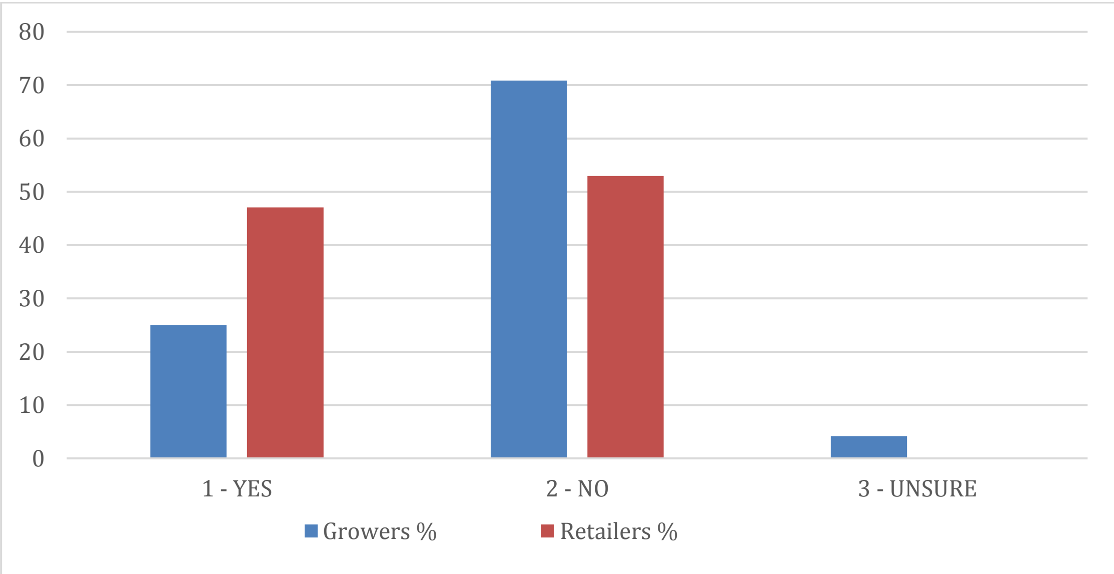

Figure 5.8: Have you ever been pressurised by a customer to be environmentally sustainable?

Considering the above information, the researcher noted that the growers and garden centre retailers have changed some of their business practices to meet the demands of their customers. These aspects will be discussed in more detail under the respective factors, e.g., pesticides, fertilizers, water, energy, growth media and waste. Other business practices were already in line with a sustainable environment in mind, and it was further investigated if the reason for this was to adhere to legislation or because of environmental awareness or business practices that are known to work as they are in tune with nature, e.g., biomimicry or as Business 28 recommends, *"rewilding open spaces that are not under shed, tunnel or used to promote indigenous fauna and flora."*

- Business 11 did caution the researcher about "green washing e.g., promoting and marketing plants and products which have reduced environmental impacts when maybe it hasn't been proven, rather prove and implement, then boast about it."

One of the aims of the study (Study Objective 2), was also to highlight the positive contribution or changes that OHISA has made towards the environment and after identifying these, make it easier to share these with their customers.

Following on from the influence that the various customers of OHISA have on the environmental practices of the business, is to investigate the environmental awareness, knowledge, attitudes, and practices of the participants in the study.

5.3 Environmental awareness and the influence of business practices on the environment

In keeping with Figure 5.1 (adaption of the KAP model), the questions from the "environmental awareness" part of the questionnaire are divided into knowledge related questions, attitude towards environmental issues and impact questions and lastly, practices that the growers or garden centre retailers implement with regards to environmental problems and sustainable development.

In this second part of the questionnaire, the researcher highlighted certain global and national environmental issues which are a result of climate change, global warming and population growth as mentioned in the literature review. The purpose of these questions was to determine from the participants which environmental factors they felt contributed to challenges within the industry as well as those industry practices which result in environmental problems. From the hierarchy of the answers given, the researcher was able to cluster the factors and form associations which resulted in easier data analysis per factor.

5.3.1 Knowledge questions

The following questions are related to the participants knowledge of environmental issues, impacts and sustainable development:

To get an understanding of environmental knowledge and investigate Study Objective 1 and Research Questions 1,2 and 3, the researcher used international goals and agendas to establish environmental knowledge. Similarly, national acts (legislation), strategies and plans which were drawn up in accordance with international goals have been used for the same purposes.

Knowledge question 1: "Which of the following general environmental declarations or legislation that apply to the ornamental horticultural industry are you aware of":

These results are shown in Figure 5.9 (international goals) and Figure 5.10 (national goals).

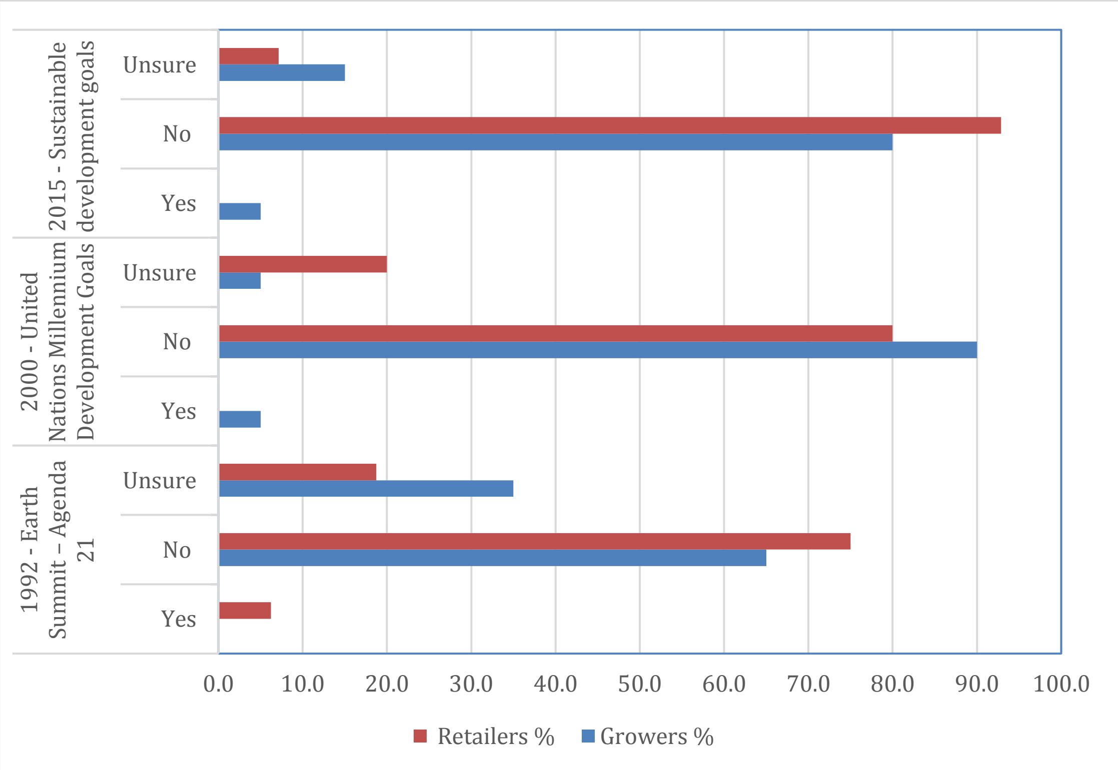

Figure 5.9: Awareness of International Environmental Goals, Plans and Strategies by participants

The combined results of the growers and the garden centre retailers (Figure 5.9) reflect that in 2021, of those Ornamental Horticultural Industry of South Africa members who participated in the study:

- 70% did not know about Agenda 21 which was an action plan towards sustainable development put forward by the United Nations and subscribed to by many countries including South Africa in 1992
- Only 5% of the growers had knowledge of the Millennium Goals
- 86.5% were not aware of the Sustainable Development Goals which were published in 2015 as a "blueprint to achieve a better and more sustainable future for all by 2030" (United Nations, 2015).

From this it was noted that the knowledge of the participants of international environmental goals was poor.

In response to the global goals mentioned above, the South African government formulated and started the implementation of the following:

- 2011 – Green Economy Accord (National – South Africa) (Economic Development Department, 2011)
- 2012 – National Development Plan (National Development Plan, 2012)
- 2015 – Vision Summit 2030 (Buti, 2017)
- 2019 – National Climate Change Adaptation Strategy (Republic of South Africa, 2019).

"South Africa is the third most biodiverse country in the world and home to over 95000 different species" (https://biofin.org), and to be able to protect and conserve the natural resources and heritage of the country, the following legislation was promulgated and is regularly reviewed and updated:

- 1983 – Conservation of Agricultural Resources Act (CARA) (Act No. 43) Updated in 2013 (South African Government, 1983b)
- 1998 – National Environmental Management Act (NEMA) (Government of South Africa, 1998)
- 2002 – Resources Development Act (Act No. 28) (Government Gazette of South Africa, 2002).
- 2004 – National Environmental Management: Biodiversity Act 10 of 2004 (Government Gazette of South Africa, 2004)

The knowledge of these national plan, strategies, and legislation by the industry role players represented by the participants in the study is shown in Figure 5.10 and 5.11 below:

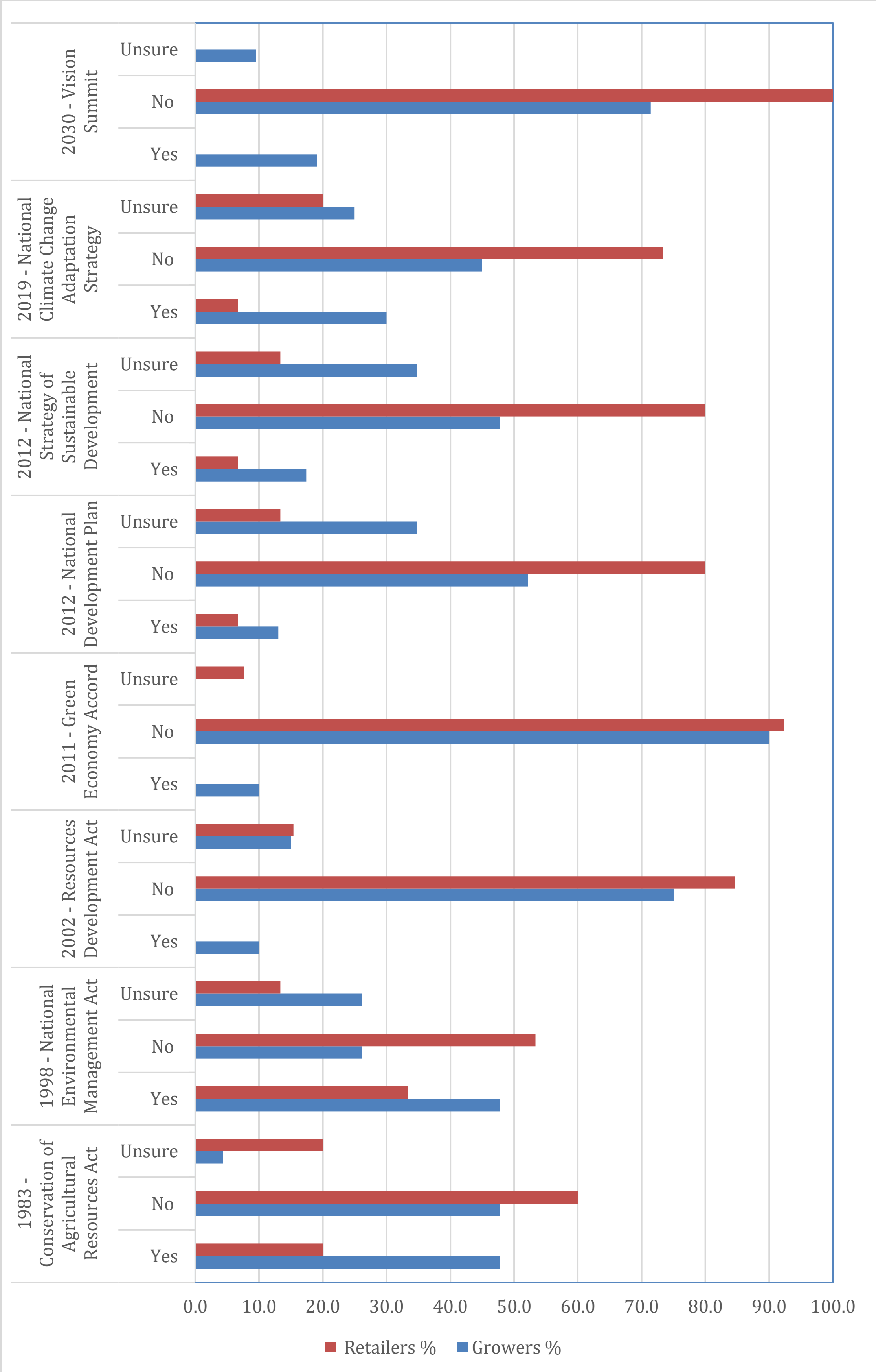

Figure 5.10: Awareness of National Environmental Acts, Plans and Strategies by participants

As can be seen in Figure 5.10, the Conservation of Agricultural Resources Act (47.8% growers and 20% garden centre retailers) and the National Environmental Act (47.8% growers and 33.3% garden centre retailers) are the best known by the participants. These Acts can indirectly influence the business if they are contravened. The environmental strategies, plan, accord etc., which the government has developed in response to being signatories to international goals and agreements are less well known, even though they are related to the industry and environmental and human well-being.

Some of the results from above (Figure 5.10) were then compared (Figure 5.11) with the awareness of legislation which has a direct impact on businesses within OHISA and these are the Plant breeders' Right Act (2018) and Plant Improvements Act (2018).

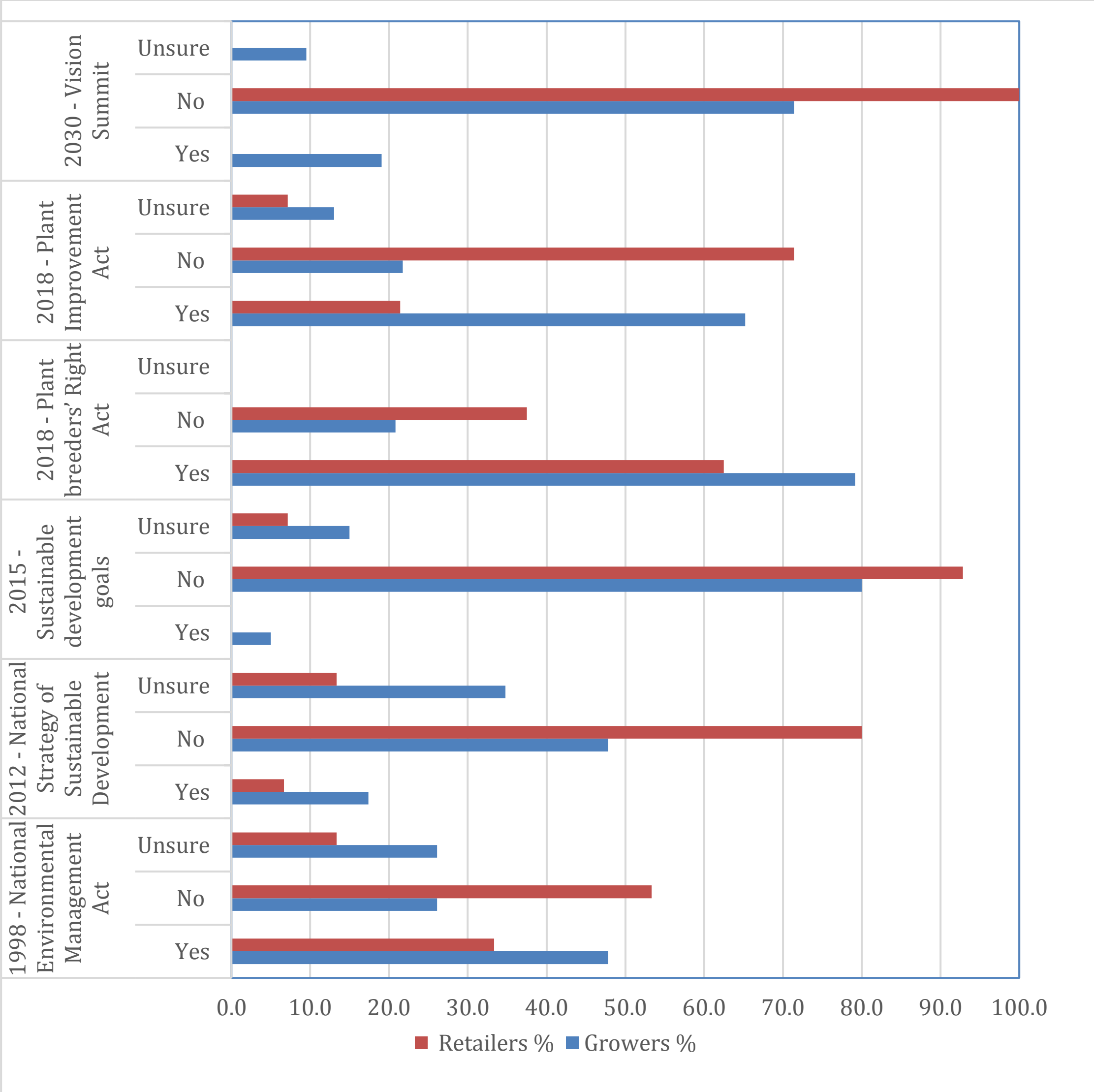

Figure 5.11: Comparison of the most appropriate Acts and Goals for OHISA

As can be seen, the legislation which directly influences the industry's ability to do business e.g., breeding, importing, and selling different plant species, including the Plant Breeders' Right Act, Plant Improvement Act and to a lesser degree the National Environmental Management Act are better known as they affect short-term profitability and plants that are produced and sold by the participating businesses. This compares to the Sustainable Development Goals and the strategies that South Africa has in place for the achievement of these goals, past and present, such as the National Strategy of Sustainable Development and Vision Summit 2030.

The next question related to knowledge and Study Objective 2:

Knowledge question 2: "Are you aware of the usage of the following factors influencing your business's environmental performance? (Number of participants of total n=41)

Table 5.2: Knowledge of natural resource usage in terms of products by participants

	Yes	No	Unsure	Not answered
Electricity consumed	40	0	0	1
Water usage	39	1	0	1
Fuel consumed	37	2	2	0
Fertilizer usage	34	5	1	1
Waste generated	32	8	0	1
Growth media consumed	31	7	1	2

As can be seen from Table 5.2 most of the participants are aware of the usage of electricity affecting their business (n=40). This is followed by water (n=39), then fuel (n=37). As recorded, the knowledge of fertilizer usage, waste generation and lastly growth media consumed was less well known. The growth media response was poor because many garden centre retailers do not use growth media or use so little that it was a negative or no response. This will be explored later in the results pertaining to growth media specifically.

The impacts of climate change, environmental degradation and natural resource shortages affect the behaviour of the members of OHISA. The graph (Figure 5.12, which pertains to Research Question 6) shows how the participants in the study perceived the environmental changes (which affect availability of resources both in quality and quantity), impacted their businesses.

Knowledge question 3: "To what extent do you think each of the following environmental impacts could negatively impact your Business with regards to your plant production and sales".

Assess these using the following criteria, no negative impact, moderate negative impact, very negative impact and not applicable in terms of water shortages, growth media shortages (e.g., topsoil, peat), energy shortages (e.g., coal, oil, electricity), waste generation, local air pollution and soil contamination.

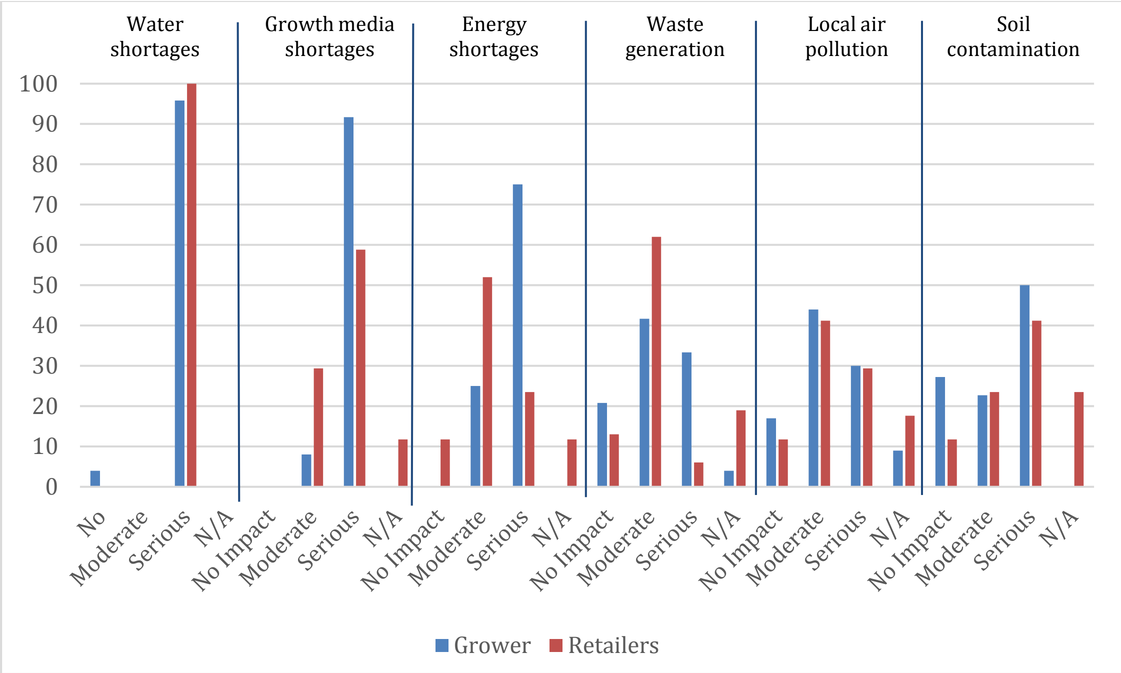

Figure 5.12: The Environmental Impacts that Affect the Industry (%)

A lack of water has the greatest impact on both growers (95.8%) and garden centre retailers (100%). There was only one grower who said that this did not affect him, as he specialised in succulents.

Growth media shortages affected growers more so than garden centre retailers. It must be noted that the researcher did not expect many garden centre retailers to complete the growth media section part of this question and yet they did. It was in discussion with them that the researcher found that organics (growth media) makes up a large proportion of their sales, thus this affects their bottom line if there is a shortage.

Energy shortages affects most businesses and those that said a lack thereof has no impact or it is not applicable are using solar energy to generate electricity.

The impact of waste generation ("*the accumulation of old plastic grow bags*" – Business 40), local air pollution and soil contamination was variable although all three impacts did affect the participants in the study but to different degrees.

5.3.2 Attitude related questions

The following questions from the "environmental awareness" part of the questionnaire are related to participant's attitude towards environmentally friendly behaviour and a willingness to change towards sustainability. These are used to explore Research Question4 and 8 which relate to Study Objective 2:

Attitude question 1: "Assess the importance of the following motivations for an environmental management policy where environmental management is defined as the methodical manner to find innovative, practical and sustainable ways for saving water, energy, and materials, while reducing detrimental environmental impacts such as pollution."

The detailed results of this question are tabulated in Table 5.3 and provide a summary of the attitude of the participants with regards to environmental issues and what the strongest motivations for change could be.

Table 5.3: Importance of motivations for an environmental policy

		Not important	Moderately important	Very important	Results combine as %
Prevent or regulate pollution	Growers	0	17	83	87.5
	Retailers	0	8	92	
Improve your relations with regulatory authorities	Growers	13	42	46	29.5
	Retailers	20	67	13	
Selling plants which have minimal environmental impact	Growers	0	17	83	77
	Retailers	0	29	71	
Improve the environmental image of your business	Growers	4	29	67	70
	Retailers	0	27	73	
Create cost-savings in terms of inputs	Growers	0	13	87	77
	Retailers	6	27	67	
Cost savings in terms of waste management	Growers	0	18	82	76.5
	Retailers	8	21	71	
Other (please specify)	Growers	0	0	0	0
	Retailers	0	0	0	

The combined results from this question show that the participants feel that the most important reason to have an environmental management policy is to:

1. "*Prevent or regulate pollution*"
2. Then both equally important are, "*selling plants which have a minimal environmental impact*" and "*creating a cost saving in terms of inputs*" would be the second most important reasons followed very closely by
3. "*Cost savings in terms of waste management*" then
4. "*To improve the environmental image of your business*" and the reason which would cause very little motivation was to "improve regulations with regulatory authorities".

Two participants included the following as other reasons to motivate the writing and implementation of an environmental policy:

- Business 29: "to improve overall business operations"
- Business 34: "zero waste, sustainable supply chain products, climate change and energy, power up for less and keeping suppliers accountable."

These answers separated out into reasons by the growers and reasons by the garden centre retailers, does show a slightly different result for the growers with them highlighting:

- "Create cost-savings in terms of inputs"
- "Prevent or regulate pollution" and "Selling plants which have minimal environmental impact equally"
- "Cost savings in terms of waste management".

Whereas the most important reason for the garden centre retailers is:

- "*Prevent or regulate pollution*"
- "*To improve the environmental image of your business*".

This was followed by the same hierarchical sequence as the combined results:

- "*Selling plants which have a minimal environmental impact*"
- "*Creating a cost saving in terms of inputs*".

The next question related to willingness of the participants to change their business practices towards the environment and more specifically natural resource use.

Attitude question 2: “Do you think you can reduce your consumption of the following natural resources and if yes, give an example:”

Table 5.4: Possible changes in the consumption of resources

	Yes - %	No - %	N/A - %
Coal	22	15	61
Electricity	80	17	2
Growth media	20	68	7
Water	73	24	0

Most of the participants said “yes” with regards to electricity usage by converting to solar power, and water usage by implementing better rain harvesting ideas, recycling water used and installing drip irrigation. All the above aspects will be explored more thoroughly in the individual sections relating to the specific factors.

5.3.3 Practice related questions

One of the ways of applying the KAP model to a business is to develop environmental policies which give background to the problems and provide practical solutions and guidelines to solving them.

The following questions are from the “environmental awareness” part of the questionnaire are related to participant’s practice demonstrating their possible contribution to the green economy and sustainable natural resource management which corresponds with above and aligns them to Study Objective 2 and Research Question 4 and 8:

Practice question 1: “Does your business have a written environmental management policy?” **Yes ☐ (1)** **No ☐ (2)**

Practice question 2: “If yes, has your business implemented this environmental management policy?”

Practice question 3: “If no, has your business considered introducing an environmental management policy?” **Yes ☐ (1)** **No ☐ (2)**

When developing a policy, use could be made of the information below to give reasons for the policy development e.g., due to the global energy crisis, global warming, climate change, legislation, cost-saving etc. Within OHISA, Table 5.5 shows the results of the research conducted in 2021 regarding the responses by the participants to their involvement in policy development.

Table 5.5. Policy Needs and Usage within the Industry

	Have environ-mental policies	Have applied environmental policies	Wish to have environmental policy	Have no need for an environmental policy
Growers %	34.8	50.0	55.6	9.6
Retailers %	11.8	50.0	41.7	46.5

From Table 5.5 only 34.8% of the grower participants in the study had environmental policies and of these only 50% apply them. Fewer of the garden centre retailers had an environmental policy (11.8%) and only half of those who had one, used it. This indicates that the development of environmental policies for the industry are essential, and they need to be tailored towards the industry members for ease of application and operation so that these numbers can increase.

The reasons that 41.5% the businesses indicated that they not having written policies are similar to those mentioned by the following participants:

- Business 3: “smaller companies, management have discussions and an understanding of what is happening so have verbal policies and not written”
- Business 12: “There are only two decision-makers, no policies are necessary.”

The next “practice question” from the environmental awareness section of the questionnaire highlights some of the ornamental horticultural business practices which have been known to affect the environment.

Practice question 4: Have any of your business activities resulted in the following:

Table 5.6: Business activities that result in environmental damage.

	Yes	No	Unsure	Not applicable
Air pollution				
Soil contamination				
Landscape degradation				
Water pollution e.g., fertilizer leaching				
Chemical spills				

If yes, give an example:

If no, give methods of how you prevent it?

The results of this question are represented graphically in Figure 5.13.

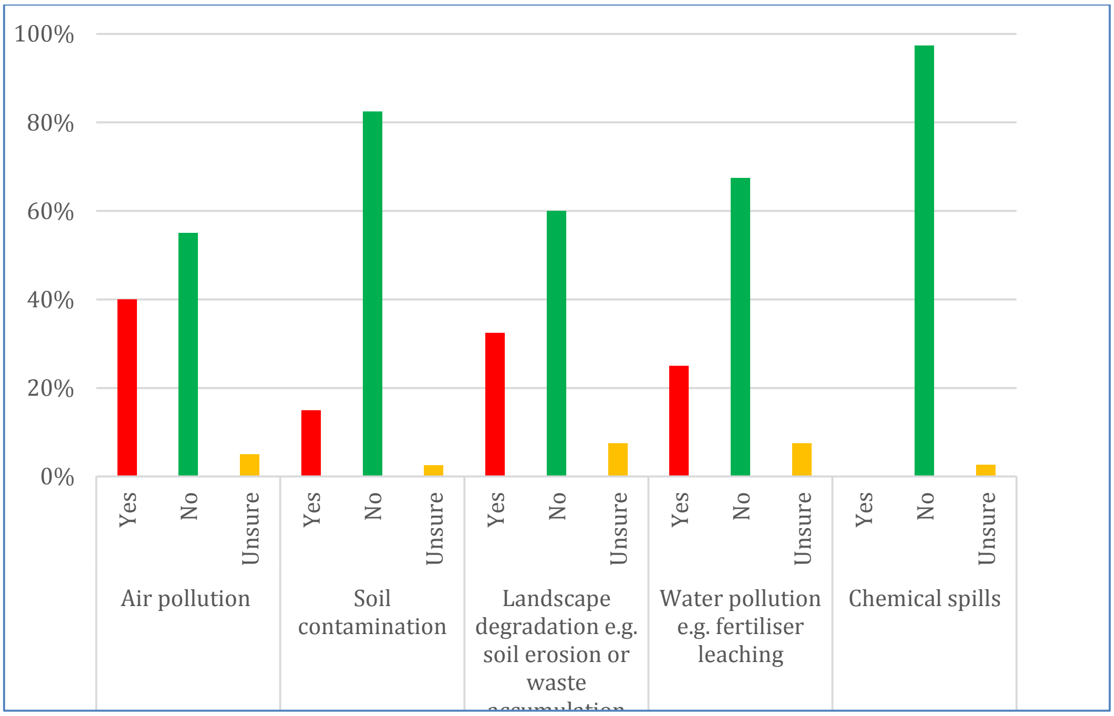

Figure 5.13: The Environmental Impacts the Participants believe the Industry has caused

These results show the industry's business practices towards the environment. The participants stated that the greatest environmental impact is that of air pollution (40%). The research shows that the contributing factors from the industry that cause this air pollution are electricity use (coal mines), pollution from boilers and generators all of which are used to create the optimum temperature and light for the production and sale of plants, provide the right quantity of water via pumps and irrigation for the plants and maintain a functioning office. The transport of plants from suppliers to garden centre retailers and garden centre retailers to consumers or landscapers as well as the use of vehicles on the farms also contributes to air pollution and the growers and garden centre retailers are aware of this.

Some of the quotes from the participants in relation to this question are:

- Business 15, 36 and 38: The industry contributes to air pollution because of *“coal fired boiler for greenhouse heating”.*
- Business 7: Deliveries from suppliers result in air pollution
- Business 18, 26, 40: “fertilizer leaching results in water pollution and water run-off causes erosion”.
- Business 41 admitted that “burning and burying were activities performed that also contributed to air pollution and soil contamination” Even Business 23 said that “they used to burn their rubbish, but they now take it to the dump where it is sorted”.

Landscape degradation, is the second highest negative environmental effect (33%) the growers and garden centre retailers report as contributing to e.g., when constructing a nursery site, building sheds or tunnels, digging dams, paving pathways, building channels for run-off etc. The following are some of the solutions that OHISA participants are implementing to prevent land degradation:

- Business 9 suggested “levelling areas to prevent erosion and replant in open areas”.
- Business 15 stated that *“levelling of new green house and roads causes landscape degradation”*
- Business 18 uses tyres for erosion control.
- Business 23 planted the “*Phylla nodiflora*, groundcover to combat run-off which causes soil erosion”
- Business 36 planted for the same reason, as well as it being water wise
- Business 17: “*our garden centre is built on a slope. We had to use building rubble to lessen the gradient of the slope and some of the soil had caused erosion due to run-off”.*

Only 25% of growers and garden centre retailers (combined total) feel that their business practices contribute to water pollution.

- Business 16, 19 and 29 indicated water run-off from the nursery flows via floodplain or vlei, into the local river
- Business 18 mentioned that *"his borehole was very deep"* which would prevent water pollution as he used minimal amounts of fertilizers and pesticides. He felt that if leaching occurred, it wouldn't reach the water table he sourced his water from.

15% of the participants mentioned that they might contaminate the soil.

- Business 12 wrote that *"they prevented soil contamination and water pollution because all water was captured and recycle within their systems."*
- Business 14 uses soil probes to a depth of 60 cm annually to determine if leaching occurred and if any pollutants are in the soil as a criterion for to be able to supply certain box stores and supermarkets.

The industry has indicated that they have not recorded any chemical spills which they feel could affect the environment.

Solutions to these problems which the growers and garden centre retailers have implemented are recorded in each related factor assessment below and shared with other members in the Best Practice Manual.

The way these practices should be understood, documented, and solved is best described in the words of Business 30: *"all the activities which influence the environment",* as mentioned above, *"have very strict, written policies / procedures to follow. Regular / consistent training is done in this regard."* This highlights again the importance of policies to be written with related procedure documents attached and the inclusion of training shows the necessity for a best practice manual to be created to address the environmental challenges of OHISA.

Once policies have been developed and applied within the business, the above environmental concerns can be minimised and the positive environmental aspects of OHISA can be highlighted and shared with each other, the public, landscapers, and government. This can be done through marketing positive environmental practices and behaviour by OHISA.

Practice question 5: When buying and / or marketing your plants and products, does your business habitually consider informing buyers or consumers of ways you have reduced your environmental impacts?

The examples given by the participants are listed below and answer the last practice question extracted from this section of the questionnaire namely:

- Business 11: Market environmental achievements and sustainable practices but “be careful not to green wash”
- Business 12: “Market the use of organic fertilizers & biological pesticides”
- Business 22: “Use positive environmental strategies as a sales tool and leverage”
- Business 26: “Use marketing to show reduced carbon footprint & give trees to schools”
- Business 8: “Signage, handouts and using social media platforms to advertise environmental business practices”
- Business 13: “Market water wise e.g., mulch & products as often possible” and use sticky labels such as “Local is Lekker”
- Business 16: Uses point of sale “signage promoting pollinator plants”
- Business 34: “Advertise sustainability measures and policies on website and live screens in store”.

The above results give an indication of the knowledge, attitudes, and practices of the participants in the study in relation to their environmental awareness and impacts, natural resource use and sustainable development. By clustering the information from Table 5.2 which focuses on the awareness of the natural resources used in their businesses the indication is that electricity, water, and fuel were best recorded. Table 5.4 asked if they could reduce the use of the factors and similarly water and electricity dominated. Thus, the clustering method shows that energy and water are regarded as very important resources to the industry and should be discussed in greater detail which aligns with the thematic results from the literature review.

In terms of the lack of natural resource availability which most affect the industry, it was shown to be water and growth media (Figure 5.12) which can then be associated with the above, thus making water, energy, and growth media important factors. The researcher also asked about where the industry most affected the environment and the results of Figure 5.13 showed that OHISA contributes mostly to air pollution, again energy generation and fuel usage. Land degradation was the second highest environmental impact of the industry followed by water pollution because of fertilizer usage and pesticide application and thus these factors are discussed later under their relevant key indicators.
At the start of the study, waste generation was seen as a smaller environmental issue but has become more and more of a problem as shown in the results (Table 5.2 and Figure 5.12).

The results from the factors highlighted in the environmental awareness part of the questionnaire (refer to 5.3.1 and Appendix 9) are further investigated and discussed below. This was done in a similar format for each factor where the first few questions relate to the knowledge the participants have of the subject using international and national legislation, their use of natural resources associated with the factor and their general awareness thereof.
Examples of some of the knowledge questions asked were:

- Are you aware of the following resolutions and legislations with regards to energy, water. growth media, fertilizer, pesticide use and waste management?
- What is your energy or water source?
- What type of growing media, fertilizers and pesticides do you use?
- What happens to the excess or leached fertilizers and how do you dispose of empty pesticide containers?

The next section of results investigated their willingness to reduce their dependency on the factor and change their business practices to become more sustainable.
Examples of the questions, either using the questionnaire or during the semi-structured interviews were:

- Has your company taken any measures to reduce their use of natural resources e.g., water, coal, peat?
- If your company recycles resources, is it to reduce input costs or gain an income?
- Has your company explored alternative sources of natural resources e.g., recycled water, fog harvesting, energy – wind energy, biomass growth media e.g., coir instead of peat, each with a smaller environmental footprint?

The researcher then investigated their actual business practices in terms of having a policy related to the factor or key indicator namely energy, water, growth media, fertilizer, pesticides, waste and their associated activities. The information obtained was used to collaborate other findings and contribute to the study as a whole as well as develop the manual, Study Objective 4. This was done via the questionnaire, site visits, interviews and documentation studied.
Examples of the practise questions asked were:

- Do you have a written policy on energy, water, growth media, fertilizer and pesticide usage and waste management within your business?
- List a few practices that your business applies to optimise the use of energy, water, growth media, fertilizer, pesticides, and waste that could be included in a best practice's manual.
- Indicate which methods you use for watering, fertilizing, applying pesticides etc.
- Do you reuse products e.g., water, growth media or waste products?
- Which type of fertilizers and pesticides do you use and how do you apply them?
- What type of pesticides do you use, and do you use them curatively or preventatively?
- How do you dispose of the empty bottles?
- Do you recycle any waste products, which and how?

Lastly, the researcher asked the question about the obstacles (Study Objective 3 and related Research Questions 5 and 7) the participants faced in trying to achieve better sustainability within their business, which again demonstrated a culmination of their knowledge, attitude, and practices.

As can be seen from the discussion reflected above in the 5 knowledge questions, 3 attitude questions and 5 practice questions, the use of the KAP model is the golden thread connecting these results.

5.4 Results from the energy related questions, interviews, and site visits

Environmental pollution is a primary concern for most nations as was shown in the literature review (Mack *et al.*, 2019; Wilkinson, Weston and Marks, 2019; Tang *et al.*, 2021), COP26 (United Nations, 2021) and can been seen by the above results. Compounded and contributing to this pollution, is the energy crisis. This leads onto the first environmental factor the industry contributes to negatively, namely energy.

All participants within OHISA who participated in the study mentioned electricity as the factor that they can influence the most. They were aware of the amount of electricity they consumed (Table 5.2) as well as the different fuel sources used to provide this electricity and as well as other fuel sources required within their businesses.

Table 5.7: Electricity and fuel awareness of participants (knowledge question)

	Awareness of electricity consumed %	Awareness of fuel used %	Unaware %	No answer
Growers	95.7	96	0	1
Retailers	100	82	6	0

In the literature review it was explained that some of the natural sources of energy e.g., coal and gas are being extracted and used at the expense of the surrounding environment causing issues such as pollution, climate change and land degradation. The participants were asked if they thought they could reduce their consumption of coal and electricity to decrease the burden on the environment. Their responses are shown in Figure 5.14.

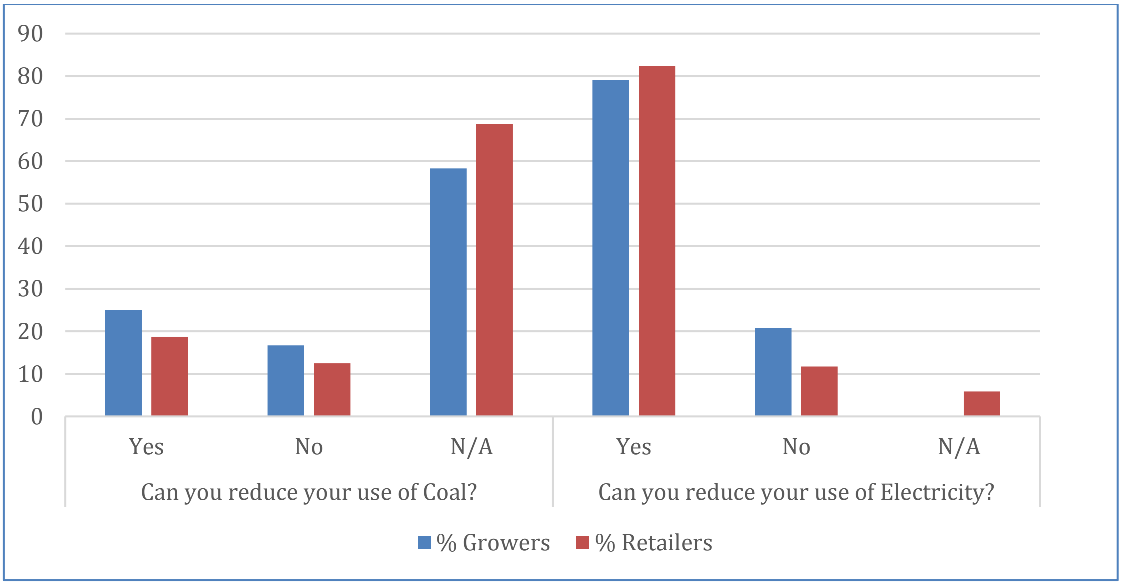

Figure 5.14: Reducing usage of coal and electricity for energy supply

Of the participants 58% of the growers in the sample do not use coal for heating their tunnels (also confirmed during site visits) and of those that do, 25% feel they can reduce it, while 17% feel that they cannot. 69% of the garden centre retailers do not use coal within their business. Of those that do, 19% say they can improve the efficiency of use while 13% say that they cannot (Figure 5.14).

The method that both the growers and garden centre retailers would use to reduce their consumption of coal and electricity would be to add solar power to their energy systems. With regards to their electricity usage, which is supplied by Eskom in South Africa 79% of the growers reported they could reduce their consumption and 21% said that they could not.

- Business 14 mentioned that they had *"scaled down our use of coal by 60% although they still use boilers on overcast days".*

With regards to the garden centre retailers, 82% indicated that they could improve on their electricity usage while 12% could not, with 6% saying that it was not applicable to them as they were already as energy efficient as was possible (Figure 5.14). Solar power was again one of the methods suggested to reduce the use of electricity while the use of LED lights was the another. These results reflect the attitude of the participants towards changing to improve the environment.

The above information provided the researcher with an understanding of the consumption awareness (knowledge) and the willingness to implement change (attitude) of the sampled participants on energy usage and air pollution. The researcher then further investigated this awareness in terms of the sustainable development goals, which can be related to environmental awareness, and the guidelines for energy use stated by the legislation and goals of the country (Figure 5.15).

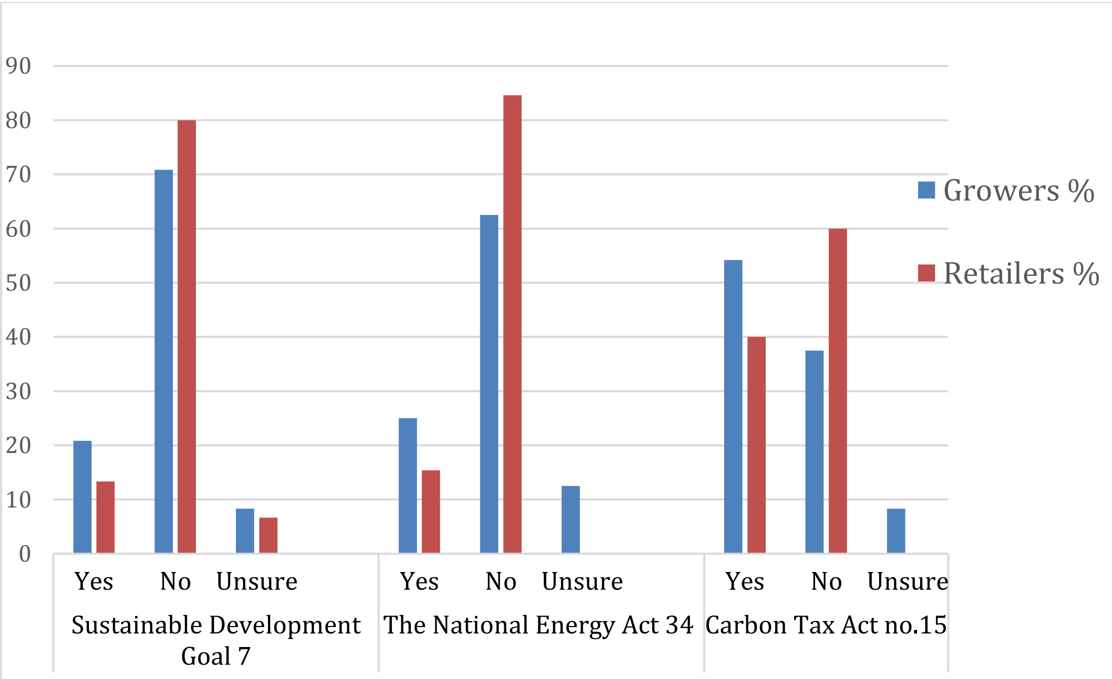

Figure 5.15: Awareness of energy related SDG and laws (knowledge question)

Figure 5.15 shows that most growers (71%) and garden centre retailers (80%) are unaware of Sustainable Development Goal 7. Those growers with awareness of SGD 7, subscribe to "*Farming for the Future"* or "*Global GAP"* principles as they supply plants into food chains and box stores - this was apparent from the questionnaire and interviews.

Another reason would be the age generation of the participants, although it was not asked in the questionnaire, it was observed by the researcher those who answered "yes", were all estimated to being younger than 40 years old.

During the interview one of the participants noted that they were aware of the Sustainable Development Goals as their corporate holding company was having a competition between the different regional and country branches to see who could achieve the highest number of SDGs within their businesses.

The only garden centre retailers who were aware of Sustainable Development Goal 7 were again part of an international corporate and it is part of their *"good business practice journey" (Business 34)*, and the other was a garden centre that is very environmentally focused as was visible during the site visit and from their newsletters.

Only 25% of the growers and 15% of the garden centre retailers were aware of the National Energy Act which states that "diverse energy resources must be made available and the promotion of efficient generation and consumption of must be researched" (South African Government, 2008a). Although many of the others (growers and garden centre retailers) said that they were not aware of the actual act, the researcher found that during the site visits some of the businesses were using alternative sources of energy and others did have energy conservation measures in place as will be shown later in Figure 5.17 and 5.18. This reiterates the triangular KAP model depicted in Figure 5.1 rather than the original linear model where only knowledge caused change in practices whereas here it could be knowledge or an attitude change that resulted in better practices for the environment.

With regards the carbon tax, 54% of the growers knew about it compared to only 40% of the garden centre retailers. The deduction the researcher made from this was that because it had been implemented in 2019 (South African Government, 2019) and publicised in the media shortly before the time of the distribution of the questionnaires so it was fresh in the minds of the participants and that it could also potentially affect their bottom line.

Only 38% of the growers and only 7% of the garden centre retailers had an energy policy (Table 5.8). Having such a policy reflects the practices which the business will adhere to, and of those participants who had policies, 50% of the growers and 25% of the garden centre retailers said they were happy to share them. Of those who did have a policy, it was discovered during the semi-formal interviews that they were verbal rather than written. The development of the best practices manual will assist in documenting the information needed for the policies which will make it easier to share them with staff members and required parties, as well as to monitor their application.

Table 5.8: Energy policies within the sample

		% Grower	% Retailers
Do you have policy on energy usage?	Yes	37	7
	No	63	86
	Unsure	0	7
Yes, willing to share	Yes	50	25
	No	25	50
	Unsure	25	25

While researching the use of energy within OHISA using the different tools such as questionnaires, informal interviews, site visits and documentation, it was noted that the following business practices were in place to optimise energy usage, and these have been grouped into seven categories:

a. Solar Energy

Two of the growers and two garden centre retailers (Businesses 14 and 18 and businesses 2 and 8, respectively) currently have solar panels in place, another has solar geysers, while another is planning to implement a solar system by 2023 (Business 23). This represents 9.7% of those surveyed who have already implemented solar panels in their business.

b. Energy saving methods with regards to watering and irrigation

These are a few of the methods that some of the participants are currently using to save energy:

- Business 22, 32, 26: Variable speed-drives on pumps
- Business 11: *"USDM pumps (alternator attached to water pump) to reduce electricity use"*
- Business 6, 21, 26: Turn off pumps when not in use.

Of the growers in the industry, that answered question 39, "List three practices that your business applies to optimise the use of energy that could be included in a best practice's manual:" 9 of the 23 (39%) have energy saving mechanisms for their pumps as mentioned above while only one of the garden centre retailers (6%) does. It was observed that many more garden centre retailers (29%) used municipal water than growers (5%) which requires no pumping (Figure 5.16). Business 19, 37 and 41 stated that "they saved energy by pumping water into their tanks at night (between 22h00 - 03h00) when the electricity demand was less, and the rate (cost) was cheaper."

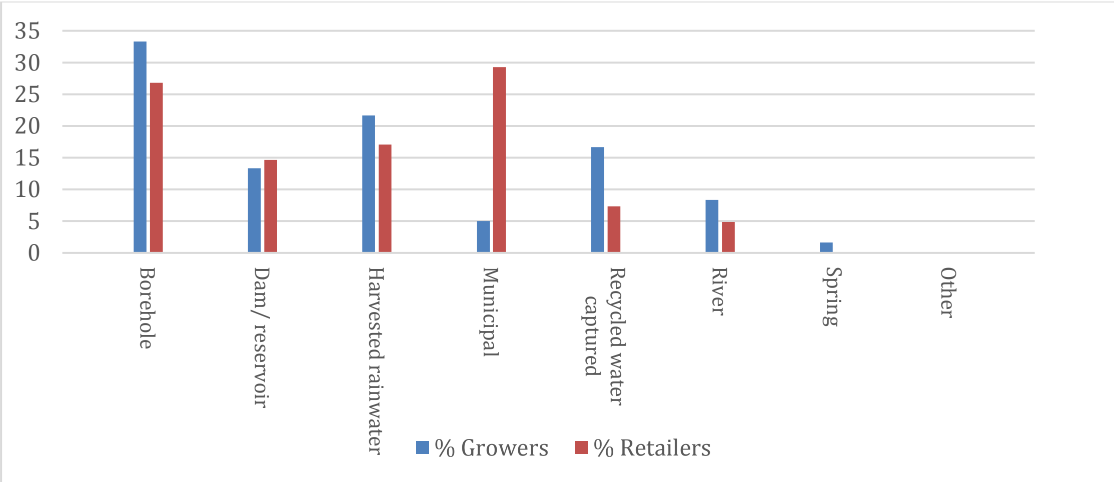

Figure 5.16: Source of water for your business

Five of the growers have designed their irrigation systems such that the water gravity feeds from tanks and dams into the irrigation system (Business 1, 12, 18, 25 and 28) thus using less energy and rather the gradient of the land on which their businesses are situated. Business 25 *stated "that due to electricity problems, they are grateful for the gravity feed otherwise they wouldn't be able to water."*

The sharing of energy conservation ideas via a best practices manual will assist the members to make informed decisions from tried and tested methods from others within the industry.

c. Electrical equipment

A suggestion to make monitoring of electricity use easier was:

- Business 34: Centrally controlled electricity monitoring e.g., meters which measure both electricity used by pumps and associated irrigation as part of a single unit
- Business 23: Meters on Distribution boards

d. Awareness

The key observation both from the site visits and the questionnaire with regards to energy conservation was *"if not necessary do not switch it on"* whether it be lights (Business 26), the sowing or potting machine (Business 37), computers and / or pumps. The garden centre retailers had a slightly higher focus on awareness of energy usage (100%) compared to the growers (95.7%) who participated in the study (see Table 5.7).

e. Equipment

More and more growers are using "*Danish trollies and tail-lifts on their trucks making for easier handling of plants when loading and delivering*" (Business 26), thus decreasing energy expenditure by staff, and using less petrol and diesel for forklifts.

- Business 37 stated: "*mechanisation increased their productivity and reduced their staff number from 120 to 80 e.g., the potting machine* which is only used when needing to fill 50000 - 100000 pots and the use of Danish trollies for transporting."
- Business 22 suggested *"using conveyors for transporting of pots to replace tractors and trailers"* thus also reducing petrol and diesel expenses and air pollution
- Business 36 has upcycled conveyor belting to use as pathways to ease movement of trolleys within the business
- Business 17: The maintenance and regular servicing of vehicles is also a method of energy conservation

f. Lighting

With regards to lighting, only 13% of the growers focused on lighting changes within their business compared to 47% of the garden centre retailers which changed to LED globes, increased use of natural light in buildings (see Figures 5.17 and 5.18). The most popular method used is LED lights (Business 4, 12, 19 and 36) and more recently some garden centre retailers suggested using motion sensors (Business 8 and 34) on lights in low traffic areas to minimise usage.

g. Heating and cooling of greenhouse, tunnels, and sheds

In the literature review, there were international examples given on how to environmentally and economically control the temperature to create the optimum growing and selling condition for plants. Some examples given by South African growers for heating and cooling include:

- Business 38: only heating areas with plants in tunnels
- Business 32: double layer insulation
- Business 8, 14: double layer plastic in tunnels
- Business 22: low energy geyser elements and green house screening to prevent draughts and wind damage to plants
- Business 14: pad and fans for wet walls
- Business 5, 15, 22: painting tunnels white in summer to reflect the sun thus reducing temperatures
- Business 22, 32, 36, 37: using mechanisation in tunnels to open and close sides and roof according to temperature.

The mention was also made of using the warmth of the South African winter sun to heat greenhouses and using misters in tunnels for cooling in summer

h. Scheduling use of energy

Both the growers and garden centre retailers used a variety of scheduling ideas to conserve energy:

- solar heating during day,
- Business 16, 41: only using pumps between 22h00 and 03h00 when electricity is at its cheapest
- Business 1: only using pumps when needed
- Business 9, 32: use timers for boreholes, irrigation, pumps, and geysers

- Business 28: "checking weather patterns and expected rainfall, evaporation rates and cloud cover" thus working with the weather to minimise energy expenditure
- Business 6*: "simultaneous use of hosepipes"* thus only pumping for limited times
- Business 21: "*manually turning on borehole*" – thus only when needed.

There are numerous different energy sources utilised by the growers (Figure 5.17) and garden centre retailers (Figure 5.18) respectively for the functioning of their operations.

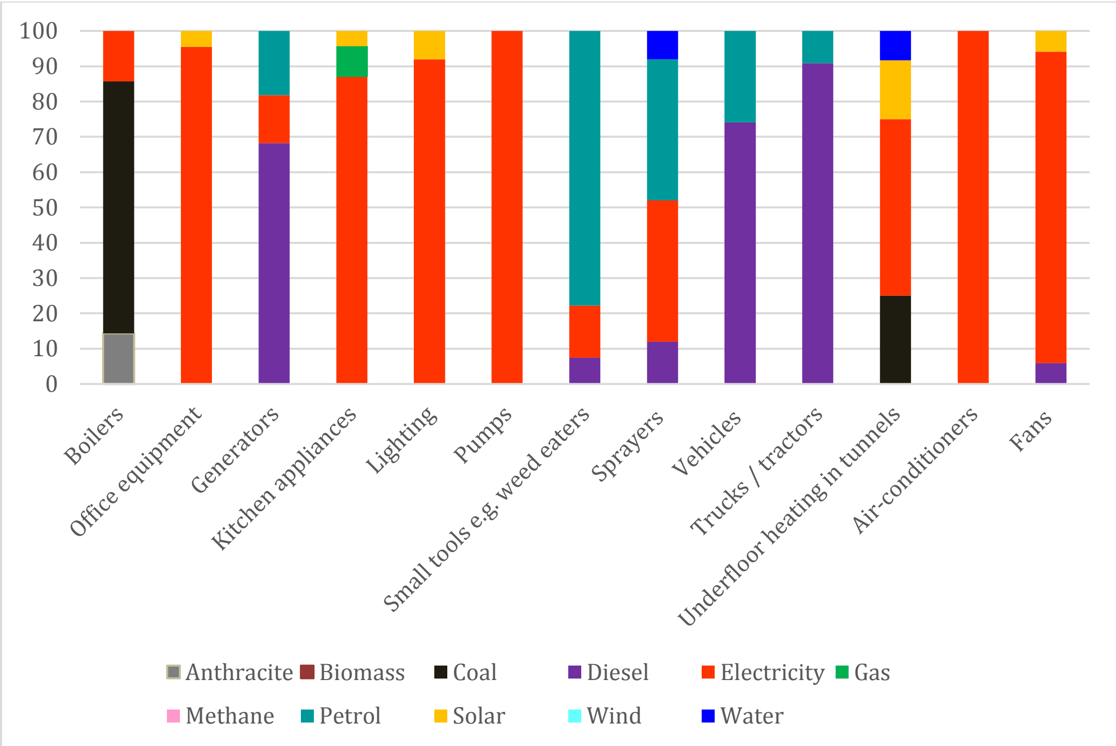

Figure 5.17: Energy sources used by growers

The chart (Figure 5.17) shows that electricity is the most widely used source of energy by the participating growers. They use it for their boilers, office equipment, generators, kitchen appliances, lighting, pumps, small tools, sprayers and heating and cooling both the tunnels, green houses, and the offices.

This is followed by diesel, which is used in their trucks, vehicles, tractors, generators and to a lesser degree small tools, sprayers, and fans. Petrol is also used by their small tools, vehicles, and generators, while very little is used by trucks. Only two (9%) of the growers use gas for their kitchen appliances, with no growers using renewable energy resources such as biomass energy, methane, or wind energy as sources of energy. Business 14 does use an alternative energy source for moving around the farm, namely *"pedal power*" and they have *"bicycles which replaced the motorbikes they once used."* Supervisors at Business 36 thought that using bicycles to move around the farm, not only saved time, energy and caused less pollution than quad bikes, golf carts and tractors but also would keep them healthier.

Some growers use solar power as a source of energy for kitchen appliances, office equipment, lighting, and tunnel fans as well as for warming water to run in the pipes used to heat their tunnels. Of the 6 growers who use boilers for heating their tunnels and green houses, 5 used coal, while one used anthracite and / or electricity*.* According to Business 5, *"these coal boilers contribute to air pollution and boiler ash results in waste accumulation".*

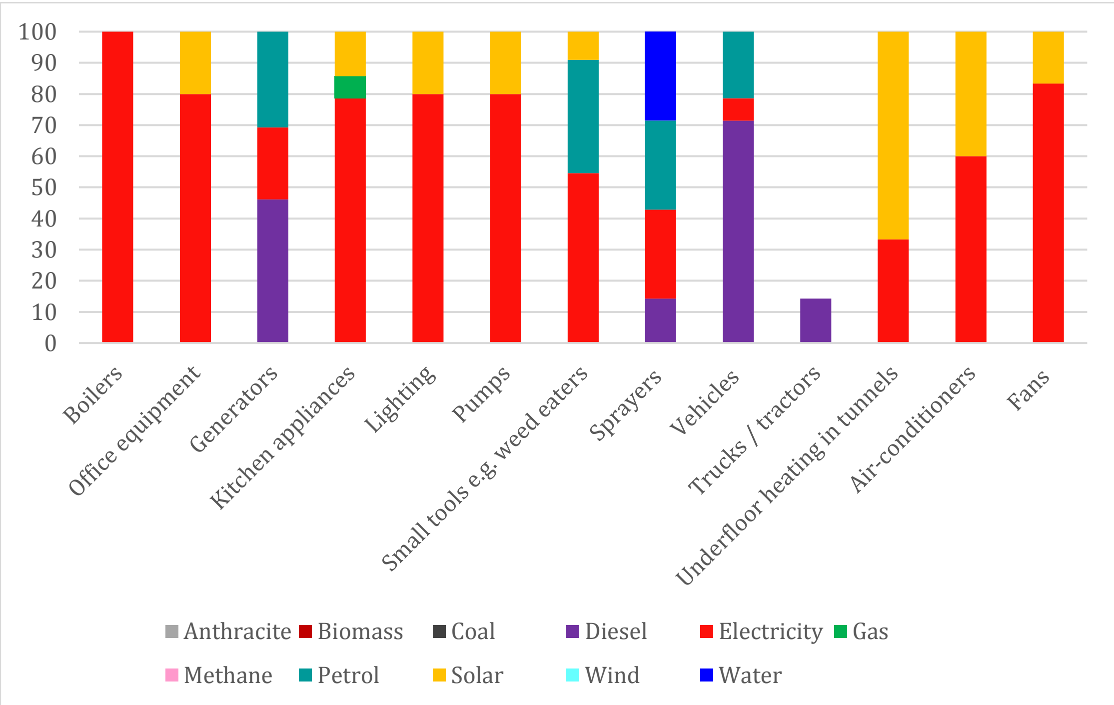

Figure 5.18: Garden centre retailers energy sources and use (%)

The primary source of energy for the garden centre retailers is also electricity, as shown in Figure 5.18. The garden centre retailers that use solar power, do so for more of their equipment than the growers e.g., office equipment, kitchen appliances, lighting, pumps, small tools, heating, air conditioners and fans. Only one uses gas in their kitchen and like the growers there is no use of wind energy, water, methane, or biomass energy as renewable energy resources. One of the garden centre retailers does use a boiler but uses electricity to run it.

From the above it is evident that coal or the use of diesel generators to produce electricity by Eskom is still the most prevalent source of energy used by both the growers and garden centre retailers.

- Business 13: noted that "the use of generators and delivery vehicles contributed to air pollution"
- Business 22 and 24: mentioned that "exhaust fumes from delivery vehicles result in air pollution" and suggested that "better route planning was needed to reduce this."

The researcher asked the participants if they were currently using alternative sources and practices to create the optimum temperature in specific areas for the production and / or selling of their plants (Figure 5.19). This figure shows that although the participants weren't all aware of the National Energy Act, their businesses do have practical examples of its application by using alternative sources and techniques to reduce the need for and use of energy.

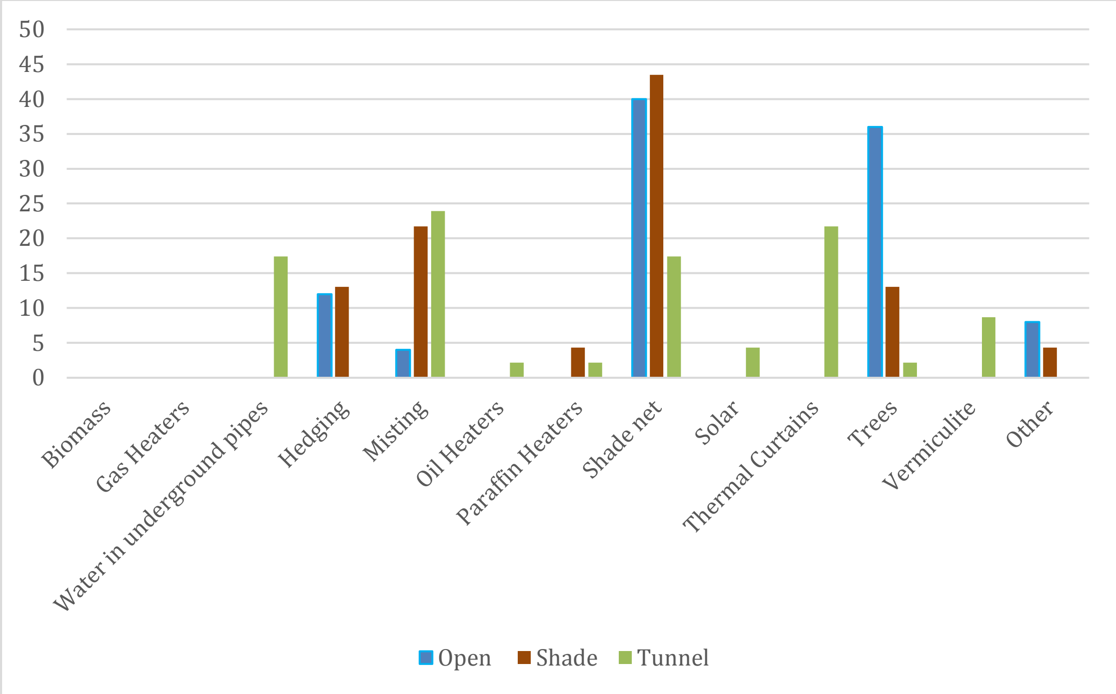

Figure 5.19: Percentage of growers using alternative sources to create optimum temperatures for growing.

- Business 34 stated: "energy saving lights and sky lights for natural lighting as well as motion detected light settings - when no movement in offices or passage, lights are switched off."

The growers use hedging, shade net and trees to provide cooling and protection. This was also observed during the site visits (Business 9, 26). Business 26 stated that they *"planted trees to reduce wind on plants and to help to not blow the water away"* The hedges and trees were planted around the existing shade net structures for protection from wind and frost and to provide a cooler environment ideal for growing plants in South Africa.

- Business 12 and 36 suggested that shade nets reduce water consumption as they reduce transpiration by plants under the nets.
- Business 21 and 36 created berms with excess growth media that would later be used as an extra layer of protection for plants in shade-netting sheds e.g., property fence – viburnum hedge – berm and then shed (Appendix 12).

- Both business 12 and 21 specifically mentioned frost cover as a method to protect plants from the cold in winter and many others do use it too.

In the winter months in the tunnels, piped warm water, oil and paraffin heaters, solar power, thermal curtains (Business 15), and vermiculite were used for heating. Most growers heat from below the plants as the warm air from the heated pipes below the tables or in the flooring creates warm air which rises and stimulates root growth and leaf protection.

In the summer months, shade net and misting were used for cooling tunnels as well as using the tunnel mechanisms e.g., opening roof and side panels to allow the circulation of air throughout the tunnel as hot air rises away from the plants and the cooler air takes its place. Shade net structures are also used to protect the plants from the harsh sun (most growers and garden centre retailers) and hail (Business 22). A few growers even *"white wash their tunnels"* in the latter part of summer to reflect the sun *and "reduce temperature in tunnels"* (Business 14 and 15).

The garden centre retailers predominantly use shade nets and trees to provide an optimal temperature environment for both the plants and their customers (Figure 5.20).

- Business 8 and 19 erected buildings with high roofs to facilitate evaporative cooling mechanisms, therefore, no need for air conditioners
- Business 37: has taller tunnels to promote natural ventilation.
- Business 8 erected permanent screens in open spaces to reduce wind damage to plants.

None of the growers nor garden centre retailers currently use biomass energy, gas, or paraffin for heating.

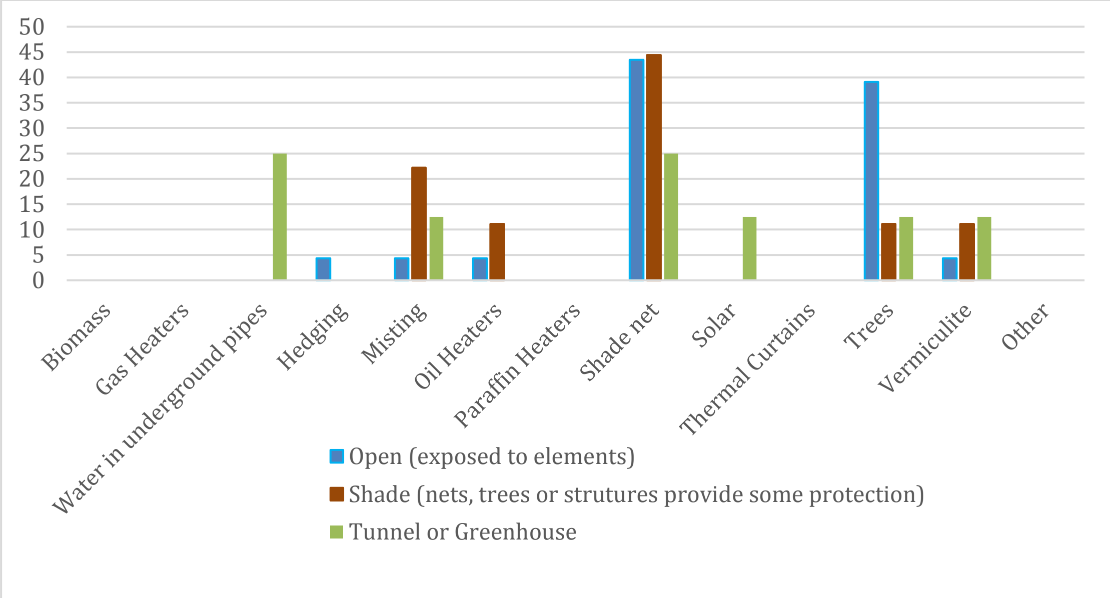

Figure 5.20: Percentage of alternative sources used by garden centre retailers to create optimum temperatures for selling plants

During the study the researcher noted that there were certain obstacles that were preventing participants from using alternative energy efficiently and these are shown in Figure 5.21.

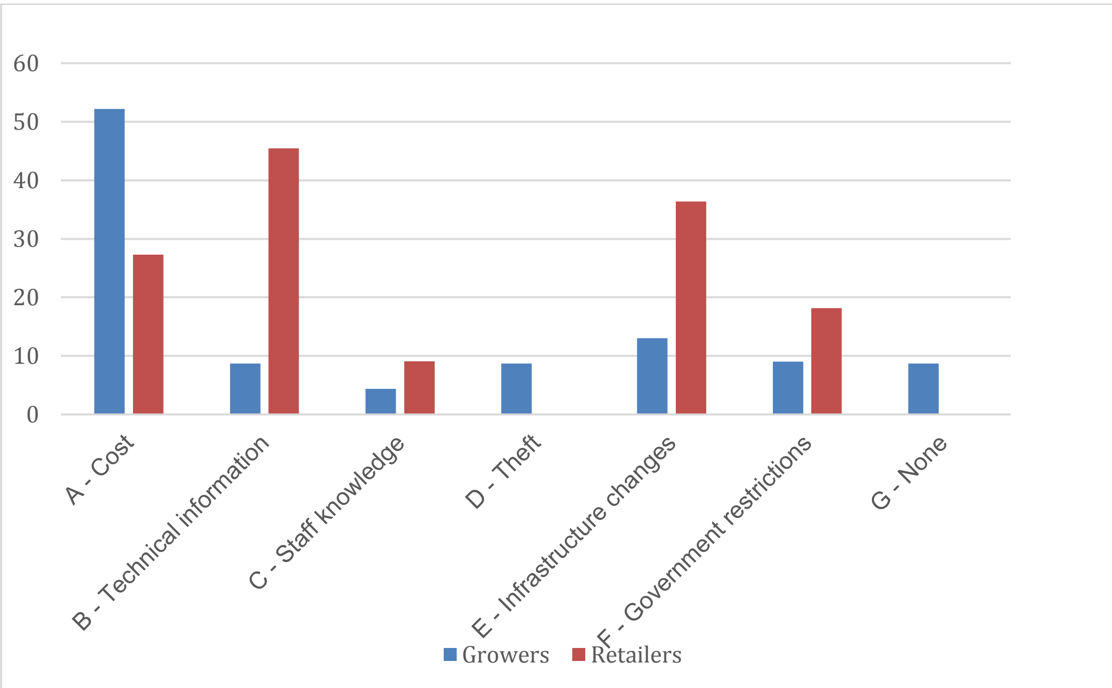

Figure 5.21: Obstacles preventing the participants from using energy efficiently

From the questionnaire responses, energy efficiency and its associated obstacles are of greater concern for growers than for garden centre retailers. All the growers completed the question with two responding that they have no obstacles, as they feel that they are using energy as best possible. Only 65% of the garden centre retailers answered the question.

Cost for growers and garden centre retailers was mentioned as an obstacle. The capital investment to convert to solar power is where the cost for most was involved e.g., Business 24, and 37 have been planning for solar installation for a few years. Apart from this initial cost, growers indicated that theft would, or has, become a threat and thus security would be needed to protect the solar systems on the farms thus increasing the costs. More than one grower had already had their solar panels stolen (Business 22, 26, 28) and security guards shot at twice (Business 22) so wouldn't be replacing the solar equipment.

Technical knowledge and aging infrastructure (Business 23) were also indicated as challenges resulting in a reduction in efficient energy use, correspondingly Business 41 answered that: *"the organic growth of the business resulted in ad hoc decisions and changes with no real plans to include energy efficient options".*

Other obstacles voiced by the recipients were:

- Business 7: "crumbling infrastructure in our area" e.g., cabling
- Business 19: "would like to install a wind turbine instead of using solar power and batteries but worries about the legislation in urban environments"
- Business 30 and 36 also mentioned the wish to install a "wind turbine as an alternative energy source"
- Business 29: "would also like to use wind power but cost is a prohibitive factor"
- Business 25: "money and government are obstacles preventing them from using energy efficiently"

Appendix 12 shows the pictures of evidence from the site visits which highlight the key points discussed above in relation to the energy factor.

In Chapter 6 these results are compared to those from the international best practices and then together the combination of the best methods used locally and internationally were used to create this section in the best practices manual for OHISA from which the members can develop policies with regards to their energy usage.

5.5 The results from the water-related questions, interviews, and site visits

All members of OHISA are dependent on water - it is the life blood of the industry and water restrictions have financial implications on the members whether they be growers, garden centre retailers or ABSTA.

Table 5.9 Aware of water usage within the Business by participants

	Awareness of water consumed %	Unaware %
Growers	100	0
Retailers	94	6

The sample of growers are fully aware of the amount of water used to grow their plants. There was only one retailer who was not 100% aware of the amount of water used to grow, maintain, and sell their plants and the reason they gave during the informal interview was that they use both borehole and municipal water sources, and they have a restaurant on the site of the garden centre thus usage is blurred as they do not have meters on taps in the garden centre.

As the businesses are aware of the amount of water they use, they were asked if they believed they could reduce their usage (Figure 5.22).

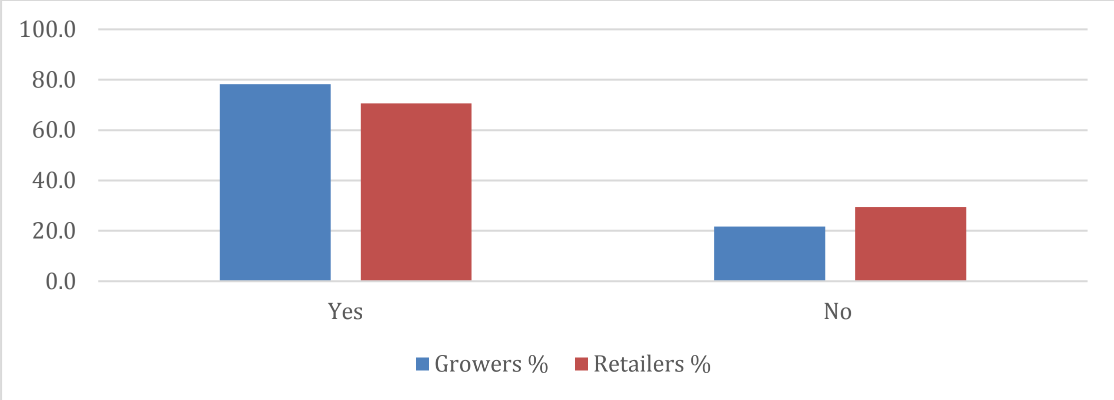

Figure 5.22: Possibility of reducing your water usage (%)

More than 70% of both growers and garden centre retailers agreed that they could reduce water use, but those who disagreed implied during the interviews that they felt they were using water as efficiently as possible and thus could not reduce it.

Together with the usage and reduction, is awareness of global and national legislation. The researcher chose the following two examples to use to determine awareness of legislation:

- United Nations General Assembly Resolution, The human right to water and sanitation 29 July 2010 (A/RES/64/292)
- National Water Act (Act 36 of 1998) which provides for water to be protected, utilised, developed, conserved, managed, and controlled, in a sustainable and equitable manner.

Both sets of legislation were discussed in Chapter 2. Figure 5.23 indicates the responses of the participants, showing that less than half of the participants have heard about the United Nation (UN) resolution and significantly more garden centre retailers than growers are not aware of it.

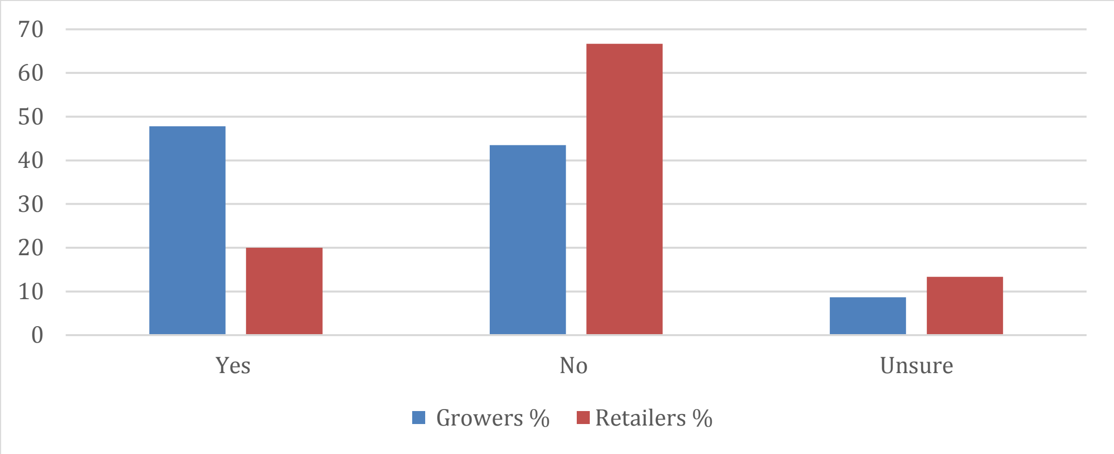

Figure 5.23: Awareness of UN resolution regards water (2010)

With regards the National Water Act (NWA), 70% of the growers and 53% of the garden centre retailers, are aware of it. (Figure 24).

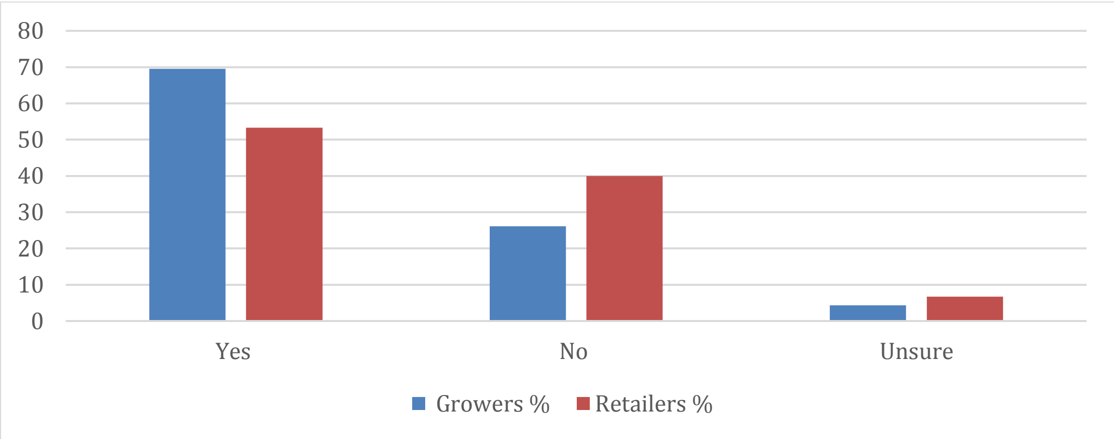

Figure 5.24: National Water Act (1998)

There are numerous reasons for the development of a policy, and these were discussed in Chapter 2, as well as in the best practice manual itself. It was noted within the participants that very few growers and garden centre retailers had a written policy (Table 5.10). When asked about this during the informal interviews, most participants mentioned that watering is the most important job in the business and all staff members are taught about watering and how to conserve water on entering the workplace. Within some of the businesses it was also noted that there are rules and methods with regards to watering practices which again are taught, and this could be the reason for the lack of a policy.

Table 5.10: Written water policy within the sample

		% Grower	% Garden Centre Retailers
Do you have policy on water usage?	Yes	25	12
	No	75	88
	Unsure	0	0
Yes, willing to share	Yes	40	50
	No	50	0
	Unsure	10	50

The researcher followed this question with, where the businesses get their water from? This being another example of awareness of this natural resource (refer to Figure 5.16 - Water sources used by OHISA sample). This result shows that there are numerous water sources used by OHISA, being predominantly borehole by the growers, and municipal water by the garden centre retailers. It is also interesting to note that both water harvesting and recycling of water is taking place within the industry (Figure 5.16).

Following on from above the research highlighted that some of the participants use more than one source of water (Figure 5.25). On the production side, more than 70% have more than one water source with one grower having five different water sources. Whereas the garden centre retailers tend to average two and three water sources per business. This indicates that a reliable supply of water is a necessity for the industry hence the numerous sources.

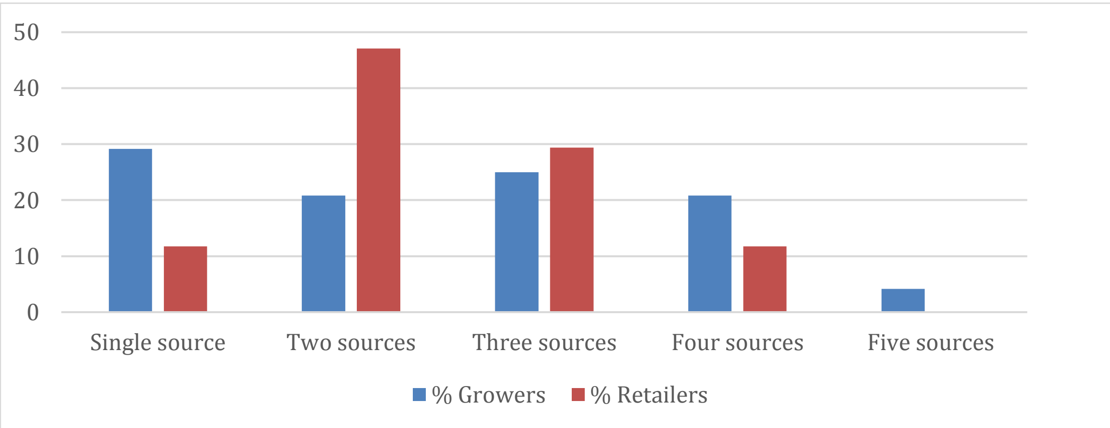

Figure 5.25: Number of water sources used by participants

The next line of questions to businesses addressed where water is either used directly from the taps or stored in dams or tanks to enter the irrigation systems later. The different methods (Figure 5.26) the participants use to water their plants is an indicator of their business practices towards the use of this natural resource.

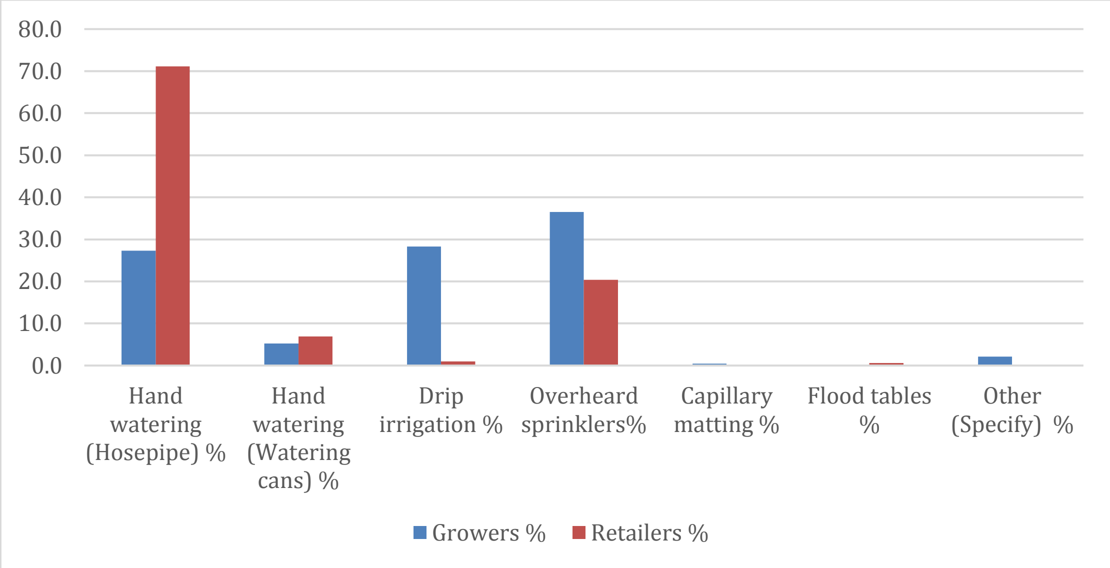

Figure 5.26: Methods of watering plants used by OHISA members

The growers have a broad spectrum of watering practices which include hand watering with a hosepipe, drip irrigation and overhead sprinklers. One grower had just started testing "*capillary matting as a method to water some plant varieties in pots*" which was seen during the site visit and mentioned in the informal interview as "*making a big difference to amount of water used*" (Business 26). The *"other*" from a grower was the growing of water plants in ponds (Business 21).

- Business 22: uses 25% drip irrigation which he stated saved *"time and quantity of water used"* as well as *"regulating flow rate*" within system
- Business 23 and 38: *"changed from overhead watering to hand watering and have shown reduced water us"*
- Business 32: *used "drip irrigation where-ever possible as a water saving and hand watering dry spots"*
- Business 20: moved 65% of their irrigation to drip and thus reduce water usage, *"saving time and money thus would prefer everything on drip.*
- Business 16, 19 and 32: monitoring of watering daily to check the water delivered versus the drainage from pots

- Business 15: has a 3 - 5 year plan to convert all watering to drip irrigation as it uses less water and less fertilizer.

Most garden centre retailers use hand watering with hose pipes for precision. They use watering cans when feeding their plants or for spot watering instead of watering a whole block.

This was expressed in their own words as follows:

- Business 7: “stricter enforcement of changed watering practises to reduce water usage”
- Business 13: “99.9% hand watering opposed to overhead irrigation to ensure efficient watering”
- Business 17: used flood tables for their seedlings which they stated was “a great water saver”
- Business 19: “100% hand watering and it is checked by management”
- Business 27: “All watering done by hand and not overhead sprayers which ensures better quality watering as well as a massive saving. Hoses are fitted with an automatic shut-off valve. Once a week the water meter is checked at closing and then again at opening to see if there are any leaks”
- Business 27 and 29 mentioned “the use of dunking plants, particularly indoor pot plants into a bucket as the most efficient method to water them.”

Considering that water use within OHISA industry is so intensive the researcher enquired about the current business practices that the participants had applied to try and reduce water consumption. These practices were grouped together into broader categories (A-J in Figure 5.27).

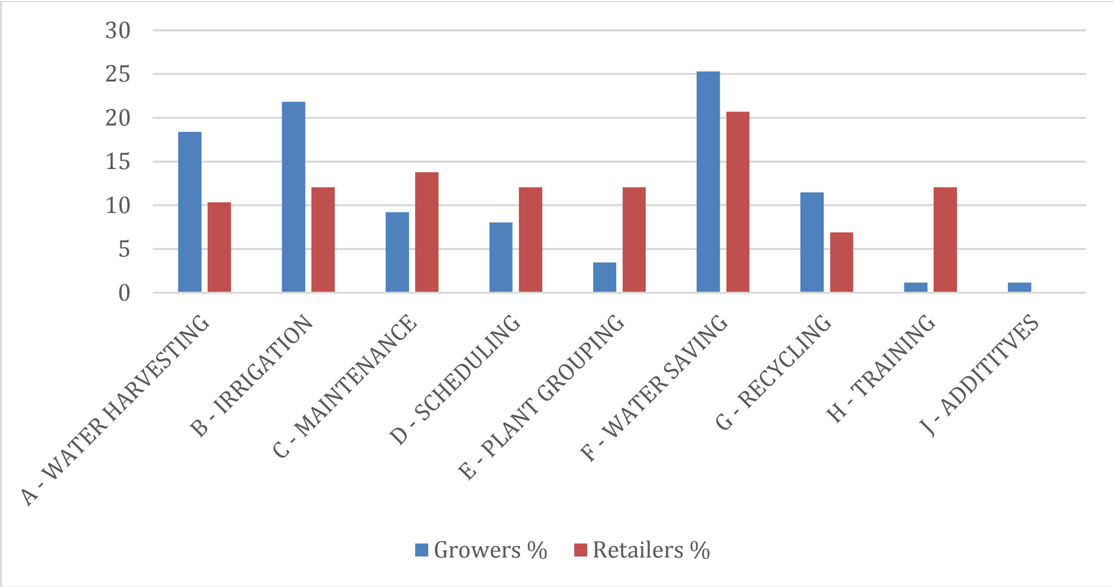

Figure 5.27: Practices applied to optimize water use

Water harvesting (Figure 5.27): e.g., rainwater harvesting (Business 1) and / or irrigation water harvesting (Business 11, 22, 24 and 37). These businesses documented that *"all run-off was collected and used again"*.

- Business 12 had all plants on hard surfaces or concrete to allow for run-off to be funnelled into channels and into dams for recycling which is why they did not feel that as a business they contributed to soil or water pollution as all watering is within a closed loop.

Similarly, Business 14 and 15 also *"paved or concreted areas to collect run-off and channel it into the dams"*. Business 20 would like to do this if funds allowed.

- Business 4: "has an underground drainage system which catches all excess water, and it can then be reused".
- Business 26 mentioned that: "the slope of the nursery leads to a retention dam at the bottom to catch run-off."
- Business 30: "catch all irrigation run-off water by ensuring all excess water can flow easily to catchment dams. Remembering to add plastic under weed matting, then flowing directly into furrows / gutters that lead into dams."
- Business 34: "rainwater and aircon water harvesting and water saving toilets and taps, and nursery run-off channelled into gardens."

Irrigation (Figure 5.27): drip irrigation (Business 1, 9, 20, 22, 24 and 32) and spot watering dry plants by hand

- Business 26 recorded that they had converted a section of plants in the nursery from overhead to drip irrigation and this *"reduced their water usage from 9000l/hr to 1200l/hr."*
- Business 28 suggested, *"replacing wasteful "old" irrigation systems with newer water saving options as well as drip irrigation"* because 97% of their watering is overhead.
- Business 28: "*actively monitor our irrigation system to prevent unnecessary and excessive water wastage*".

Maintenance (Figure 5.27): ***"****good maintenance of all irrigation"* (Business 22) and checking for leaking pipes and taps.

- Business 26 stated that "making sure leaking taps and hoses are fixed as soon as possible" reduces water usage.

The maintenance was not only of the irrigation equipment and pumps and Business 17 mentioned using *"non-damaged pots"* saved water, and Business 30 said that *"Always have land cleared of any alien invasive species"* is also important to save water.

Scheduling (Figure 5.27) changing watering practices both frequency and times of day with the seasons, using timers for irrigation.

- Business 28 *"assesses rain patterns"*, while Business 9 documented *"using climatic conditions"* to determine watering schedule in the business.

This was further endorsed by other businesses which actually adhered to specific watering times for a limited amount of time e.g., Business 8: *"Only watering from 8 to 10 in summer and 8 to 11 in winter and all watering together so that pump is only on for a limited time".*

- Business 9: wrote about a "water demand management e.g., certain areas need less water and controller is set accordingly".
- Business 31: "watering for 45 minutes via irrigation on a timer at 05:30 in the morning, run-off is channelled back into dam for reuse. Spot watering later if necessary".

- Business 25 recommends *“computerising irrigation schedule”* to optimize water usage.
- Business 18 reduced watering by hand, reducing frequency of watering and having enclosed tanks rather than reservoirs or dams.
- Business 36 mentioned: “water plants early in the morning and irrigate plants not paths”.

Plant grouping (Figure 5.27): grouping plants with similar water needs e.g., drought tolerant plants. A few businesses do practice hydro-zoning in their display gardens (Business 13).

- Business 10, 28, 30 and 33 “group plants of similar watering needs, so as not to be watering too much for one and too little for the other.”

Water saving (Figure 5.27) covering of reservoirs and dams to prevent evaporation and contamination, as done by Businesses 5, 6, 20, 23, 32, 36 and 38. Business 11 mentioned that their five dams were too big to cover (cost-wise) but they did have duckweed in them which did reduce the amount of evaporation from the water surface although it is an invasive species.

- Businesses 28, 36 and 37 use wind breaks e.g., hedging.
- Business 9 and 30 use water sensors to prevent overwatering.
- Business 34 has water saving toilets and taps (sensor-based).
- Business 14 *“introduced water wick system on plants”* to minimise watering of pots
- Business 40: *“installation of water tanks”* to reduce water usage.
- Business 30 wrote that they, “*measure water consumption continuously (we use apps such as “Hydrowise” from Hunter controllers – if water consumption goes outside of set parameters, immediate alerts are sent to our phones)”*

One example mentioned by Business 6 was “minimising bag size” to reduce watering. Business 28 also “changed their bag sizes, not only for watering reduction purposes but also for reduced growth media usage and easier and lighter for transportation e.g., they grow in an 8l instead of 10l and a 15l instead of 20l.”

Recycling (Figure 5.27): drainage channels and tunnels or sheds designed to catch run-off or excess water and feed back into system. Business 22 mentioned that this was one of best methods to save water. Business 6 recommended *“concrete furrows to channel run-off water to catchment dam”* as was done by many businesses above to harvest rainwater.

- Business 5 suggested, “reusing wastewater (grey water) by installing a “BioBlue” sewerage plant which has filtration tanks above the ground”.
- Business 40 also suggested *“using grey water – recycled sewerage water”* known as black water, as a water source, to reduce using potable water.

Training (Figure 5.27): “*water only as needed”* stated Business 5.

The education of staff and customers is important and different businesses used various methods to do this:

- Business 34 *“via website and live screens in store”.*
- Business 4 *“uses educational signage for customers and staff”.*
- Business 27 said that *“as a new staff member enters the business water practices training takes place and it is re-enforced for all annually before summer.”*
- Business 36*: “staff are trained to water efficiently”* and Business 20 also *“trained staff on good watering practises”*
- Business 17 documented that: *“staff know what water is needed through inhouse training and development.”*
- Business 26 – *yes we do training, 1 x per month with all watering employees”.*

Additives (Figure 5.27) some businesses add products to their water or growth media to improve the absorption of water and minerals by the plants because a more favourable pH enables these processes to occur more easily

- Business 6 “adds ammonium sulphate to the growing media as the water used is too alkaline for the absorption of minerals by plants from the fertilizer” and for water saving.
- Business 17 and 36 adds “water retention granules to growing media”.

- Business 26 stated that "adding air to water decreases phytophthora and fusarium and results in improved root growth of the plant and 25% better water usage of plant as a whole".
- Business 11 documented that although they do not use additives to purify their water, they "planted aquatic plants to prevent silting and act as a filter to help purify water in their dams" which is working successfully.

Many businesses practice one or more of the water-saving ideas mentioned above, e.g., Business 3*: "water retention additives, drought resistant plants and covering dams to prevent evaporation.*"

The examples above will be itemised within the best practices manual to ensure co-operative learning from tried-and-tested water saving techniques within the South African environment.

In Chapter 6 the results from the South African businesses participating in the study will be compared to those best watering practices suggested by international industry to see if they are similar or different and where improvements can be implemented by OHISA.

All the participants in both the grower and garden centre retailer category, except for two who did not answer the question, have taken steps to reduce their water usage showing a positive attitude towards changing for the betterment of the environment. Some of the steps taken are graphically shown in Figure 5.28 as well as the prevalence of that option by the participants.

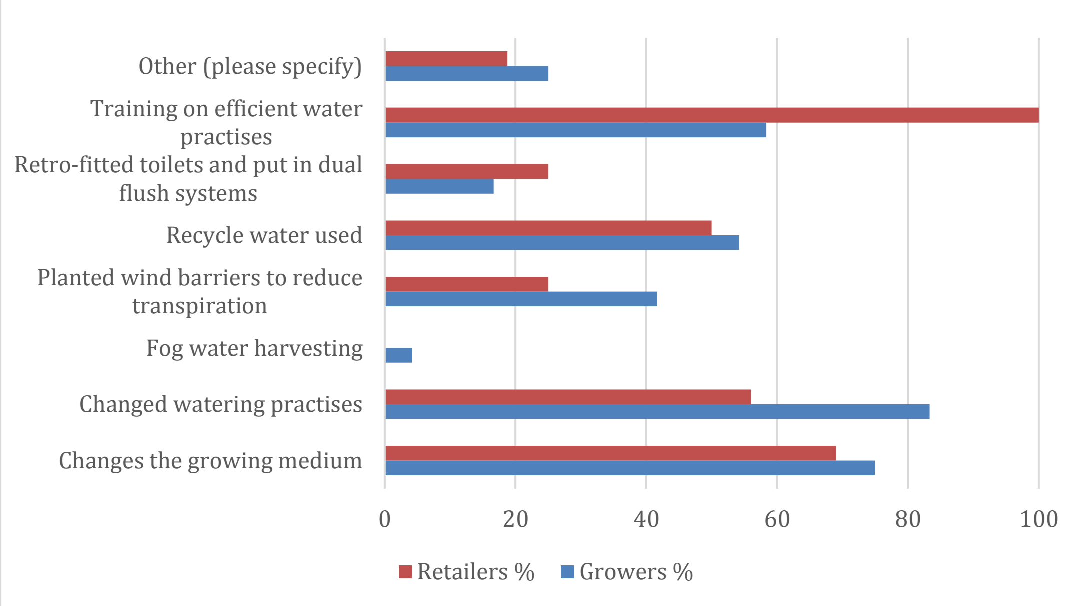

Figure 5.28: Practices used to reduce water usage (%)

Figure 5.28 shows that the growers' preference for change has been to enhance their water practices and then improve their growing media.

- Business 41: "watering times, drip often used, reuse and catching of run-off water, no leakage or breaks tolerated."
- Business 7: "adding water retention granules to basket mixes".

The growers e.g., Business 22, reduced watering input by changing from bark in growing medium to coir. Some of the growers not only started including coir but imported their growth media for optimum growing of a particular plant varieties and increased water holding capacity of media by *"adding soil wetting agents"* (e.g., Businesses 5, 14, 36, 37 and 38).

The garden centre retailers focused on training both their staff members and their customers.

More than half of the growers (54%) and half of the garden centre retailers (50%) reduced their water consumption by taking steps to recycle the water they have and use e.g., Business 39, 31. Another method to reduce water usage not highlighted in the questionnaire but noted during the site visits was the mulching of pots and containers and even the bed surfaces on which the plants were sold from. e.g., Business 17, 19, 27 and 31 – see Appendix 13 for photographic evidence.

There are a few factors that the participant sample felt were obstacles for their using water efficiently, and these are:

- Business 5 - Human errors – *"ongoing training to avoid overwatering"*. Business 6 agreed with the "*human factor*" being an obstacle.
- Business 2: time, old infrastructure, nature of the business were obstacles for this garden centre retailer. They had numerous challenges as they must use municipal water because the ground water is too polluted even to use on the plants. Their solution to this problem was to install a water purification plant to reduce the use of potable water on their plants. Business 28 also stated he would like to install a "*water purification plant as they have to treat the borehole water for pathogens*".
- Business 29 found municipal restrictions and water restrictions from irrigation boards as well as load shedding (Business 23) problematic
- Business 37: finances e.g., the cost of converting from overhead to drip irrigation.
- Business 18: lack of knowledge.
- Business 22 suggested that one of the obstacles for efficient water use is that plants are in containers and spaced creating a larger area to irrigate than if they were planted in a landscape where they would be more water wise as is done in field nurseries internationally.
- Having to stock non water wise varieties due to popular demand by consumers.

For many of the participants in the sample, financial constraints and the capital investment needed were the most frequent obstacles mentioned by the growers and retail garden centres. The knowledge and attitude to change that many of the participants have has been shown in the results above and reiterated below e.g.:

- Business 34: "environmental infrastructural change wished for is the use of grey water".
- Business 16: "install drip irrigation for trees".

Although the cost is a limiting factor, Business 32 countered this conundrum with his personal experience and stated that, "the capital cost of converting to drip irrigation was higher than overhead but over time the cost is recovered due to less water and less fertilizer usage."

Photographic evidence from the site visits that highlights the key points discussed above in relation to the water is shown in Appendix 13.

5.6 The results from the growth media related questions, interviews, and site visits

Soil was the original growth medium and for open field and edible crop production this is still the case, although the land available for this to happen is being lost and the quality of the soil is deteriorating (Semendo, 2017). This has propelled the advancement of hydroponic production and the growth media industry where crops and ornamental plants are grown in soil-less media. There are numerous different growth media available, and many growers have their own formulation or blends that they have trialed and tested with the plant varieties that they produce. "Growing medium is the foundation to a healthy, quality plant" (Hu, Zhang and Dunn, 2022).

The quality of the growth media is also important, and growers must determine which quality of this resource they can grow in. This does cause the lowest environmental deterioration when the ingredients chosen are renewable e.g., coconut pith (coir) and compost (Arpin and Maxime, 2010b; Peano *et al.*, 2012). It is recommended that growers carefully choose every ingredient of their growing media based on its origin and how it was produced (Arpin and Maxime, 2010b).

In the environmental awareness section of the survey results, it was shown that the availability of growth media is almost as important as the availability of water, and this is re-iterated in the results below which show that 96% of the growers are aware of their consumption. When asked why, it was clarified that some of the ingredients are imported making it costly e.g., peat and coir. Others are locally sourced e.g., bark but also at a cost, so the procedures for handling and use are important both financially and environmentally.

Table 5.11: Aware of growth media usage within the business by participants

Growers		
Awareness of growth media used %	96	
Unaware of amount of growth media used	4	
Do you think you can reduce your consumption of the following natural resources?	Yes	No
	26	74

Thus, 74% of the growers did not think that they could reduce their consumption of the natural resources related to growth media. From the interviews some growers would like to learn how to better manage and save the growth media that they use.

Together with the usage and reduction, is awareness of global and national legislation related to soil and growth media. The relationship between soil, growth media and people is highlighted in the Revised World Soil Charter (Food and Agriculture Organization of the United Nations, 2015) which promotes soil health productivity to ensure food security. Figure 5.29 shows that more than 55% of the participant growers were not aware of the Soil Charter, Soil Conservation Act 45 or the Norms and Standards with regards to soil conservation and land rehabilitation which is an opportunity for the industry to use these Acts and Standards to provide nature-based solutions and assist the Government in achieving sustainability.

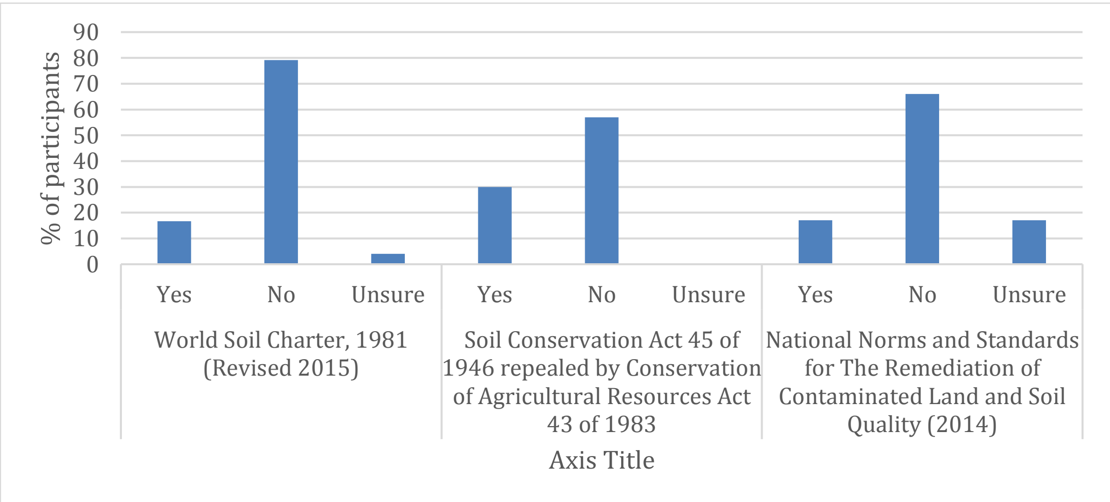

Figure 5.29: Growers awareness of legislation and documentation

Under half (45.8%) of the growers have a growth media policy and of those, 53.3% were willing to share it (Figure 5.30). It was reported that many of the policies that the growers have are verbal and not written as their operations are too small, and it is usually only two to four people making the business decisions. This is where the best practices manual will help the growers and garden centre retailers formalise their policies making it easier for them to share the information with their teams. Those companies that were unable to share their growth media policy said it was because they contain the recipes or formulations for the growth media specific to the plant varieties that they grow, and this secret formula gives them the growing advantage.

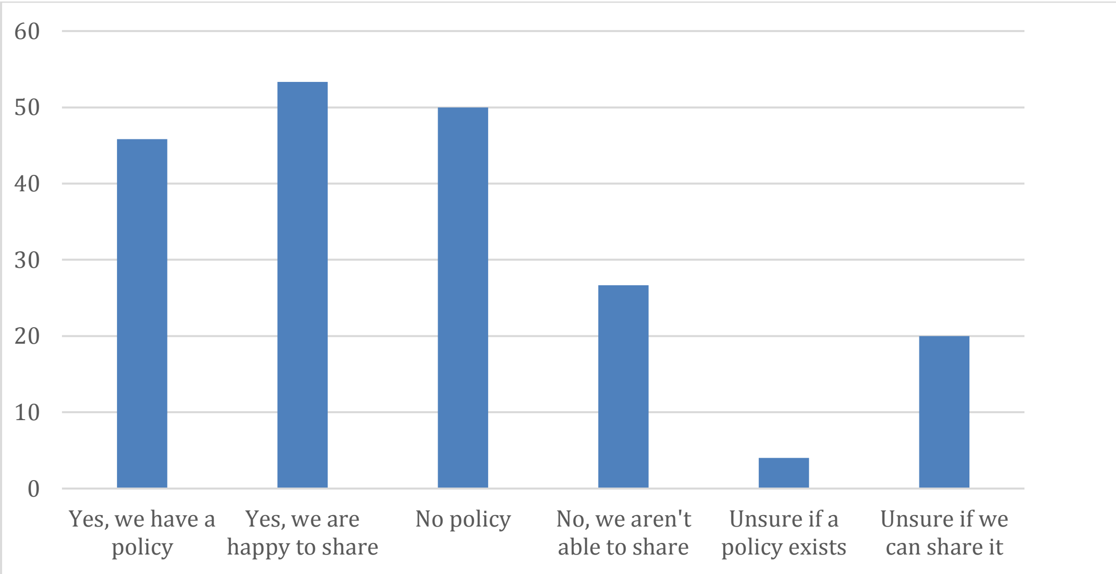

Figure 5.30: Growth media policy written within the sample and willingness to share it (as a % of the total participants)

The purpose of using different growth media components is to provide the plant with water, air, nutrients, and support, specific for different plant requirements. The nutrients are addressed later in the fertilizer section, but the type of growth media used is what provides the spaces for air and water and support for the plant (Smith and Lopes, 2010). The formulations of growth media for the different plant species are combined in different quantities by the different growers to create their optimum growing media (with the addition of nutrients). Figure 5.31 lists the different natural resources (ingredients) used by the growers.

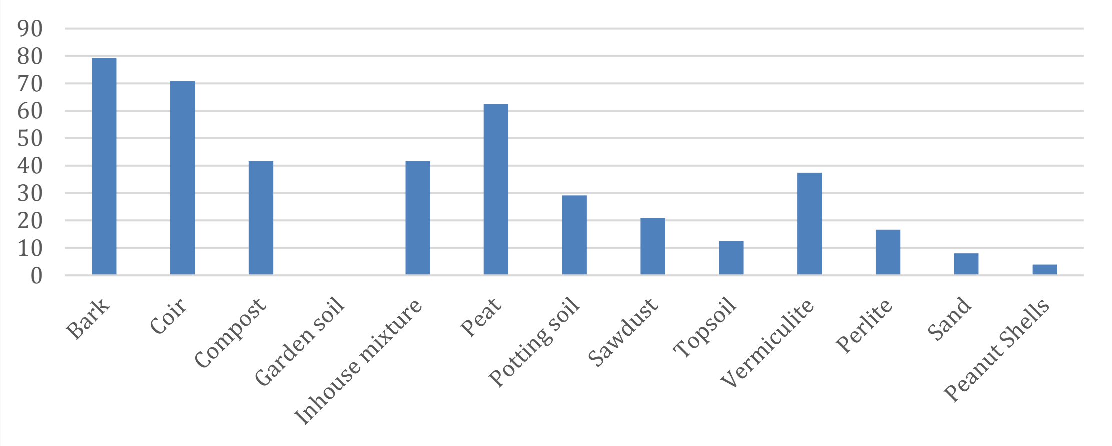

Figure 5.31: Raw materials (%) used by OHISA growers in growth media formulations

There are a wide variety of growth media ingredients as seen above but the two which negatively affect the environment the most are topsoil and peat. Other ingredients of the growing media mixes that the researcher did not list, and growers included were:

- Horse manure: Business: 12, 20 and 21 mentioned that they included decomposed horse manure and bedding which contained a combination of straw, sawdust, and manure. Business 12 added a high nitrogen-based fertilizer to the piles of this manure mix to speed up the decomposition process
- Silica sand: Business 21 grow very specific plant varieties and add silica sand. Business 40 also added *“river sand (also known as silica sand) when growing plugs”*
- Mulch: Business 9 mentioned “not using topsoil in planting bags and treating existing soil with regular mulch.”

During the site visits, some of the growers mentioned that they obtained their bark, compost, potting soil, peanut shells, and sawdust locally while the inhouse (premixes), peat and coir were imported.

- Business 7: “Consistency of local growing media varies very often preventing us from using it efficiently”. Business 6 concurred that the “inconsistency of the growing medium” is an obstacle.

The imported products have a higher cost and carbon footprint. Correspondingly, the two main environmental challenges regarding growth media are the mining and exploitation of the raw materials used in the growing mixes e.g., peat, perlite, topsoil, and the transport of the growth media to site.

- Business 37: only uses peat in specific mixes e.g., growth media for cuttings and plugs
- Business 15: “peat and coir are added to reduce water usage” but mentioned that “5 people would lose their jobs if all the growing media was imported instead of only the coir and peat”
- Business 18: “changed their medium from a local medium to a more professional, plant specific medium with good results”.

Business 14 and 38 concurred that the imported products are not only consistent in their formulation, but they guaranteed consistent pH and EC figures which is important when growing imported quality plants from seed or plugs.

A few of the locally sourced components of growth media are by-products from other industries e.g., bark from forestry (Business 37) and paper making, horse manure (Business 12 and 20) from stables, peanut shells from the peanut processing factory (Business 11) thus the industry is starting to utilise a circular economy concept. This concept was reiterated by Business 28 - “*they buy-in weed free, pathogen free growing media which is manufactured from a waste product*,” namely blended fine bark.

This concept is an example of a circular economy and a method of sustainable development, not only environmentally but financially too. As mentioned above growth media is a cost of production and can vary between 8 - 15% of the total production cost depending on components in the formulations. The growers have developed methods to optimize its usage (Figure 5.32).

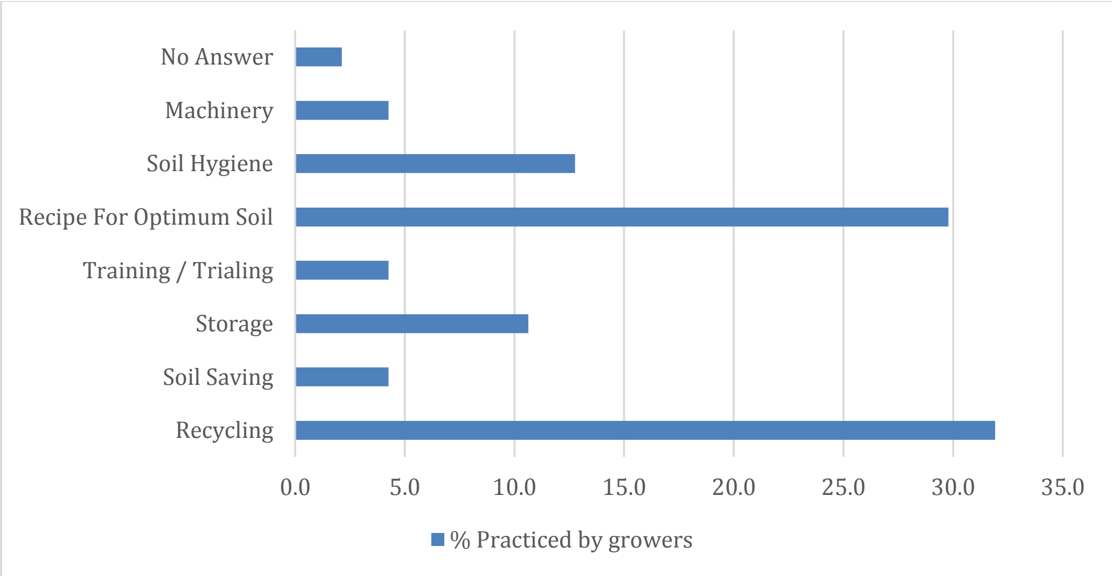

Figure 5.32: Practices applied to optimize growth media use

The results in Figure 5.32 were reinforced when the grower participants were asked if they have different recipes for different plants. 71% answered “yes” and 29% said “no”, highlighting the importance of unique formulations including pH, EC (electrical conductivity) and air-filled porosity for the different plant varieties.

Garden centre retailers do not usually have to worry about growth media availability for the production of plants but their organics sales e.g., compost, potting soil, mulch, bark, germination mix etc., make up a large percentage of their overall sales and thus if there is a shortage, it affects their turnover.

With this being said, Business 4 mentioned how they save growth media for their customers by offering: *“a repotting service for clients so they do not have to buy a big bag”* not only saving money but raw materials too.

The recycling or reusing of growth media, are recommended methods to reduce the environmental impact of harvesting or mining growth media components as documented by Business 22, and in turn minimising the effects of transportation. In this study, the growers shared methods demonstrating how they effectively utilised growth media. One of the most important was growth media (soil) hygiene:

- Business 26: “make sure the soil is stored in a safe place to prevent contamination”
- Business 30: stressed the importance of “soil to NEVER touch the ground and get contaminated”
- Business 32: recorded similar statements about contamination - “prevent contamination of growth media with soil borne diseases” by proper storage and handling of growth media components
- Business 38: pointed out that the *“storage of growth media e.g., out of sun, rain was important*.” Also purchase as you need, do not overstock it.

During the site visits it was noted that those that imported growth media were particularly stringent with regards to the storage and use of the media. Potting machines were found in separate areas with concrete flooring to prevent loss of media and maintain cleanliness. Also, once a bag had been opened it was used promptly and no half-opened bags lay anywhere (Appendix 14 – shows photographic evidence hereof namely Businesses 5, 15, 32, 36 and 38).

Recycling of growth media, is practiced by 31.9% of the growers for optimisation but the challenges associated with recycling growth media are:

a. Sterilization of the growth media (e.g., Business 21) if it is going to be reused in containerized plants, however according to Business 37 there are no fumigation methods or chemicals that are proven to be effective and thus soil bacteria and pathogens are transferred with the soil which can cause plant diseases.
b. Weeds or seeds in the growth media being transferred to the new containers (Business 36) or into the gardens.
c. Organic material (plant material) not composted sufficiently taking extra nitrogen from the medium which needs to be used by the new plants in the containers or gardens.
d. Some beneficial properties of the growth media are altered in the original plant growing process, making the recycled media less efficient e.g., particle size and absorption properties. An example provided by Business 36 being, *“growing media becomes very fine and has poor drainage”.*

e. Solid waste materials in recycled growth media e.g., labels, plastics.

It is for this reason that when growers were asked if they recycle their growth media, 82% answered yes, but only 31.9% see it as a financial saving or optimisation method. Many of the growers do not use it again in containerized plants but they recycle it into garden beds and landscapes (Business 5, 38). They also use it for the growing on of shrubs and trees in large bags where soil quality is not as important as in germination of seedlings, bedding plants, young plants, cuttings, or speciality plants.

- Business 22 mentioned that the "utilisation of a potting machine optimised the quantity of growth media used".

Very few of the growers mentioned having any obstacles with regards to utilising growth media optimally but the reasons some gave are like those regarding the recycling of growth media and include:

- Supply and inconsistency of growing medium
- Soil borne disease e.g., "transfer of Phytophthora and Fusarium" (Business 23, 24)
- Weed control
- Need to sterilize growth media
- Training on which raw materials and growth media mixes are most suitable for growing which plant varieties
- Lack of facilities for sterilisation of media
- Fluctuating exchange rates (Business 30)
- Wind which if growth media are not stored properly blows it away or contaminates it with other products (Business 30)
- The capital cost outlay of buying in bulk (Business 30)
- Pollution by solid materials e.g., labels, stones as described above in the growth media
- "Variety of products grown" (Business 41)

These results are from OHISA and in Chapter 6 some of the practices recorded here will be compared to international best practices. Aspects included in the best practices manual will allow OHISA growers to learn from each other how best to use the different components of growth media and if necessary, make changes to their formulations to minimize costs and environmental impacts to ensure sustainability.

5.7 Results from fertilizer-related questions, interviews, and site visits

Fertilization is an integral part of growing operations in the production of quality plants. In retail garden centres, the application, use and knowledge of fertilizers is vital as this needs to be shared with the customers to ensure that they have success with their plant purchases. There are a variety of different fertilizers available and for the purpose of the study, nutrient application, and usage, whether it be organic, or inorganic were investigated under the umbrella term of fertilization.

Plants require different nutrients, minerals, and elements at different stages of their growth, depending on the choice of growth media they are growing in. Knowledge and skill is required in finding the balance of optimum feeding (fertilization) using the most suitable application method at the correct time in the growth cycle to produce a quality plant without overfeeding, which could result in excess fertilizer used, damaging the plant or leaching out into the environment e.g., excess nitrogen in plant tissues makes them extra succulent which makes them more susceptible to insect attack, drought and breakages especially when transported (Johnson, Mangiafico and Obropta, 2013).

The researcher firstly investigated if the participants fertilized their plants, with the results shown in Figure 5.33.

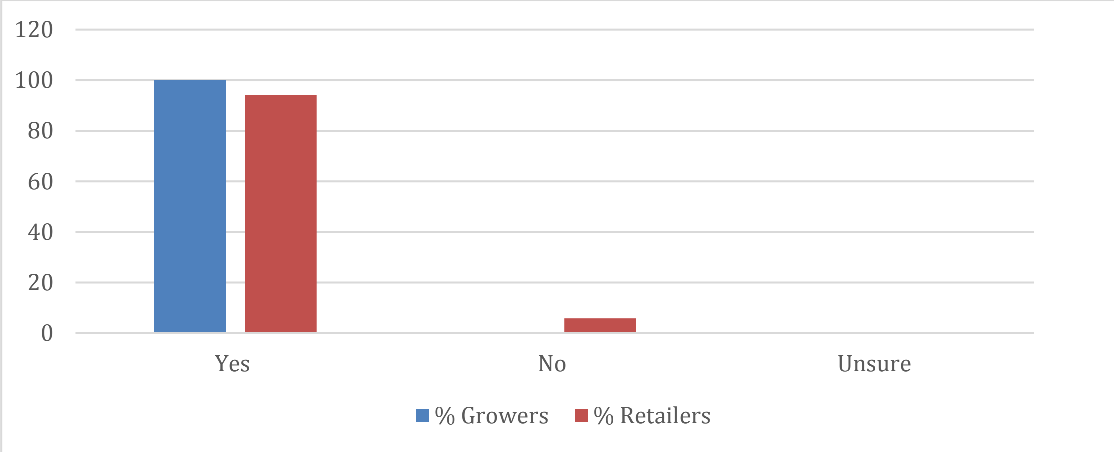

Figure 5.33: Use of fertilizers on plants by participants

As can be seen, 100% of the growers fertilize their plants so that they can ensure quality plants with a shelf-life on the retail floor.

Almost all (94%) of the garden centre retailers do fertilize their plants but Business 19 and 27, replied that they *“do not fertilizer their plants as no plant should stay in their garden centre long enough for it to need feeding”* which is a sign of good retailing and that they stock plants which have a fast turnaround time.

Following on from this, the participants were asked the knowledge question: “do you know the amount of fertilizer used by your business?” Most growers (91%) and just more than three quarters (76%) of garden centre retailers were aware of their usage.

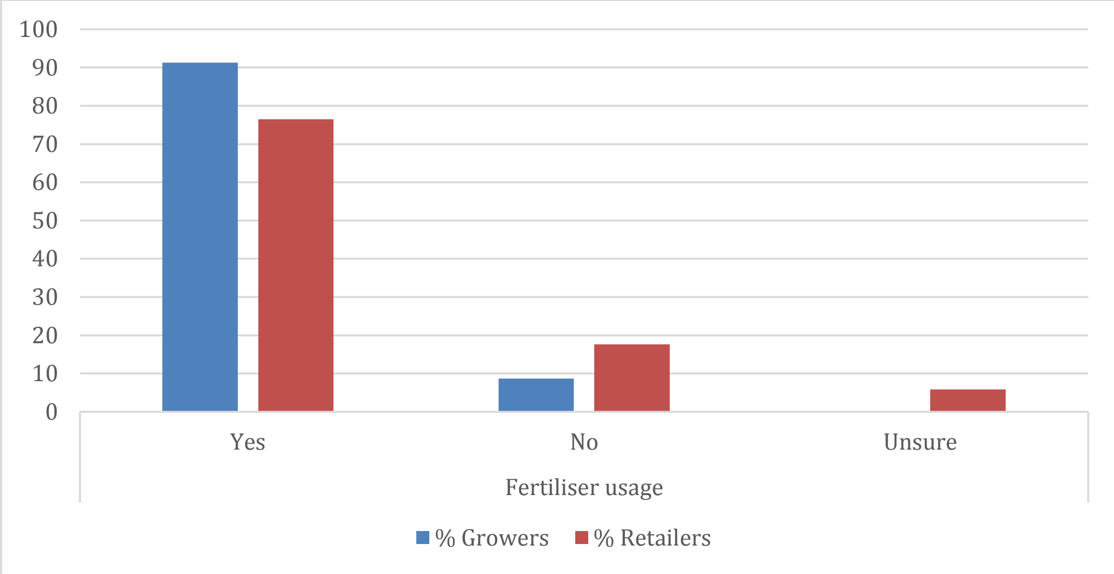

Figure 5.34: Knowledge of fertilizer usage within their business

Figure 5.35 shows a few of the different types of pollution that the ornamental horticultural industry can contribute towards through its daily business practices e.g., fertilizing and using pesticides. The participants are most conscious of the water pollution that they could be contributing to.

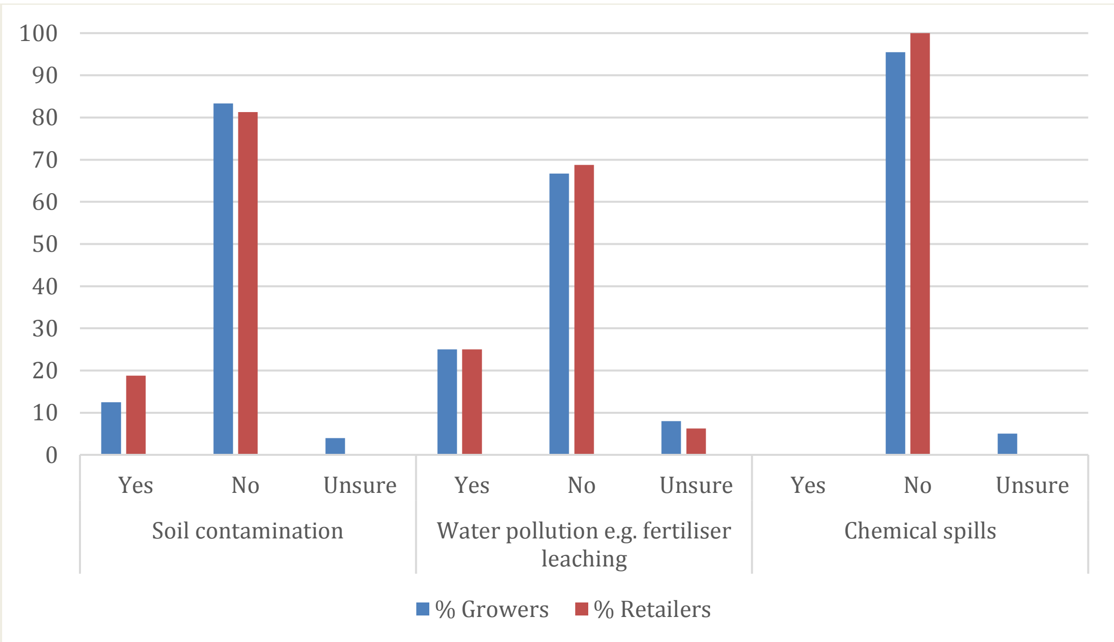

Figure 5.35: Awareness of the potential pollution caused by the ornamental horticultural industry (as % of the participants)

A quarter (25%) of both growers and garden centre retailers are aware that their fertilizing practices have the potential to cause water pollution (Figure 5.35) but as will be noted later they have methods in place to try and reduce this from happening.

Hand in hand with the above awareness (Figure 5.35) is the knowledge of specific legislation related to the importation and use of fertilizers.

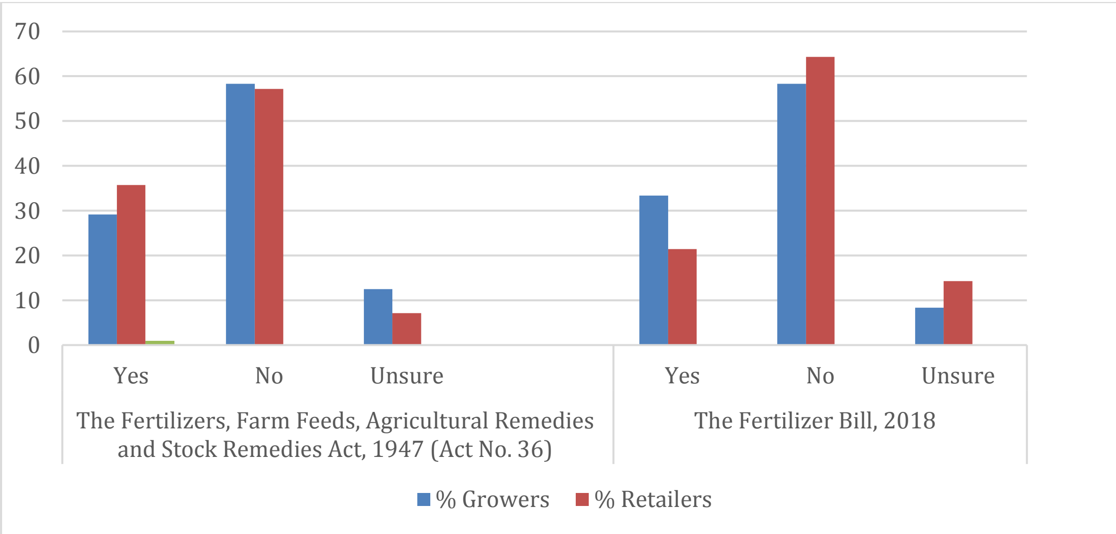

Figure 5.36: Awareness of legislation regarding fertilizers (as % of the participants)

The awareness of the Fertilizer, Farm Feeds, Agricultural Remedies and Stock Remedies Act is not well known by the growers and garden centre retailers (more than 50% from both sectors said they did not know it) and they are even less aware of the Fertilizer Bill (Figure 5.36).

Those that were aware of the Acts were implementing safe practices e.g., Business 32 which practiced “safe handling of chemical products for all staff working with chemicals and fertilizers - Bunded chemical store, fertilizer, and diesel tanks - Spill kits in pumphouse and chemical store - Monitoring of drainage water volumes.”

The lack of awareness of legislation did not mean that they weren’t practicing health and safety with regards to fertilizer and chemical storage, handling, and use. During the site visits, the researcher noted that good fertilizer practices were adhered to, and the use of registered products as stated in the Act was applied. During the site visits it was established that there is a good relationship between the allied trade association of SANA (fertilizer and pesticide suppliers e.g., Andermatt (Madumbi), Ball Straathhof, BioGanic Fertilizers, Efekto, Insect Science, Makhro Home Garden, Protek, Talborne) and the growers and garden centre retailers with regards to the sharing of information, technical support, and training offered on fertilizers that are stocked and used by both growers and garden centre retailers.

Fertilizer usage is important and as such, there should be a related policy for it in the business to ensure that it is done correctly. From Figure 5.37, 54% of growers and 27,5% of garden centre retailers in the sample have a policy and of those that have, 50% of both growers and garden centre retailers would be happy to share it.

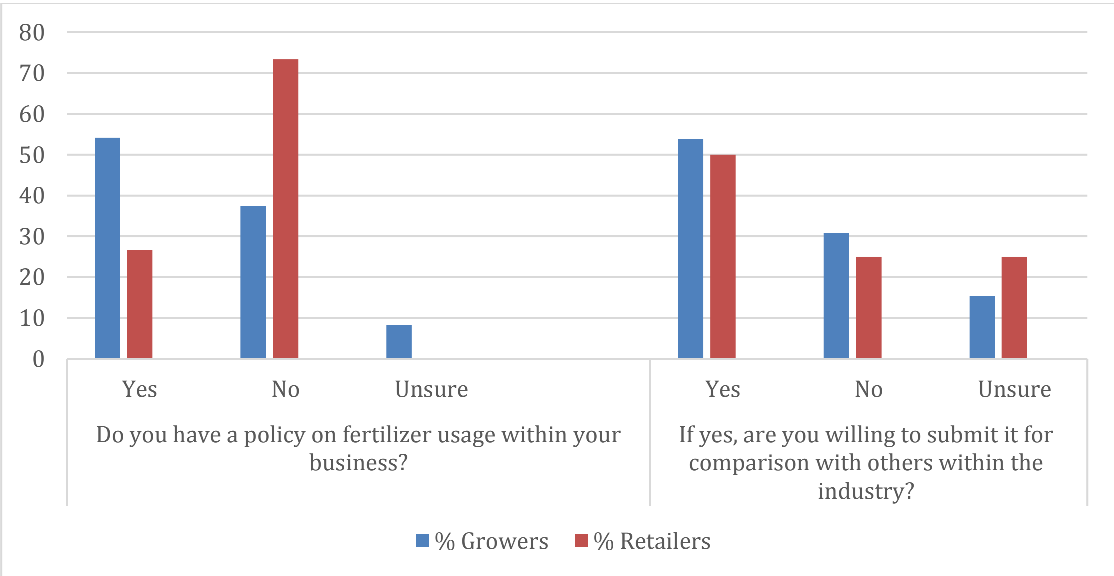

Figure 5.37: Fertilizer policy and wiliness to share

Within the policies are the procedures recommended to achieve the goals and methods set out in the policy. It can be noted that the different growers and garden centre retailers have numerous procedures and practices to optimise their fertilizer usage. Figure 5.38 highlights the different ways (in categories) that fertilizer usage is optimised.

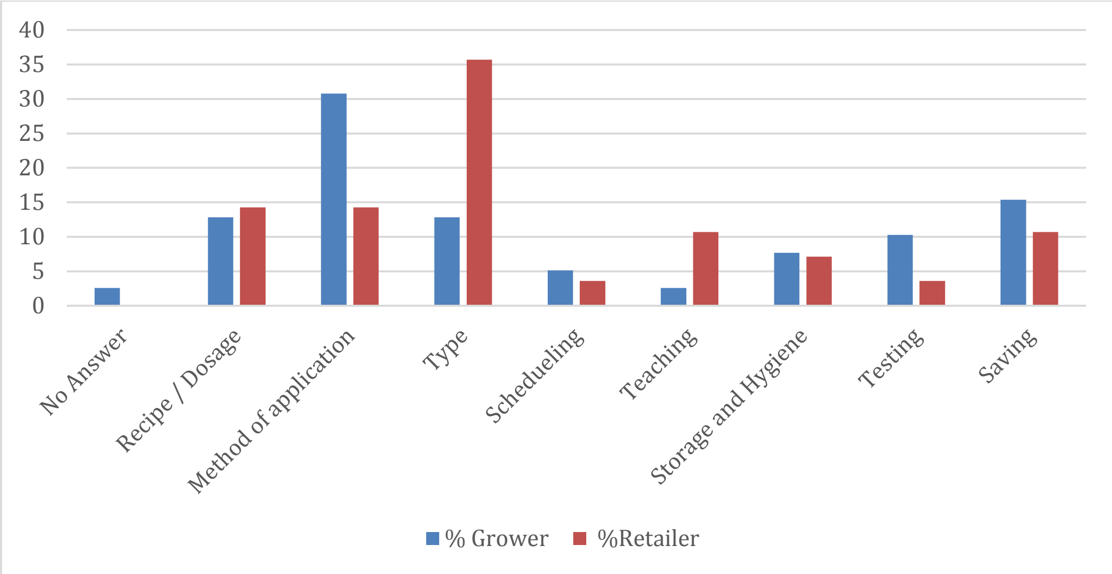

Figure 5.38: Methods to optimise fertilizer usage by participants

These categories are further explained below with the responses that the participants shared with the researcher and as part of the policies which again were most often verbal:

a. Recipe and dosage

- Using the correct fertilizer, in the correct quantities or dilution rate depending on the application e.g., a Dosatron (Business 12 and 36) (in-line) or by hand (teaspoon measurements) (Business 6, 12 and 16)
- Using different nutrient recipes for different plant varieties
- Using specific fertilizers for specific needs (Business 9)
- Using a premixed fertilizer e.g., osmocote or basocote
- “Better quality substrates (growth media) meant less fertilizer used” Business 22
- “Soil mix to optimise absorption and adding ammonium sulphate to increase availability of fertilizer” Business 6 as mentioned before also uses it as a water saving method.

b. Method of application

- Mix the correct amount of a controlled fertilizer into potting mix prior to planting (Business 38) to optimise absorption of nutrients by roots

- Fertigation using drip irrigation *“lessening waste”* (Business 30), hand watering and / or a Dosatron
- Manual application to prevent burning of plants (Business 28), *“periodically by hand”* Business 26, which was repeated by Business 30 *“hand feed with organic fertilizer, lessening possible burning of plants”*
- Measuring pH and EC regularly to ensure the dilution occurs in-line (Business 23) and via the Dosatron is correct (Business 5)
- Control dosage, quantity specific to plant variety (Business 20 and 32).

c. Type

- There is a high preference for organic fertilizers, and those that aren’t currently using organic are starting to include it more and more (Business 40 and 17), especially the garden centre retailers (Business 10 - “always *used organic fertilizer, even in growing*”)
- Alternate monthly between chemical and organic (Business 4)
- Use only controlled-release fertilizer (Business 11, 21, 28, 37 and 38)
- Only using organic on edibles and surrounding gardens (Business 4 and 12)
- Using pellet-based fertilizers to prevent spillage (Business 17)
- Using a seaweed conditioning throughout the year (Business 18)

d. Scheduling

- Have a spray programme in place
- Monitor use of fertilizers
- Fertilize with knowledge of weather

e. Teaching

- “Only supervisor decides which plants to be fertilized” (Business 35)
- Training offered to staff on fertilizer application, dosage, and use (Business 29)
- A couple of the garden centre retailers do not sell any superphosphate as it can cause groundwater pollution (Business 13 and 19)

- No harmful fertilizers used.

f. Storage and Hygiene
  - “Use Personal Protective Equipment (PPE) when applying fertilizer” (Business 11 and 26)
  - “Store in a dry space” (Business 26)
  - Clean tanks (Dosatron) every second month (Business 26)
  - Extra temporary staff employed to assist with weeding (Business 24)
  - Do not spill and if you do, clean it (Business 30).

g. Testing
  - Use EC meters to see if more fertilizer is needed
  - Calibrate meters (Business 26)
  - Measure pH and EC in the bag or pot.

h. Savings
- “Err on side of less” (Business 41)
- Determine needs of plants and only use as much fertilizer as is needed
- By hand minimises use and potential damage to plant (Business 28)
- Using better quality substrates (growth media) means less fertilizer is used
- “Reducing watering intervals conserves fertilizer in containers” as less leaching occurs (Business 22)
- “Mulching to cover soil to reduce losses to environmental factors” (Business 28).

This shows that there are numerous ways that growers and garden centre retailers are conserving costs by using fertilizer optimally. One of the first responses was how the choice of fertilizer is changing and this is reflected in Figure 5.39. There are no growers in the sample who use only organic. 17.6% of the garden centre retailers only use organic fertilizers. Many of the participants are starting to use organic-based fertilizers in combination with the chemical-based ones as expressed by some of the participants, 62.5% of growers and 70.6% of garden centre retailers as shown in Figure 5.39.

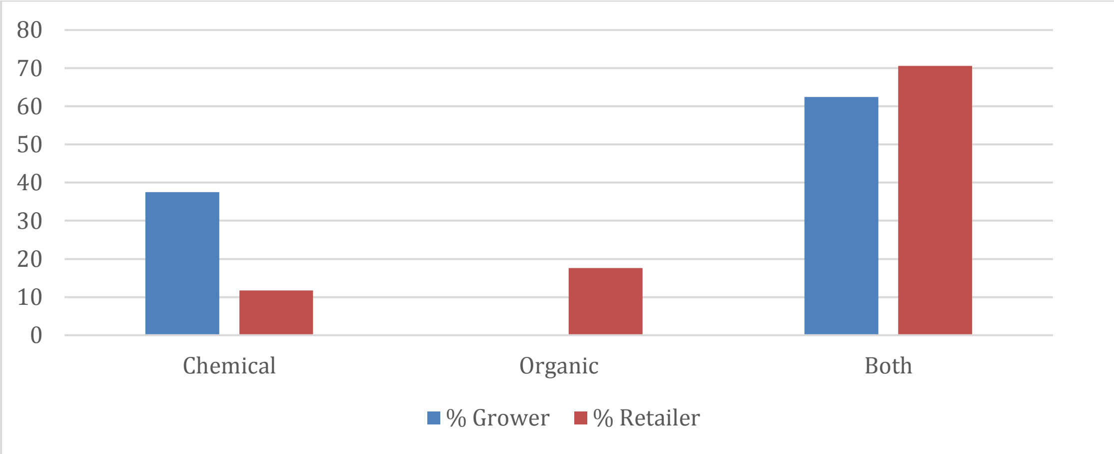

Figure 5.39: Which type of fertilizers do you use?

This graphical representation was further enriched by the notes of the participants:

- Business 3: “high preference for organics”
- Business 8: “we use organic feeding on all our retail floors”
- Business 10: “we only use organic”
- Business 12: “we limit use of chemicals and use organic where possible”
- Business 13 “in-store organic with limited chemicals”
- Business 25: “foliar feed weekly and chemical feed monthly”.

The application method of the fertilizer is also important. Figure 5.40 displays the different methods used and the preferences of the growers compared to the garden centre retailers. The question “how do you apply your fertilizer?”

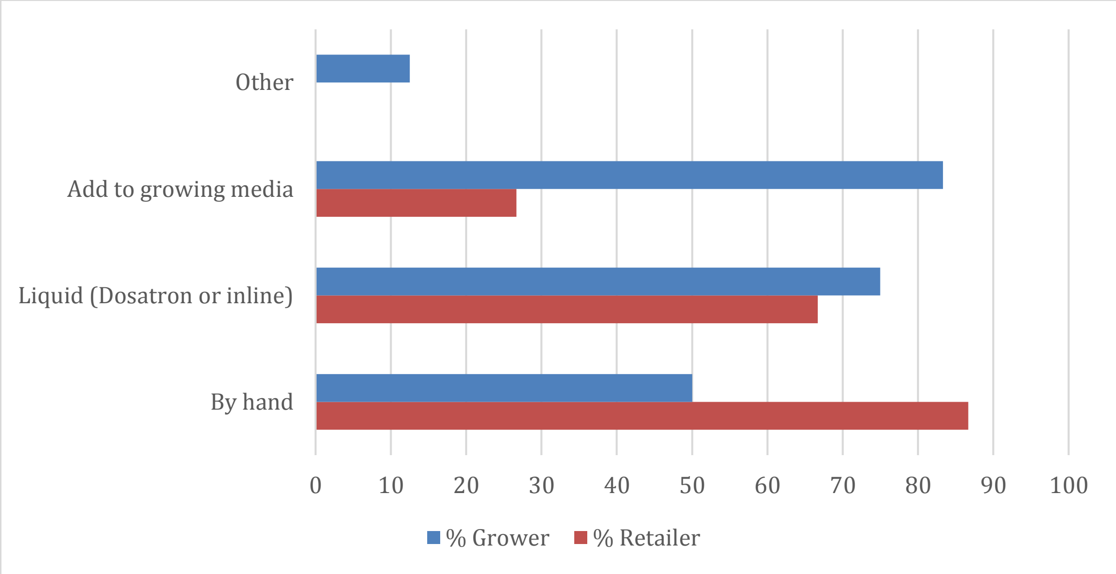

Figure 5.40: Fertilizer application preferences

As can be seen these results reflect the nature of the businesses, 83.3% of the growers add fertilizer into their growing media and from the interviews this is usually a controlled release fertilizer which will feed the containerised plants for six months. 75% growers and 67% of the garden centre retailers dilute their fertilizers and apply it in-line or via a Dosatron when watering their plants. 87% of garden centre retailers compared to only 50% of growers apply their fertilizer by hand (Figure 5.40).

Foliar feeding was a method not specified by the researcher as it can be done via a Dosatron or in-line (as above) or as Business 16 and 25 commented via a watering can or hand sprayer.

Even though the growers and garden centre retailers are practicing optimum fertilizer usage, there are situations when it could leach e.g., when the plants are over watered or there is too much rain. This leaching has the potential to have a negative environmental impact and so the researcher investigated what might happen if this occurs. The results are shown in Figure 5.41.

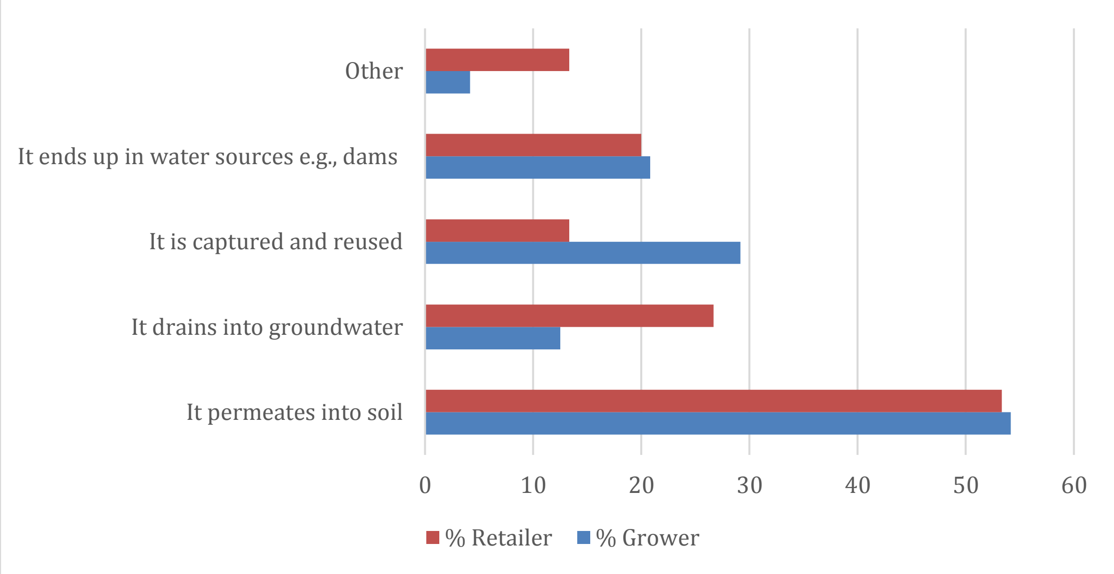

Figure 5.41: The result of excess or leached fertilizer

From Figure 5.41, it is noted that if leaching occurs more than 50% of the excess fertilizer in both the production nurseries and garden centre retailers, permeates into the soil with the potential to cause soil pollution or added extra elements and minerals. For 20% of garden centre retailers and slightly more for the growers it ends up in their water sources where it can be used by other plants and / or cause soil and water pollution e.g., Business 14 wrote "*fertilizer that is in the system is irrigated onto the lawn and garden beds"*, thus reused. Leaching or over fertilizing is a financial loss to the businesses as well as having the potential to be an environmental risk and so is avoided by the participants.

Two retail garden centres mentioned that they removed certain fertilizers from their garden centre shelves namely: superphosphate, LAN and / or 2:3:2 fertilizers as they have the potential to over phosphate the groundwater because of over-use by customers. For the same reason, Business 19 also did not stock superphosphate.

The obstacles preventing the sample from using fertilizer effectively are shown in Figure 5.42. Most growers have no obstacles, and those that do, say it is costly to make infrastructural changes e.g., drainage channels or build retention dams with biofilters.

- Business 3: "capital investment required to remodel nursery"

- The application effectiveness and ease of use are the second most prevalent obstacle for growers. For the garden centre retailers, the lack of training is an obstacle, e.g., Business 40 wrote "*lack of knowledge on all fertilizers available and the different methods to apply the fertilizer.*"

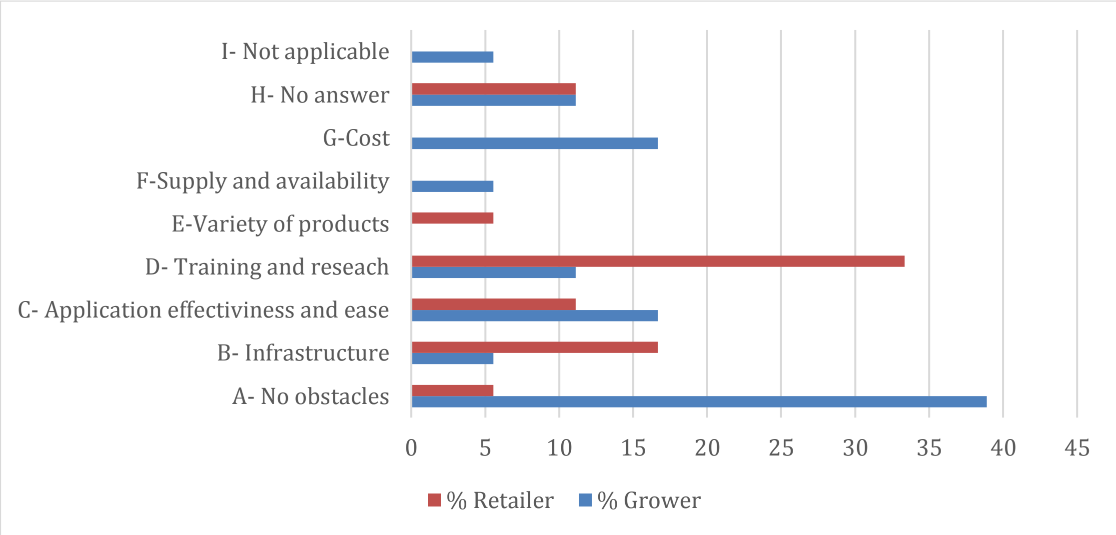

Figure 5.42: Obstacles to using fertilizer optimally by participants

Photographic evidence from the site visits that highlights the key points discussed above and reduces the bias and improves authenticity of information found in relation to the fertilizer is shown in Appendix 15.

5.8 The results from the pesticides-related questions, interviews, and site visits

The intensive nature of ornamental horticultural plant production and quality plant sales often results in the use of pesticides to prevent plant damage and crop loss. Pests can be fungi, bacteria, insects, birds, reptiles, mammals, viruses, vectors (Dent, 1995) and plants (weeds). There are a variety of different methods and mechanisms used to kill these pests. Pesticides are formulated for this purpose and thus there is *"no such thing as a safe pesticide"* (Gerber, 2006), but the risks to humans and the environment are minimised by the use of an integrated pest management (IPM) strategy.

Globally, case studies have been conducted on life cycle assessment (LCA) of pesticides which revealed that pesticides are contributing to ± 70% toxicity in humans and 50% toxicity in freshwater ecosystems (Foong *et al.*, 2022).

South African agriculture plays a vital role in global crop production especially of high-value horticultural crops e.g., pears, citrus, and green maize for export. To maintain the productivity and the quality of the plants and produce, pesticides are used (Degrendele *et al.*, 2022). South Africa is the largest consumer of pesticides on the African continent (Food and Agriculture Organzation (FAO), 2021) and due to its semi-arid nature and water scarcity it has a high risk of pesticide pollution which will affect all organisms and natural resources within the habitat (Tang *et al.*, 2021). With this in mind and similar to fertilizer usage, pesticide registration, use and disposal is strictly regulated in South Africa.

During the research, the participants were asked their awareness, knowledge, and use of pesticides within their businesses.

The Fertilizer, Farm Feeds, Agricultural Remedies and Stock Remedies Act, together with the use of fertilizers and nutrient management is also relevant in this section, particularly the part which states that, *"No person shall for reward or in the course of any as substituted industry, trade or business- by section 8 of (i) use, or recommend the use of, any agricultural remedy or stock remedy for a purpose or in a manner other than that specified on the label on a container thereof or described on such container; (ii) use any agricultural remedy unless he is a pest control operator registered in terms of this Act or otherwise than in the presence and under the supervision of a pest control operator"* (South African Government, 1947). Business 16 stated that *"During training sessions especially with retail garden centres, this information is highlighted as it is usually stressed that the salesperson should set an example and actually open the box and read from the packaging label even if he knows about the product and how to use it*."

In addition to above Act are the regulations prescribed by Agricultural Pests Act (Act No. 36) which is to "*provide measures by which agricultural pests may be prevented and combated*" (South African Government, 1983a). 62.5% of the growers and 47% of the garden centre retailers in the sample are familiar with this Act (Figure 5.43).

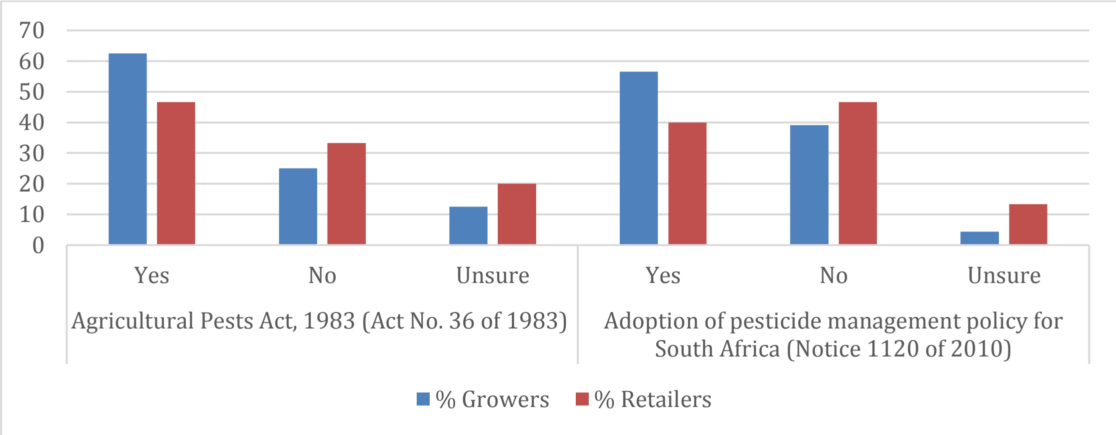

Figure 5.43: Knowledge of Acts and policy related to pesticides in South Africa

The related policy adoption (2010), which is to ensure that pesticides are used in a manner that reduces their negative effects on human health and the environment is slightly less known, 56.5% and 40% of growers and garden centre retailers respectively.

The knowledge and application of the policy is important in the achievement of sustainable development goals (Figure 5.44):

Figure 5.44: Sustainable development goals related to pesticides

This research showed that 91.7% of the growers and 94.1% of the garden centre retailers do use pesticides (Figure 5.45). Pesticides are not used by 4.2% of the growers and 5.9% garden centre retailers in the sample. The reasons stated are that they are harmful to the environment and the plants do not stay in the business long enough for pests to be a problem.

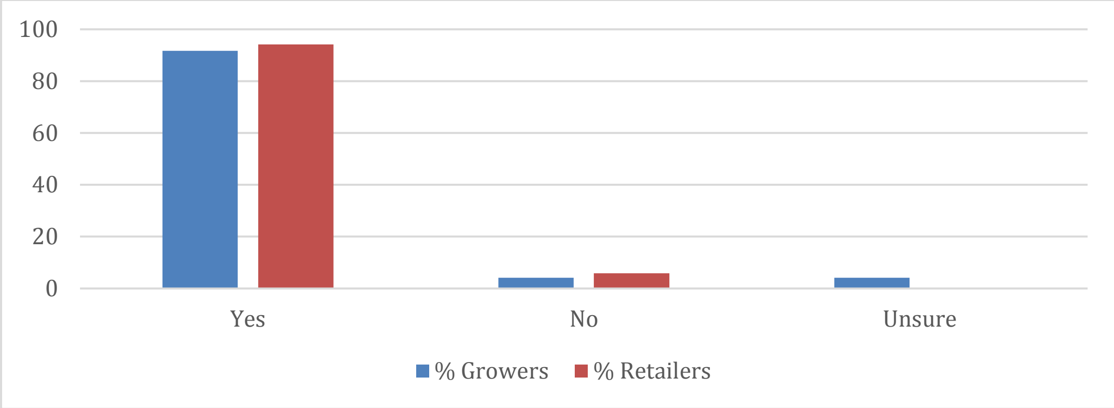

Figure 5.45: Do you use pesticides in your business?

During the discussions with the growers and garden centre retailers, it was noted there is a move away from harmful pesticides e.g., certain retail garden centres do not sell “Round up” any longer and the growers are trying to use more and more biological controls in production greenhouses. Biological pesticides are those that are bacteria, insect, fungi (living predators) which attack plant pests, hence they have a short lifespan. Natural pesticides are those made from either natural products e.g., oils or pyrethrin. A few of the growers stated that many biologicals are not easily available or registered for certain pests which causes challenges for the businesses trying to achieve more environmentally friendly practices. Figure 5.46 displays percentages of the broad categories of pesticides used by the participants.

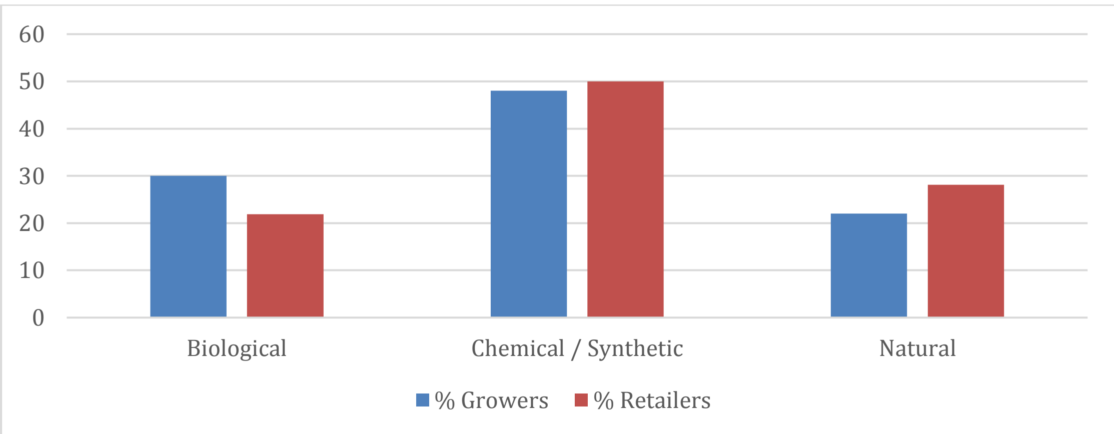

Figure 5.46: Preference as to type of pesticides used

The type of pesticides used, whether it be chemical or natural (organic) still has the intended purpose of killing the pest and if they are used incorrectly, they can do harm to humans and the environment. An example is canola oil, which is often part of a natural remedy and used to block the breathing organs of the pests but if this is sprayed near water, the oil droplets will negatively affect the aquatic life in the pond or river (Gerber, 2006).

This is why Business 14 mentions “efficient weed control to control of insects”. Business 40 stated that: “pollution is an important concern in terms of pesticides and herbicide use however organic is not always as effective and often more costly.”
Depending on the plant species grown, Business 22, wrote that, “the use of biologicals wouldn’t work because of quick turnaround time of colourful perennials and so the biological won’t have a chance to multiply.”

- Business 3: “no spraying of pesticides during the flowering season”
- Business 6; uses *“free range chickens as pest control”* and other naturally occurring birds e.g., dikkops, guinea fowl and plovers to eat snails and slugs which could damage plants
- Business 11: grows a specific plant species and mentioned that they “use biological products mainly and have not sprayed a chemical pesticide for 2 years. We also use beneficial insects”
- Business 12*: “only uses organic fertilizers and biological pesticides”* as majority of their plant species grown are edibles
- Business 23: mentioned that “farmers spray at night to cause less harm to beneficial insects e.g., bees. They plant lavender and perennial basil to encourage pollination by beneficial insects of fruiting crops”
- Business 26: “do as preventatively as possible to not make use of any red labelled pesticide products”.

More growers (53.1%) than garden centre retailers (31.6%) use pesticides preventatively (Figure 5.47). It is vice versa with regards to curative treatment as when plants arrive at the garden centre retailers, they should always be pest and disease free, if not, the receiver would return them and so it is only when the plants show signs of pest damage are they treated for that specific pest, thus

68.4% of the garden centre garden centre retailers treat pests curatively compared to 46.9% of growers.

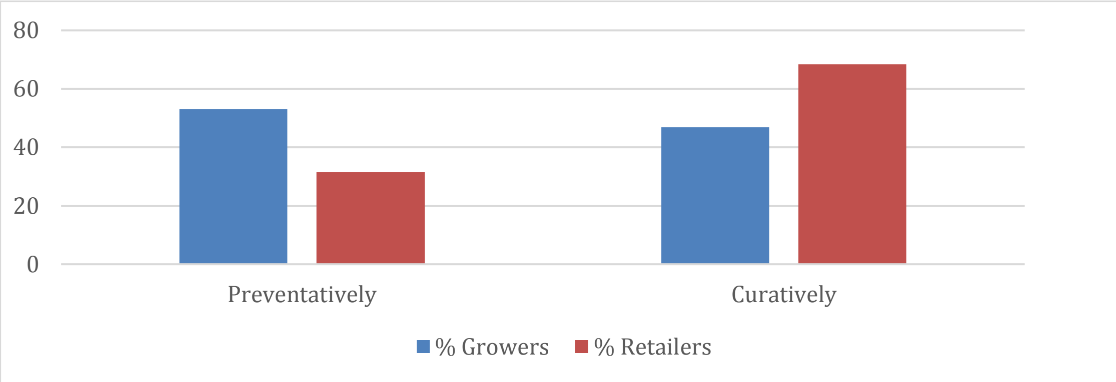

Figure 5.47: Treatment of plants for pests - preventatively or curatively

- Business 25: sprays neem oil weekly as a preventative.
- Business 24: uses *"garlic oil"* for the same purpose.

Internationally, having an integrated pest management (IPM) system is the way forward both environmentally and economically. The IPM has various sustainable strategies based on scientific research regarding the life cycle of the pest, the environmental conditions favourable to its reproduction and technology available to make decisions which minimise damage to plants, people, and the planet. The results from the research of the participants in the study show (Figure 5.48) that 50% of the growers have an integrated pest management plan and only 21.4% of the garden centre retailers do.

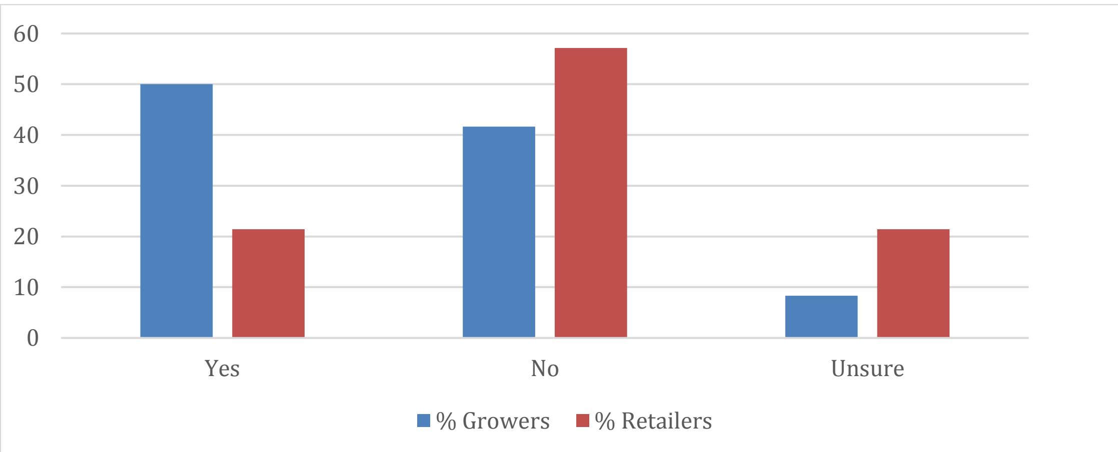

Figure 5.48: Do you practice integrated pest management strategies?

From the results and the interviews with the participants, the garden centre retailers believe that they do not have to have an integrated pest management strategy as they receive healthy plants from the grower and hopefully sell them before any pests can attack them. If this isn't the case, they treat curatively and usually with an organic pesticide as reflected in the result above.

The growers on the other hand are more likely to have an IPM but as Business 38 stated*: "first focus on the optimal cultivation practices"* and then use different strategies for pest management as listed in Figure 5.49.

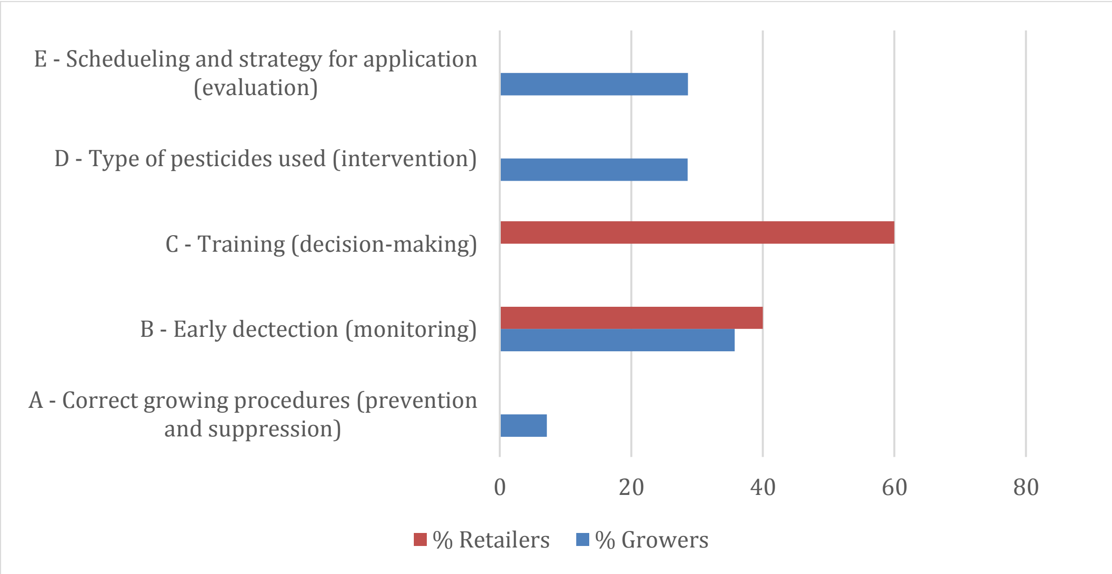

Figure 5.49: IPM strategies suggested by sample

Some of the methods listed above match those recommended principles of IPM (Barzman, Bàrberi, Nicholas, *et al.*, 2015):

a. **Prevention and suppression** – as mentioned above by Business 38 – optimising cultivation practices and preventing attack from pests.
b. **Monitoring** – scouting (Business 23) - daily visual observation and using thrips strips or bug tape (observation) (Business 1, 5, 14 and 36). Forecasting problems and predicting methods of treatment Business 1, 4, 5, 15 and 36.
c. **Decision-making** – based on plant varieties using multiple measurement methods and threshold allowances.
    - Business 4: "only one person is allowed to measure out, only one person spraying and specific measuring out for specific pesticides."

d. **Intervention** – biological *"predators released into tunnels*," (Business 23), organic, then chemical with a reduced amount of pesticide being used thus causing as little damage to the environment as possible. Also changing the active ingredient used to reduce resistance build-up in pests. This is done systematically and strategically e.g., Business 37 *"we start with biological control and if not successful treat curatively on infected plants".*

e. **Evaluation** – record the process and products used and the effectiveness of them to accurately assess strategies and make necessary changes for improvement.

Resulting from the recommendations made by the European Commission, South Africa has legislation on the methods of disposal of pesticides that are not used or have expired. One grower mentioned that this was a *"big problem"* (Business 26) and went so far to include *a "chemical waste disposal"* as part of his environmental management change if cost was not a factor. Although this is the case, participants in the study said that they disposed of the pesticides and their containers using the following methods (Figure 5.50).

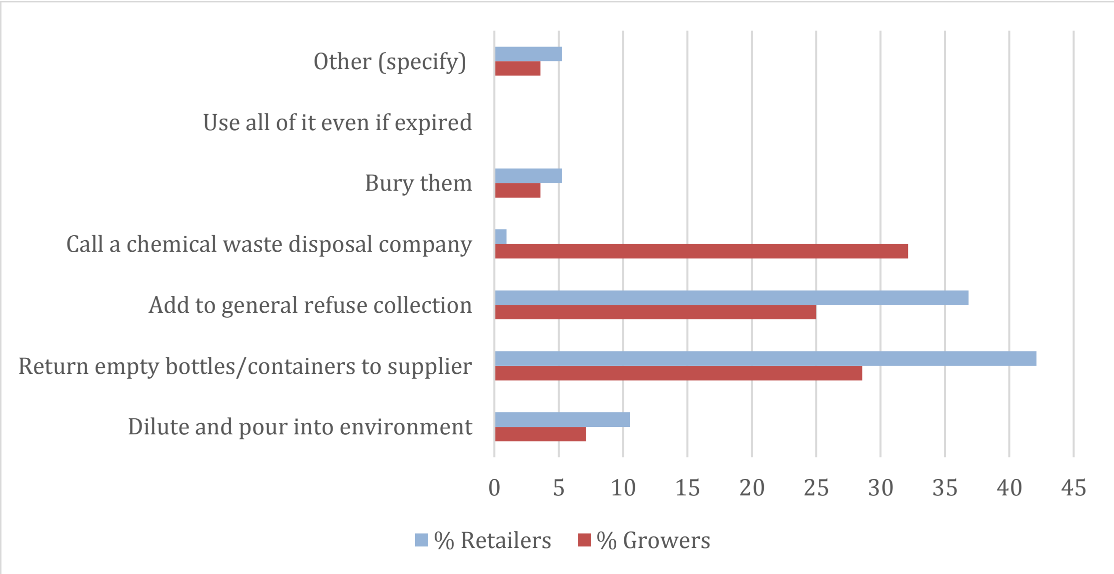

Figure 5.50: Disposal of pesticides and their containers by sample

Again, the practices of the participants in the study show a different aspect of their knowledge. Although they do not acknowledge knowing the regulations, from the responses received, most of them do practice within the confines of the law:

- Business 2: answered that “as per legislation they record all chemicals used”
- Business: 1, 36 and 38 and a few others stored pesticides in a dry room with a concrete flooring under lock and key
- Business: 26 stated that, “chemicals mixed on concrete to prevent soil contamination”
- Business: 1, 5, 11, 30 and 32 “dispose of pesticides correctly by either returning them to the supplier” or sending them to a “specialised chemical waste disposal company”
- Business: 2, 6, 23 and 38 said that they washed, then punctured holes into the empty container so that they could not be used again before adding them to the general waste. Others similarly said: it was only when the bottles were completely empty, and the containers had been rinsed were they added to the general waste
- Business: 38 suggested the ideal solution would be as is practiced in “Denmark where a “BioBed” is built, and you pour chemicals into environment, and it comes out clean “.

Photographic evidence from the site visits that highlights the key points discussed above in relation to the pesticide usage and storage by participants in the study is shown in Appendix 16.

5.9 Results from waste and recycling-related questions, interviews, and site visits

In the production and selling of a healthy plant, by-products and waste are generated. Using the principles of a circular economy and waste management strategies such as reduce, reuse, recycle, repair, rot, remanufacture and regenerate, the ornamental horticultural industry can make a difference. The growers of SANA were asked at a meeting in 2017 whether they would like training regarding recycling - they did not feel it was as important as water, fertilizer and pesticides (Appel, 2017) but when asked again during the informal interviews in 2021, it was affirmed that the industry has to take steps to better manage their different waste products e.g., plant material, pots and trays, growth media, pesticides and chemicals, and office related products etc.

As with the other factors the researcher tried to determine awareness of waste legislation to see if it was the catalyst that changed behaviours and business practices. As can be seen in Figure 5.51, 57.1 % of the garden centre retailers and 33.3% of the growers are aware of this legislation. During the interviews when asking about waste disposal, a few of the growers from the more remote areas mentioned that they did have problems as there was no waste management services provided for by the municipalities as was the case in the more urban areas.

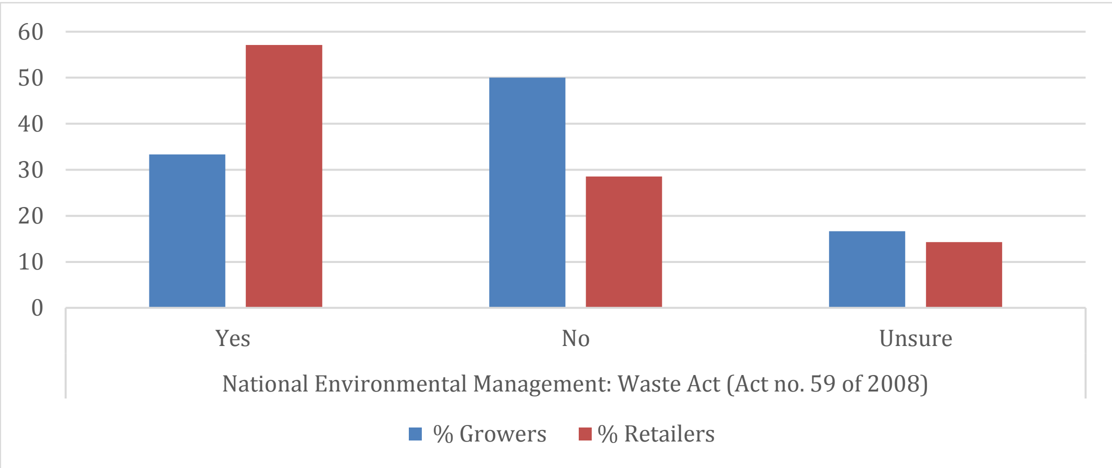

Figure 5.51: Awareness of legislation regarding waste

The premise of the Act is to "protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development" (South African Government, 2008b). As mentioned in the previous section on pesticides this Act is evolving to incorporate more sustainable measures and corporate or company responsibility from the creation to the end of a product's journey. To reduce waste and minimise the effects of pollution from a business there should be a policy whereby company employees know how to best manage the various waste products they encounter within the company.

The participants in the study were asked about their waste management policy, and the results are reflected in Figure 5.52.

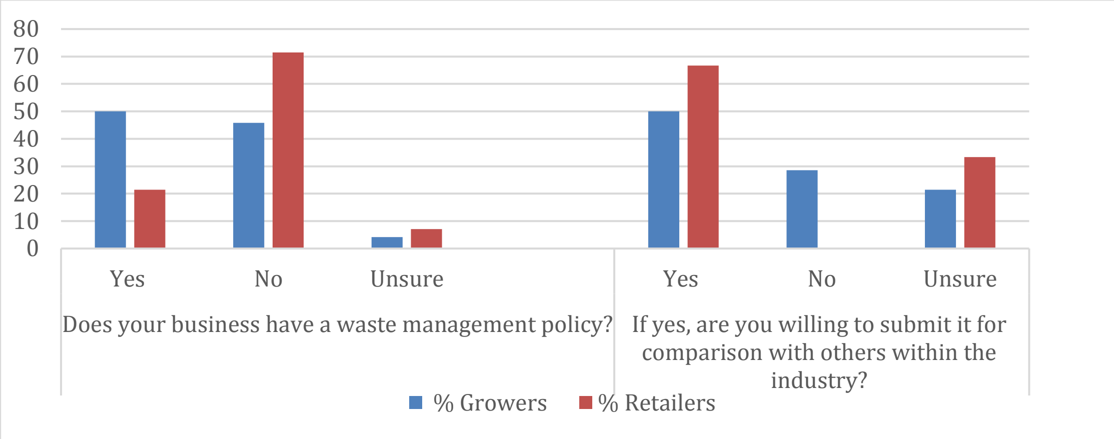

Figure 5.52: Presence of participants policy on waste and their willingness to share

An interesting observation here is that although fewer growers are aware of the legislation, there are 50% who have a waste management policy compared to the garden centre retailers, where only 20% had one.

- Business 16: said their policy was a “verbal arrangement” and “return trays and pots to supplier”.

As part of a waste reduction strategy, the sample was asked if they recycle or reuse any products involved in the production and / or selling of their plants, which are either by-products or waste. Figure 5.53 shows that all growers recycle or reuse certain waste products within their business and 92.3% of the garden centre retailers do the same. These figures show that the participants in the study are already working towards sustainable development and reducing their environmental footprint.

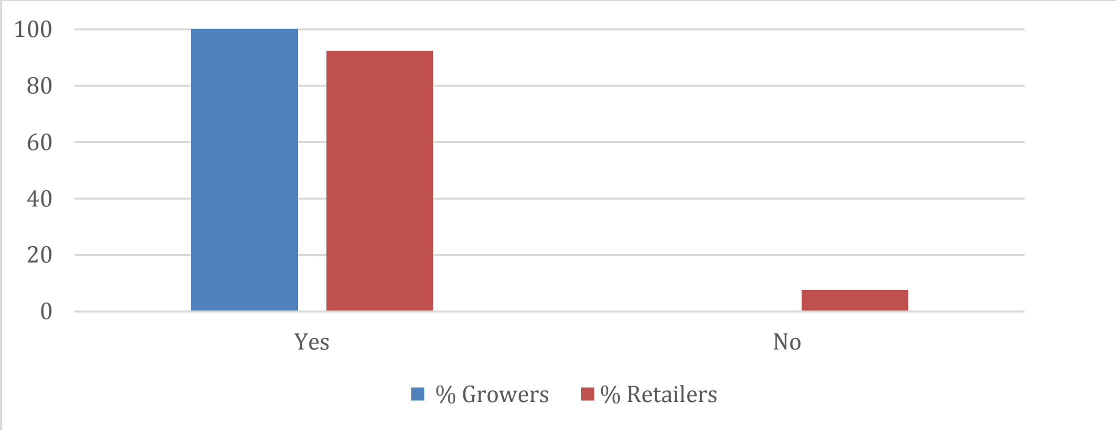

Figure 5.53: Do you recycle or reuse any products involved in the production and / or selling of your plants, which are either by-products or waste?

The variety of products that the participants reduce, reuse, recycle, repair, rot, remanufacture and regenerate are shown in Figure 5.54. The majority of what the growers recycle is a direct reflection on their business practices e.g., pots, soil, and plastic bags.

- Business 37 stated that they "*reused their pots at least 3 times compared to the plastic bags which were single use and ended at the municipal dump.*"

The garden centre retailers have a much more varied recycling regime, but plastic pots, cardboard and related packaging are high. Soil follows next in the top three products recycled. One garden centre retailer even bought an old Volkswagen beetle that would have gone to scrap metal and was using it as a planter and part of a display at the front of their garden centre.

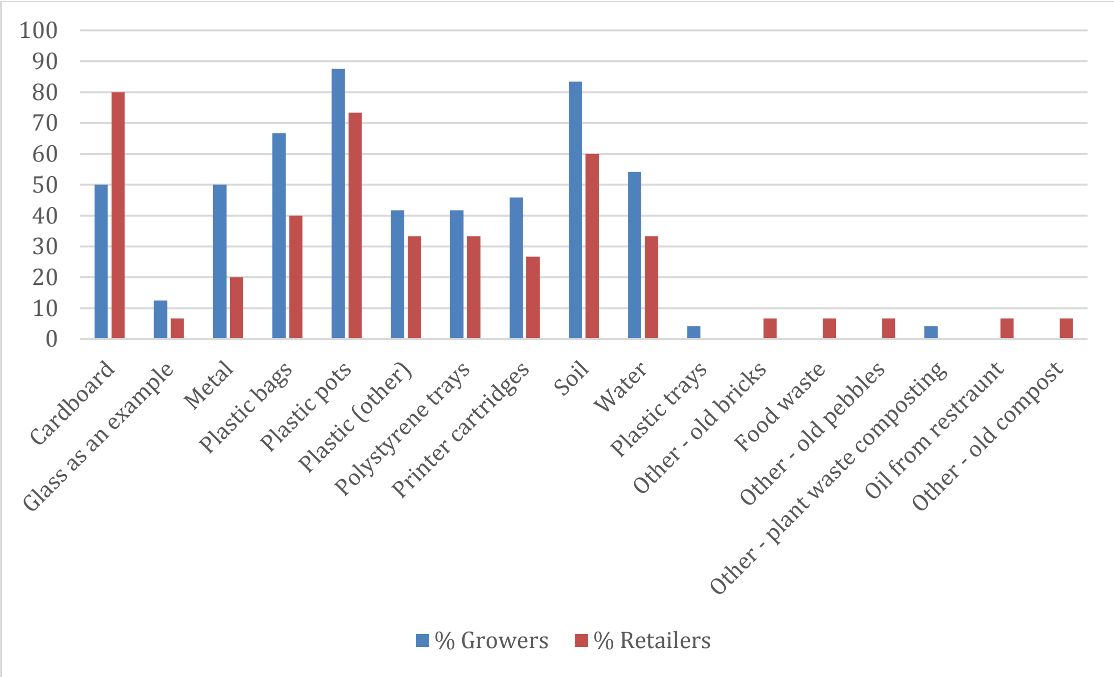

Figure 5.54: Products which are recycled by participants

The way the participants reduce their waste was different and these methods are highlighted below in Table 5.12.

Table 5.12: How materials, products and resources are reused

Material or product to be reused or recycled and methods used by workplace		Material or product to be reused or recycled and methods used by workplace
Cardboard		Polystyrene trays
Employees collect & sell it Business 22		On-site collection Business 22
Recycle collection company / persons (Waste pickers) Business 5, 7, 8, 13, 15, 19, 27 and 32		Clean & reuse Business 5, 25 and 26
Recycling depot Business 30 and 36		Use as flooring in tunnels Business 40
Composted Business 28		Printer cartridges
Packing material for loading Business 2, 4 and 17		On-site collection Business 22
Glass as an example		Back to supplier Business 14, 15, 32 and 37
Recycle collection company Business 27, 30 and 32		Refill Business 8, 16, 26, 30, 36
Metal		Soil
Employees collect & sell it Business 22		Reuse in larger containers Business 22 and 36
Sold for scrap Business 8, 21, 28, 32 and 37		Reuse Business 2, 4, 8, 19, 21, 24, 28 and 40
Recycle collection company / persons Business 5, 15 and 30		Make compost Business 5 and 31
Reused to build new equipment Business 26		Fumigate & use again Business 37
Used to make concrete products Business 17		Re-decompose Business 30
Old equipment used for displays Business 4 and 35		Reuse in landscapes & gardens Business 25, 35 and 38
Plastic bags		Sold to someone who makes compost Business 14
On-site collection Business 22		Sterilize & reuse Business 20
Recycle collection company / persons Business 15, 16, 32 and 34		Sent back to grower Business 16
Reuse Business 8, 11, 24, 25, 28 and 40		Used in displays Business 17
Use biodegradable bags which are made from recyclable material e.g., brown paper bags Business 19		Water
Given to schools or anyone in need Business 35		Reuse in trees Business 22
Plastic pots		Recapture & use on-site Business 5, 28, 30, 35and 37
On-site collection Business 22, 37		Goes back to the river Business 25
		Dams Business 15

Material or product to be reused or recycled and methods used by workplace		Material or product to be reused or recycled and methods used by workplace
Plastic pots		Water
Washed & reused Business 5, 8, 19, 21, 24, 28, 31and 32		Underground drainage Business 4
Cleaned, steamed & reuse Business 14		Designated catchment area Business 8
Recycle collection company / persons Business 15and 34		Other
Give to customers for free Business 13 and 17		Other – old bricks – sold for drainage Business 4
Bin for customers to return old pots Business 4		Old pebbles bags – sold as bulk gravel Business 4
Sent back to grower Business 16		Plastic (other)
Used in displays Business 35		On-site collection Business 22
Given to schools or anyone in need Business 35		Recycle collection company / persons Business 4, 5, 14 ,15, 16, 34 and 37
		Recycle depot Business 17, 28 and 30

- Business 35: has their benching made from recycled plastic.
- Business 7: used to upcycle pallets for benching but now is converting to steel benching which has a longer lifespan.
- Business 18: sterilises his pots and trays by rinsing them in a sunlight liquid mix and drying in sunlight and by doing this, he can reuse them for at least 7 - 8 cycles.

The purpose of recycling and reusing the by-products using the methods mentioned in Table 5.12, for the participants was either to create an income or reduce input costs (Figure 5.55). The reduction in input costs was the majority reason provided by both growers 85.2% and garden centre retailers by 53.8%.

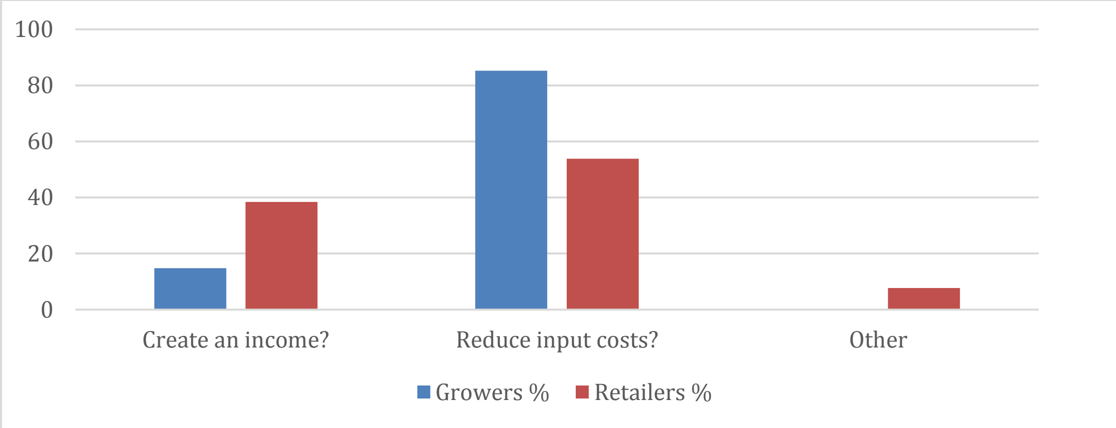

Figure 5.55: What is the purpose of recycling and reusing?

Photographic evidence of recycling and waste management strategies assist with the triangulation of the information investigated during the study, see Appendix 17.

- Business 16: “use newspaper or cardboard boxes instead of plastic boot liner in our customers cars”
- Both Business: 2 and 41 wished for an “efficient refuse composting system” on their premises.

5.10 Is there a need for a Best Practices Manual for the Ornamental Horticultural Industry of South Africa?

The results from this chapter reflected the answers of the participants from the questionnaire, site visits and informal interviews.

The feedback results from the participants (growers and garden centre retailers) point to many gaps, areas for improvement and new applications within their businesses. This provides for an ideal opportunity within OHISA members to develop both policies and procedures. These could be informed by an industry based best management practice document.

The feedback results from OHISA participants, were then actually used to create a best practices manual which will encourage members of the horticultural industry of South Africa to write and implement policies on how best to achieve the relevant sustainable development goals for each factor.

5.11 Conclusion

The findings from the mixed-methods research described in Chapters 3 and 4 are presented in this chapter. These are portrayed using charts, figures, and tables to represent the evidence that was collected from the questionnaires, interviews, site visits and document analysis. These results were given in relation to the key indicators which thematically grouped the data together namely energy, water, growth media, fertilizer, pesticides, and waste with respect to the ornamental horticulture industry in South Africa. The analysis in relation to global best practices, current OHISA practices and other information highlighted during the literature review will be assessed in Chapter Six.

The results show that the triangulation of knowledge, awareness and practices (KAP) documented from the questionnaire, recorded during the site visits and investigated via observations at the businesses and related document analysis confirmed that there is a definite need for awareness, knowledge sharing and practical implementation with respect to the relevant sustainable development goals for environmental conservation within the ornamental horticultural industry of South Africa. The development of written policies related to resource usage and pollution minimisation to enhance the environmental responsibility practices of the industry, will in the long-term, increase productivity and profitability no matter how small the steps are that the business takes towards sustainability.

In Chapter six, these results are compared to the information from the literature review and conceptual framework e.g., other best practice manuals related to the ornamental horticultural industry or documentation of sustainable development goals and best methods to achieve these.

Chapter 6: Comparing International BMP Data and Additional International Horticultural Research with OHISA Data (Results and Discussion).

6.1 Introduction

The design of this Chapter examines results and analysis of international best practices when considering aspects of the energy, water, growth media, fertilizer, pesticides and waste management.

Humans are living beyond the carrying-capacity of the natural environment so that the use of limited natural resources, excessive emission of waste products causing pollution as well as land degradation has negatively affected the self-restoration capabilities of the planet (Meyer & Newman, 2020). These global problems, exacerbated by population growth, unsustainable use of resources and climate change (shown in Chapter 2, Figure 2.1) impact South Africa.

As a result, agriculture is one of the industries most affected by variation in rainfall and temperature associated with climate change (Gohar and Cashman, 2016; Celik, 2020). As discussed in Chapter 2, strategies to ensure food security and strive towards the soil-water-food-energy nexus must be implemented so as to offset the negative environmental impacts of current crop production methods (Hatfield, Sauer and Cruse, 2017; Kopittke *et al.*, 2019).

Likewise, the cultivation of ornamental horticultural plants is energy intensive, especially if greenhouses and tunnels are used. Although they do have a reduced environmental impact, high volumes of materials and resources are used to produce quality pot plants and even landscape plants (Darras, 2020). Thus, ornamental horticultural practices must evolve to improve their use of natural resources in the production and sale of ornamental plants and to reduce negative environmental impacts. Fortunately, ornamental horticultural products contribute a wide range of benefits such as enhancing social and human lifestyles by improving the environment in which people live (Lillywhite, 2014). In addition, they absorb carbon dioxide and other pollutants and release oxygen, they provide beauty, act as filters, and regulate temperatures of their surroundings (Maxime et al., 2014).

The advantageous benefits from plants should be used to counteract the negative environmental impact in their production. The present research indicated that environmental sustainability is important to study participants from OHISA who supported "*minimal or no negative impact on the environment"* and *"going green"* - sentiments similar to those recorded by the participants in the nationwide survey in the United States over a decade ago (Dennis *et al.*, 2010).

From the early 2000's, international best practice manuals highlighted environmental concerns with most manuals being written between 2005 and 2015, mainly in the United States, Canada and Australia (Smith and Lopes, 2009; Yeager *et al.*, 2010; Johnson, Mangiafico and Obropta, 2011a; Southern Nursery Association, 2013; Florida Department of Agriculture and Consumer Services, 2014; Maxime *et al.*, 2014; Virginia Tech & Virgina State University, 2015). European countries and Australia focused on the implementation of environmental and social standards as well as legislation in adherence to global and national regulations that prompted a move towards more sustainable horticultural practises. These included the Nursery Industry Accreditation Scheme Australia (NIASA) (1995) that promoted best management practices for production / growing to improve efficiencies while reducing environmental impacts (Nursery and Garden Industry Australia Ltd., 2009). Aligned to this and to help nursery-related businesses improve their environmental management was ECOHORT certification and guidelines (Horticulture Innovation Australia and Nursery & Garden Industry Australia, 2018) as well as the Milieu Programma Sierteelt (MPS) prescribed by Dutch growers and auctions in 1995, the GLOBAL GAP certification recommended by British chain stores in 2003 to which growers should adhere when selling floricultural and horticultural products, as well as the Veriflora (2005) certification stipulated by the American growers and retailers (Darras, 2020).

Best practice manuals and certification procedures have evolved over time from focusing initially on efficient water use within the industry (Nursery & Garden Industry Australia, 2010; Florida Department of Agriculture and Consumer Services, 2014) to then include many of the different aspects of sustainable development such as social (working conditions, liveable wage etc.,) and environmental (GHG emissions, efficient water use, pesticide free etc.,) developments (Briercliffe, 2017; Kumar *et al.*, 2017; Wani *et al.*, 2018; Eisenmenger *et al.*, 2020; Bonaguro *et al.*, 2021; Nursery & Garden Industry Australia, 2021). Table 6.1 shows the evolution of this change per country or region.

Table 6.1: Referenced list of ornamental horticulture best management practices through to sustainability.

	Year	**Title of BMP or sustainability paper, reports, or recommendations**
Australia	2010	Nursery Industry Water Management Best Practice Guideline by the Nursery & Garden Industry Australia (Nursery & Garden Industry Australia, 2010)
	2014	Nursery and Garden Industry Australia Environmental Sustainability Position (Nursery and Garden Industry Australia) Ltd., 2009; Nursery & Garden Industry Australia, 2014
	2018	Guidelines for Managing the Environment (Horticulture Innovation Australia and Nursery & Garden Industry Australia, 2018)
	2021	The Australian-grown Horticulture Sustainability Framework (Horticulture Innovation Australia, 2021)
Canada	2013	A National Strategy for Ornamental Horticulture Research and Innovation (Canadian Ornamental Horticultural Alliance) & Vineland (Canadian Ornamental Horticultural Alliance and Vineland Research and Innovation Centre, 2013)
	2014	Environmental Best Practice for the Canadian Ornamental Horticulture Sector (Maxime et al, 2014)
	2014	Phytoserv's publication for Growers – irrigation and water related articles (West, 2014, 2019, 2020)
	2018-2021	Ornamental Horticulture Research and Innovation (Canadian Ornamental Horticultural Alliance, no date)
	2021	Ontario Horticulture Research Priority Report (Aalbers and Morse, 2021)
United States	1996	Southern Nurseryman Association BMP 1996, 2007, 2013 (Southern Nursery Association, 2013)
	2009	BMPs for Nursery Crops (Massachusetts) – Nutrient management revised in 2014 (Smith and Lopes, 2009)
	2010	Florida Best management practices: past, present, and future (Yeager et al., 2010)

	Year	Title of BMP or sustainability paper, reports, or recommendations
	2010	Sustainable Production Practises Adopted by Greenhouse and Nursery Plant Growers (Dennis, et al., 2010)
	2011	BMPs for Climate Friendly Nurseries (Oregon) (Rideout et al., 2011)
	2011	Protecting Natural Resources at Field Nurseries (New Jersey) (Johnson, Mangiafico and Obropta, 2011b)
	2013	Master Gardener Recommended Horticulture Best Management Practices, (Virginia Tech & Virgina State University, 2013, 2015; Mack et al., 2019)
Italy	2014	Assessing environmental impacts of nursery production (Beccaro et al., 2014)
	2016	Green House Gases (GHG) emissions from the ornamental plant nursery industry (Lazzerini, Lucchetti and Nicese, 2016)
	2021	Environmental Analysis of Sustainable Production Practices Applied to Cyclamen and Zonal Geranium (Bonaguro *et al.*, 2021)
New Zealand	2015	Sustainability in the New Zealand horticulture industry (De Silva and Forbes, 2016)
	2018	New Zealand Plant Producers Incorporated (New Zealand Plant Producers Incorporated, 2018a)
South Africa	2012	Waterwise partnership Project (Rand Water and South Africa Nursery Association, 2012)
	2014	Woolworth Farming for the Future (King and Thobela, 2014)
	2016	Best Practices Guidelines for nurseries regards pesticide use (Croplife) (SANA, 2016)
		Recycling company details (SANA, 2016)
	2019	SIZA Environmental Standard (Suitable fruit farming) (World Wildlife Fund, 2019)
		Invasive species documentation, 2015, 2021 (Invasives South Africa, 2021)
Germany	2020	Sustainability challenges and Innovations in the Value Chain of Flowering Potted Plants for the German Market (Havardi-Burger, Mempel and Bitsch, 2020)
United Kingdom	2022	The Horticultural Trades Association (Horticultural Trades Association, 2022)
	2021	RHS Sustainability Strategy (Griffiths, 2021)
	2022	Environment (Hillier Nurseries Limited, 2022)
Netherlands	2021	Milieu Programma Sierteelt (MPS and LetsGrow.com, 2021) - Floriculture Environmental Programme

Table 6.1. shows that a standard or baseline was set by the use of best management practices and there has been a movement from efficient non-renewable and / or natural resources use to collaborating with local governments to strategize on how to adopt national and suggested international goals e.g., the sustainable development goals.

Following on from the literature collected and described in Chapter 2.4.1 and the document analysis (4.5.4) in Chapter 4 which showed to process involved in the development of the themes and how these were focused into more specific key terms or factors (4.7.2). With this background, Chapter 6 shows the comparison and analysis of information but it was not a straightforward process and, as a result, information comparing OHISA and international practices analysed and compared cannot be presented in the same format for each of the factors analysed.

Using the above listed documents, publications, research articles, common themes, environmental indicators, hotspots, key resources and webinars from international horticultural associations and research, a pie chart was created (Figure 6.1). This pie graph represents the key indicators mentioned in each studied resource as a percentage indicating their importance with regards to environmental challenges linked to the global ornamental horticultural industry.
These have been described both internationally and locally throughout this present research and include energy, water, growth media, fertilizer, pesticides, and waste management.

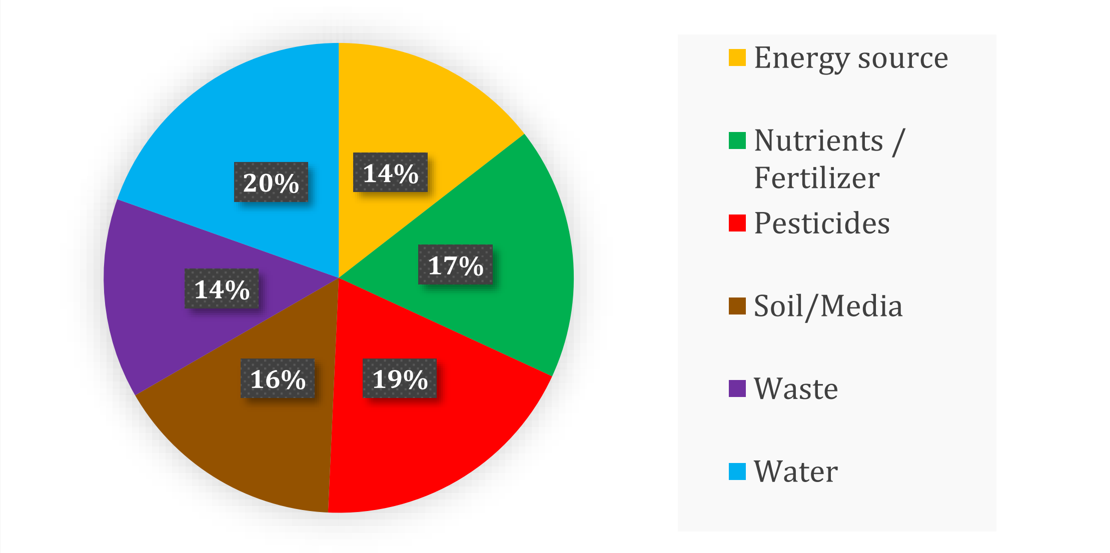

Figure 6.1: Relative importance of environmental sustainability factors emphasised in international research literature

Each of these indicators has been investigated to look for commonalities and differences between OHISA and international practices, using the results from Chapter 5 as representing the South African ornamental horticultural situation. Many of the challenges that OHISA face have been highlighted by other countries, and the manner and methods that they have applied to overcome or further investigate them is discussed below.

As was done in the earlier years of development by members of the ornamental horticultural industry in the United States, Canada, and Australia (see Table 6.1), a best management plan was developed. As can also be noted from Table 6.1, once the knowledge and practices were described and implemented from the best management practices, these then evolved in more recent literature into sustainability practices and life cycle assessments of the products, thus working towards the achievement of relevant sustainable development goals. This prompted the researcher to follow suit to develop a manual of best practices for use in South Africa by OHISA members that is uses the KAP model and is focused on improving sustainable environmental awareness (attitude) and increasing knowledge which, in turn, will promote positive behaviour (practice) change towards the environment. In trying to "kill two birds with one stone" the practices in the manual were linked to sustainability through the writing of environmental policies and implementation of recommended procedures.

This was done because as the results of Chapter 5 showed that, although South Africa has the policies and laws to protect natural resources and the environment, the knowledge of this legislation isn't always evident. This despite some principles having been applied by several members of OHISA. Another reason for the manual using the KAP model as a learning and implementation strategy was that the background, demographics, education, and culture of the South African population and thus, of those within the industry, are diverse and this can result in alternative or unexpected reasons for different attitudes and behaviours towards environmental responsibility (Carlson and van Staden, 2006).

International research has shown that a strong environmental ethic contributes towards behaviour that is environmentally positive within individuals (Young *et al.*, 2010) but it is debatable whether such behaviour is applied in the workplace (Young *et al.*, 2015). With the suggestions from Young (2010) in mind, the present South African study focused on the business strategies and environmental practices and not on individual knowledge and attitudes towards sustainability which might not be a true reflection of understanding of what is happening in the workplace.

This research, then, reiterates the need for the training manual on best management practices not only to improve knowledge but highlight beneficial practices, followed by policy development and procedure implementation to ensure each business can move towards a more environmentally friendly and sustainable future. As the strategies are implemented and each business becomes more confident in their environmental productivity practices, it is anticipated that actual figures can be shared in terms of energy and water usage or rand value per product produced as well as resultant waste. These figures can then be used to set benchmarks towards which the industry should strive, as has been done in other countries as their sustainability awareness improved (Hunt, no date; Sarri *et al.*, 2013).

Chapter 6 first presents a summation of the global environmental problems related to the key indicators and natural resources that they impact on, then compares that information to the local situation happening in OHISA.

In the Canadian study, the greatest contributor to the carbon footprint was energy, then use of plastics, followed by growth media (the sourcing and transporting sphagnum peat moss and perlite for germination and growing of seedlings) and finally irrigation and fertilization - pesticide use and emissions was excluded from the study (Maxime *et al.*, 2014). In Germany, water shortages, pesticide use, and the increasing carbon footprint of products were the main environmental concerns. However, aligned to the Canadian research, the highest emissions of greenhouse gases were caused by the energy needed for heating and transport followed by growth media sourcing (Havardi-Burger, Mempel and Bitsch, 2020). Research from the United Kingdom showed that water has been the focus of sustainability practices since 2008 and different aspects continue to be investigated; integrated pest management since 2010; energy efficiency since 2017 and most recently fertilization in 2019 (Horticultural Trades Association, 2022). This demonstrates the parallels in the key indicators of the international ornamental horticultural industry and OHISA, but the priority (or timing) of the investigations, development and innovation ideas varies from country to country.

This chapter also highlights where the results from the present study as presented in Chapter 5 agree with or differ from international studies and best practices and discusses the reasons. Using global guidelines and best practices, the researcher was able to develop a comprehensive BMP for the South African ornamental horticultural industry to provide OHISA members with the necessary knowledge, best local and international practices as well as documentation to enable a change towards a more sustainable future in the ornamental horticulture industry.

6.2 Discussion and interpretation of results by key indicators in relation to sustainable development goals

As indicated, countries have contributed by varying degrees to sustainability and these efforts are encompassed in the 17 sustainability development goals recognised by the United Nations as part of their 2030 Agenda for Sustainable Development (United Nations, 2015). Figure 6.2 represents the interrelationships between the different SDGs and the foundations upon which they are based, including the biosphere, society, and economy. Although they are separate, working towards achieving one will contribute to the success of another by using smart strategizing and collaborative solutions (Keesstra *et al.*, 2018).

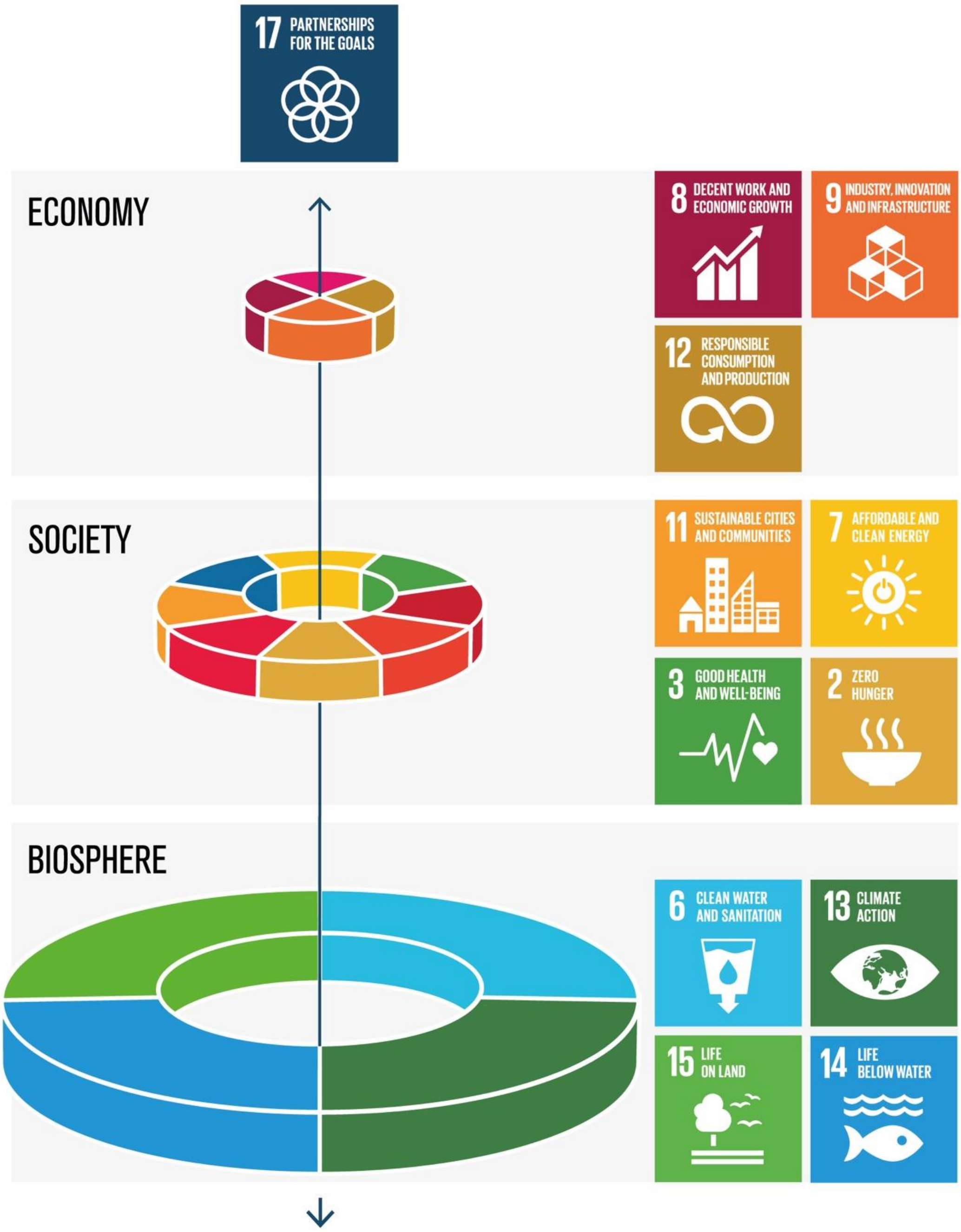

Figure 6.2. An alternative way of interlinking the sustainable development goals (Rockström and Sukhdev, 2016). Image adapted from Azote Images for Stockholm Resilience Centre adopted by author to show those discussed in this study.

Key indicators of the ornamental horticultural industry are common across the globe, and this allowed the researcher to link these to the most relevant sustainable development goals to provide the framework for the present research and the development of the best practices manual for OHISA. These SDGs are listed below:

“GOAL 2: Zero Hunger

GOAL 3: Good Health and Well-being

GOAL 6: Clean Water and Sanitation

GOAL 7: Affordable and Clean Energy

GOAL 8: Decent Work and Economic Growth

GOAL 9: Industry, Innovation, and Infrastructure

GOAL 11: Sustainable Cities, and Communities

GOAL 12: Responsible Consumption and Production

GOAL 13: Climate Action

GOAL 14: Life Below Water

GOAL 15: Life on Land

GOAL 17: Partnerships to achieve the Goal (United Nations, 2015)

Different countries have different sustainability priorities so that, in comparison to the three themes in the Rockström and Sukhdev (2016) model (Figure 6.2), the recently published Australian Sustainability Framework (Horticulture Innovation Australia, 2021) chose four themes to align the Australian horticultural industry with the SDG targets for government, industry and private sector and to show headway made with regards the *“SDG transforming Australia”* report. These were:

- “*Nourish and Nurture: Food to nourish people, plants to nurture communities and safe, traceable and quality?*” synthesise SDGs 2, 11 and 13 and interlink the biosphere and society.
- *“People and Enterprise: productive, profitable growers; safe and ethical work, leadership and governance, innovation, thriving communities, trade and economic value”* link SDGs 2, 4, 5, 8, 9, 11, 12 and 16 to emphasize relationships between society and economy.
- *“Planet and Resources: waste, landscapes, climate, energy and biosecurity”* link all three domains of sustainability via SDGs: 2, 6, 7, 8, 9, 12, 13, 14 and 15.
- *“Less Waste: food waste, packaging and farm waste”* encompass SDG 12 which although a single goal, is achieved by finding nature-based

solutions for goals from the biosphere using creative thinking (SDG 6, 13, 14 and 15) to improve societal challenges using circular economy principles and system feedback loops (Keesstra *et al.*, 2018).

The sustainable development goals stressed in the present research focused on the biosphere and are aligned with environmental concerns of, "planet and resources" and "less waste" from the Australian Horticultural Framework. Others were also included to provide a more comprehensive picture of the relationships between ornamental horticulture, the environment, humans, and economic development. An example of the connections between the SDGs is that the researcher included SDG 3: Good Health and Well-being (United Nations Department of Economic and Social Affairs, 2015) which is part of the societal domain to remind OHISA members that they should strive towards providing a safe and healthy environment, and thereby, OHISA show their taking responsibility for the industry by taking steps to prevent illness and death due to the contamination of resources such as air, water, and soil which are used to provide nourishing food for communities.

Sharing knowledge and skills based on the principles of best practices and the SDGs should also contribute towards sustainability of the environment as well as to that of OHISA. Each of the six key South African indicators highlighted in the present study (energy, water, growth media, fertilizer, pesticides and waste management) has associated practices and SDGs which may coincide or differ from those chosen by the international ornamental horticultural associations (Dennis *et al.*, 2010; Rideout *et al.*, 2011; Wani *et al.*, 2018; Havardi-Burger, Mempel and Bitsch, 2020; Salehpour, Khanali and Rajabipour, 2020) and this is discussed below.

6.3 Discussion related to energy

As mentioned in Chapter 2, publications have described global research into climate change and the detrimental effects it is causing to our environment. This global crisis needs action to be taken now to avert disaster both for the human population and the ecological systems upon which we depend. Green finance and in turn a green economy was introduced to provide opportunities to minimise environmental damage and encourage economic growth in a sustainable manner (Nawaz *et al.*, 2021).

The horticultural industry as a whole is an energy intensive industry as is highlighted by research conducted in Canada (Maxime *et al.*, 2014), Germany (Griffin, 2010; Dominguez, Mibus-Schoppe and Sparke, 2017), Italy (Lazzerini, Lucchetti and Nicese, 2016), Korea (Cho, Kim and Heo, 2015), USA (Oregon) (Rideout *et al.*, 2011) and USA (Massachusetts) (University of Massachusetts Amherst, 2022). These publications highlight the relative amounts of greenhouse gases and air pollutants released to produce a wide variety of plants. Energy is needed for temperature regulation in greenhouses, irrigation and functioning of pumps, machinery e.g., vehicles and office use - these are direct uses of energy. Indirectly, the manufacture, distribution and use of plastic pots and bags, the manufacture of greenhouses either glass or plastic, the formulation and mining of growth media ingredients etc., also requires energy. This has been discussed in Chapter 2 and 5. These environmental concerns aren't restricted to the northern hemisphere, as even the Australia horticultural industry recommended the construction of growing operations that reduced greenhouse gases (GHG) by using more renewable energy resources (Horticulture Innovation Australia, 2021).

The recent results indicated in Chapter 5 confirm this and show that OHISA participants in the study believe that their greatest negative contribution is pollution, namely air pollution, because of the electricity used (coal mines), fuel for vehicles and pollution from boilers and generators. Thus, despite both southern hemisphere countries (Australia and South Africa) having favourable daylight conditions for growing plants, they still rely on electricity and fuel for the growing, transporting, and selling of plants.

The funding of the conversion to a green future relies on policy development and procedural implementation from the public sector and private company partnerships. This was shown in the United States where JP Morgan "committed to $200 billion" to green financing (JP Morgan Chase and Co, 2018). It follows that in the United States the cost of the renewable technologies associated with wind energy and solar energy have dropped by 39% and 82% respectively, because of increased demand, resource availability, reduced costs, government and businesses policy decisions and global and national regulations (Centre for Climate and Energy Solutions, 2021). In Korea research showed that government incentives towards the industry should be changed from promoting the use of petroleum-based products and reduced electricity tariffs to supporting the conversion of horticultural greenhouses to use geothermal heat pumps or even area-thermal heat pumps (Cho, Kim and Heo, 2015). In Australia the nursery industry also investigated solar power, wind energy and biogas as alternative sources for electricity generation, with solar power being preferred (Chen *et al.*, 2017).

Fossil fuels, namely coal, account for 85% of the electricity produced in South Africa and the additional 15% is made up from biomass energy / waste, nuclear and hydro sources (Ndlovu and Inglesi-Lotz, 2020). The latest sources of energy that are being investigated in South Africa are imported liquefied natural gas, local natural gas in the form of coalbed methane and shale gas (Radebe, 2019). In addition, “South Africa has secured $500 million (R9 billion) to aid the just transition from coal to renewables” (Omarjee, 2022). Thus, South Africa has the funds available to transition away from coal to more environmentally friendly and healthier, renewable energy sources and progress towards the achievement of SDG 7.

Table 6.2: Meta-analysis of energy practices relative to SDGs targets

Sustainable development goals	**International Literature Review of Horticultural Industry Practices**	**South Africa (Statistics South Africa, 2019)**	**OHISA (2021)**
Target 7-2 Increase global percentage of renewable energy	In Germany, renewable and sustainable technology can save up to 80% of energy in OHI (Dominguez *et al.* 2017)	14.56% share of renewable energy consumed by SA in 2013	96.3% of the growers in OHISA use non-renewable resources for energy
	Research in Iran showed that diesel usage in boilers and other	26.20% share of renewable energy	3.7% use renewable energy

Sustainable development goals	International Literature Review of Horticultural Industry Practices	South Africa (Statistics South Africa, 2019)	OHISA (2021)
	equipment causes natural resource depletion and environmental damage, and thus alternative fuel sources such as wind energy, solar power, biogas, and biodiesel should be investigated for Primrose production (Salehpour, Khanali & Rajabipour, 2020)	consumed by SA's in 2015	resources within their business to function
Target 7-3 Double the improvement in energy efficiency	Upgrading lighting at Blooming decreased electricity costs by $2200 / annum and offset 11 tons of CO_2 (Rideout, 2011)	2.07TJ / million rand (2011)	Although it isn't double, there is a start to energy efficiency and more growers were keen to change their energy source if costs and security allowed
	Decrease energy usage by 80% by using "modern mechanical and lighting systems" (Idaho, USA) (Kipp and Snodgrass, 2006 ex. Chen et al. 2018)	1.89 TJ / million rand in 2015 energy intensity measured in terms of primary energy and GDP	
Target 7-A Promote access to research, technology, and investment in clean energy	*"Renewable energy production on farms"* is research conducted by the University of Massachusetts Amherst (2022) (Centre for agriculture, Food, and the Environment)	Working for Energy (Biomass Energy) is a project of the DEA which is investigating the use of biomass energy to produce different forms of energy	By combining resources OHISA could learn from the Working for Energy project on how to use biomass to produce energy.
12.C. Explain why inefficient fossil-fuel subsidies are	In Korea, research showed that geothermal heat pumps were most effective in heating greenhouses, followed by	Research has been conducted in the use of renewable resources in	This is a start in this best practices manual

Sustainable development goals	International Literature Review of Horticultural Industry Practices	South Africa (Statistics South Africa, 2019)	OHISA (2021)
provided when they promote harm to the environment. Rather phase these out and encourage renewable energy technologies to be taxed less or grant government incentives for these.	aero-thermal heat pumps which are more reasonable in cost for smaller enterprises (Cho, Kim and Heo, 2015).	Africa but like Korea, there must be policy change from government to encourage and fund development for infrastructure and training to increase knowledge and skills related to it. Solar PV, wind energy, concentrated solar power (CSP), hydro, biogas and biomass energy were investigated with solar power, wind energy and CSP being preferred (Naicker & Thopil, 2019)	

Table 6.2 shows the international horticultural industry is strides ahead of OHISA with regards to energy technology and its efficient use. The reasons for this were briefly mentioned in Chapter 2 as energy related issues were investigated as early as 2010 (Vox *et al.*, 2010; United States Agency for International Development, 2014; Soode *et al.*, 2015; Darras, 2020b) internationally and at that time in South Africa, electricity and fuel were relatively cheap but within the last decade the prices have increased, and availability become inconsistent, resulting in the need for alternative sources.The conversion, (both of South African power producers and businesses, more specifically those within the ornamental horticultural industry) for a more sustainable future and to mitigate the impact of

intensive energy use of fossil fuels on the environment and lessen health risks, must take place.

Originally the idea was to develop greenhouses which provided ideal growing conditions for the plants with minimal impact on the environment (Dominguez, Mibus-Schoppe and Sparke, 2017) but it has been found that the natural resources needed to provide this environment (ideal growing conditions in a greenhouse) are costly – environmentally (land degradation, biodiversity loss and pollution), socially (pollution and waste are detrimental to humans and ecosystems) and financially.

In the United States, there were areas with an unreliable electricity supply which have converted to more cost effective, local sources of power for horticultural production processes. These include a mix of diesel and propane generators, wind energy or solar power generation, biomass-powered gensets, and micro-hydro power, even human or animal energy for pumping and transport (USAID, 2009). This was a necessity as some of the growers in the United States and Canada used 75% of their energy for heating, 15% for electricity and 10% for vehicles (Maxime *et al.*, 2014). From research published in 2010, 58% of the growers using only greenhouses had already implemented energy efficiency strategies such as solar power and alternative lighting (Dennis *et al.*, 2010) and variable frequency pumps and better insulated greenhouse coverings (Rideout *et al.*, 2011). The European horticultural industry implemented some of the following strategies to improve energy efficiency: packing plants in different patterns to increase natural resource utilisation in an area; decreasing container sizes (which was also mentioned in the present study by Business 28 of OHISA) and improving production to reduce losses which would, in turn, improve overall sustainability in addition to energy efficiency (Serra, 1994).

Some participants in the study have already implemented some of the changes e.g., solar power and gas (Figure 5.18 and 5.19) but electricity (mainly produced using coal) was identified by most participants of OHISA as the primary source of energy, followed by diesel and petrol.

The Canadian Horticultural Alliance (Maxime *et al.*, 2014) recommended using nature-based solutions such as trees and shrubs for temperature regulation particularly cooling. Many growers and retail garden centres within South Africa do the same, using plants for temperature control surrounding their tunnels and shade sheds. This not only cools but also provides wind breaks and reduces transpiration as was reported in Chapter 5.

The irrigation systems used in the agricultural industry use an average of 30% of all energy consumed (Rideout *et al.*, 2011) which corresponds with research conducted in Queensland, Australia (Chen *et al.*, 2017) and Oregon, USA (Rideout *et al.*, 2011) where 30% of electricity used was for irrigation and pumping. To increase energy efficiency in nurseries in these regions, they have converted to variable frequency drive pumps to reduce their electricity consumption.

Correspondingly, irrigation was the second most important energy conservation category after electricity for OHISA participants especially with regards to water movement from water sources to irrigation systems e.g., pumps and the scheduling of energy use e.g., to pump at night when tariffs are lower, or demand is less and the improvement of irrigation systems. Similarly, some participants in the present study had also converted to variable frequency drive pumps to save electricity. The improvement in irrigation systems and watering practices by OHISA, as has been shown by the Oregon growers and Australian nurseries (Nursery & Garden Industry Australia, 2010; Rideout *et al.*, 2011), will not only decrease water and energy usage.

Lighting changes are one of the easiest and most cost-effective ways to start any energy efficiency programme (Rideout *et al.*, 2011; Dominguez, Mibus-Schoppe and Sparke, 2017) as was recognized by the 47% of the garden centre retailers and 13% of the growers on OHISA.

International publications have shown that the predominant drivers for change towards energy efficiency were decreasing natural resource availability and the increasing costs of resources (Krug *et al.*, 2008; Lazzerini, Lucchetti and Nicese, 2016; Michigan State University, 2016). Climate change and the increased emissions of greenhouse gases also increased environmental concerns from consumers which resulted in sustainable certification of members in the international horticultural industry e.g., Veriflora started in 2007 in the USA and in the Netherlands, Milieu Project Sierteelt (MPS) commenced in 2009. Both these programmes had energy efficiency as one of the criteria that needed to be addressed before certification could take place (Dennis *et al.*, 2010).

As an institution, OHISA can learn from those countries who have experienced similar challenges and although some participants in this South African research have started implementing energy efficiency strategies there are many ideas and options which require more in-depth research specific for the South African local industry e.g., alternative sources of energy for heating (i.e. not coal), better lighting options, decreasing dependency on fossil fuels for electricity, following plant trends and planning production to reduce losses and choosing plants that are naturally adapted to our climate thus requiring less resources for growing them successfully in South Africa.

The above was recognised as the most important issues regarding energy usage and impacts on the environment. In the energy module of the BMP, there are numerous other suggestions learnt from the international growers and retail garden centres as well as those locally that would assist retail garden centres and growers to minimize their energy usage by evaluating current methods and improving them where necessary to mitigate their effects on climate change.

6.4 Discussion related to water

Water was recorded as the greatest natural resource that affects OHISA. This was also true for other international nursery associations when research had been conducted e.g., the Canadian Nursery and Landscape Association (Canadian Ornamental Horticultural Alliance (COHA), 2013), Nursery and Garden Industry Australia, Smart Approved Watermark (Nursery and Garden Industry Australia Ltd., 2009; Nursery & Garden Industry Australia, 2014) and many others in the United States (Smith and Lopes, 2010; Rideout *et al.*, 2011) and Europe (Havardi-Burger, Mempel and Bitsch, 2020; López Gunn *et al.*, 2021).

Apart from energy shortages, water shortages and droughts resulted in some of the first BMP's to be developed, especially in countries or states most affected (Table 6.3) and continue to be relevant and revised as technology practices are enhanced, and research is done.

Table 6.3: Literature review of ornamental horticultural research where the key indicator was water.

Country	**Year**	**Title of BMP or sustainability paper, reports or recommendations related to water**
USA	2000	Survey of Best Management Practices in Container Production Nurseries (Fain *et al.*, 2000)
USA	2002	Water management is key in reducing nutrient runoff from container nurseries (Bilderback, 2002)
South Africa	2009	A proactive water supply shortage response plan focusing on the Green Industry in the Rand Water supply area (Hoy, 2009)
Australia	2010	The Nursery Industry Water Management Best Practice Guideline by the Nursery & Garden Industry Australia (Nursery & Garden Industry Australia, 2010)
USA	2010	Sustainable Production Practices Adopted by Greenhouse and Nursery Plant Growers (Dennis *et al.*, 2010)
USA	2010	Florida Nursery Best Management Practices: Past, Present, and Future (Yeager *et al.*, 2010)
Germany	2010	Germany-Sustainable horticulture crop production (Griffin, 2010)
South Africa	2010	Sustainable Horticultural Crop Production in South Africa (Sydow, 2010)
USA	2011	Protecting Natural Resources at Field Nurseries: Sustainable Agricultural Management Practices for Soil, Water, Nutrient and Pesticide Conservation (Johnson, Mangiafico and Obropta, 2011a)
South Africa	2012	SANA Marketing Water Partnership Project – Water Wise Plants for Birds, Bees & Food Gardening (Rand Water and South Africa Nursery Association, 2012)
Australia	2014	Nursery & Garden Industry Australia Nursery & Garden Industry Australia Environmental Sustainability Position Industry Working in Harmony with the Environment for a Sustainable Future (Nursery & Garden Industry Australia, 2014)

Country	Year	Title of BMP or sustainability paper, reports or recommendations related to water
USA	2014	Water Quality / Quantity Best Management Practices for Florida Nurseries (Florida Department of Agriculture and Consumer Services, 2014)
USA	2016	The Next Ten Years: Strategic Vision of Water Resources for Nursery Producers (Fulcher *et al.*, 2016)
South Africa	2018	Response strategies and marketing communication efforts of Cape Town gardening and plant retailers in reaction to the water crisis: an explorative study (Meiring, 2018)
USA	2019	Greenhouse and nursery water management characterization and research priorities in the USA (White *et al.*, 2019)
USA	2019	Validation of Nursery and Greenhouse Best Management Practices through Scientific Evidence (Mack *et al.*, 2019)

As described in Chapter 2, water shortages and restrictions published by government have very negative consequences for the industry as consumers fear fines and sales of plants within retail garden centres drop drastically especially bedding plants (Business 1, 13, 15 and 38) and (Olivier, 2022). It is in times of water crisis that the nursery industry gets to showcase best practices when it comes to watering and this has been done not only in South Africa, particularly by the Capetonians (Business 27, 29 and 41), but also in Florida (USA) where excessive water use can generate negative public and political pressure and so nursery operations are able to show the public how best to conserve water (Florida Department of Water Quality / Quantity Best Management Practises for Florida Nurseries, 2014).

In countries where water availability isn't a priority e.g., Canada, research reported on the water needs of the plants at a production-site and how this is conveyed to the consumer who plants or pots that same plant (Canadian Ornamental Horticultural Alliance (COHA), 2013). Thus, again showing the importance of the retail garden centre where the information from the grower can be passed onto the consumer. In Italy, it was briefly mentioned as an indicator of sustainability and relevant to ecological footprint assessment but only in relation to the energy needs required for irrigation purposes and hence not investigated further at the time. Thereafter, it was reported that it should be done in future studies (Beccaro *et al.*, 2014) or in relation to irrigation and pumping equipment and the quality thereof for irrigation purposes and not only quantity available and conservation thereof (Lazzerini *et al.*, 2018).

Corresponding to the literature in Chapter 2 and the above which has emphasised the importance of water quantity and quality, there are five sustainable development goals (SD 3, 6, 11, 12 and 15) that refer to water-related issues as part of their indicator descriptions. Table 6.4 focuses on SDG 6 - “Ensure availability and sustainable management of water and sanitation for all” (United Nations, 2015) which is the primary focus of the horticultural industry in water-stressed countries. The other SDGs will be addressed as the related indicator causes the problem e.g., water pollution from fertilizer leaching.

Table 6.4 compares the international horticultural industry, South Africa and the results that were similar from OHISA in relation to SDG 6. It shows that the horticultural industry recognises that they contribute to water pollution and the steps taken internationally to reduce this include:

- The use of plastic sheeting or semi-permeable floor covering to decrease seepage into groundwater.
- Concrete channels and pathways are used to capture runoff.

Table 6.4 Sustainable development goals relative to the international horticultural industry, South Africa and to OHISA

Sustainable development goals	**International Literature Review of Horticultural Industry Practices or Global achievements**	**South African achievement**	**OHISA (2021)**
Target 6-1 Safe and affordable drinking water	In Europe and Northern America 96% of the population has achieved this (United Nations, 2020a)	94% of population has access to safe drinking water (Statistics South Africa, 2019a)	100% of participants have facilities for safe drinking water for staff
Target 6-2 End open defecation	In United States 98% of the population has achieved this (United	78% of population is using safely-managed sanitation	100% members have flushing

Sustainable development goals	**International Literature Review of Horticultural Industry Practices or Global achievements**	**South African achievement**	**OHISA (2021)**
and provide access to sanitation and hygiene	Nations General Assembly, 2020)	services (at a basic level) (Statistics South Africa, 2019a)	toilets to maintain hygiene for staff
	In Australia and New Zealand, 76% of the population has achieved this (United Nations General Assembly, 2020)	67.5% have handwashing facilities in their homes with soap and water (Statistics South Africa, 2018)	17% participants have retrofitted toilets and put in dual flush toilet systems
Target 6-3 Improve water quality, wastewater treatment, and safe reuse	Industry contributed to groundwater pollution by using fertilizers and pesticides but plastic, or semi permeable sheeting or concrete is used to reduce leaching (Beccaro *et al.*, 2014) Limited use of wastewater by horticultural industry due to salinity and quality. The treatment of this water varies depending on crops but adds to bottom line of product making it unfavourable with growers (White *et al.*, 2019)	52% of waste water is treated (Statistics South Africa, 2019b)	20.8% participants fertilizer is captured in runoff water and reused
	38% respondents tested their water quality at least monthly ((White *et al.*, 2019)	58% of water bodies with good water quality (2017) (Statistics South Africa, 2019b)	Less than 10% participants tested their water quality annually
Target 6-4 Increase water-use efficiency and ensure	30% of respondents used on-site or municipal recycled water in their production (White *et al.*, 2019)	Renewable internal freshwater source per capita is 45 cubic metres / year (2019) (World Bank, 2019a)	54% participants recycle water used

Sustainable development goals	**International Literature Review of Horticultural Industry Practices or Global achievements**	**South African achievement**	**OHISA (2021)**
freshwater supplies	3% respondents changed production practices to improve water efficiency but 37% changed infrastructure to increase efficiency (White *et al.*, 2019)	41% freshwater withdrawal as a proportion of available freshwater in 2000, 64% freshwater withdrawal as a proportion of available freshwater in 2019 (World Bank, 2019a)	71.5% participants changed watering practices to conserve water
Target 6-5 Implement integrated water resources management	65% used groundwater sources, 32% surface water sources and 19% used city water sources (Fulcher *et al.*, 2016)	Integrated management including enabling environmental, institutions and participation and management instruments and financing grew from 65 (2017) to 71 (2020) as a score out of 100 (UNEP United Nations Environment Programme, 2021)	30.8% used groundwater sources, 20.6% used surface water (rivers, dams, and reservoirs), 17% used municipal and 31% used rainwater harvested or recycled water
Target 6-6 Protect and restore water-related eco-systems	Regulations and the application of best management practices increased sustainability measures and environmental protection of natural resources (White *et al.* 2019)	3379 km^2 of water-related ecosystems in 2005 includes lakes, rivers, estuaries, and artificial water bodies. 3415km^2 of water-related ecosystems in 2015 (UNEP United Nations Environment Programme, 2018)	Two Growers use a wetland to capture excess runoff and recycle it
			None of the participants recorded a chemical spill that affected water sources

The challenge that the industry has is that the reuse of waste water in the production of young plants and seedlings as it has to be treated first to remove pathogens, change its alkalinity and / or salinity and many growers both local and international do not have the facilities to achieve this. The recaptured water is thus used to grow bigger plants and on landscape gardens.

Changes that have been made to conserve water vary considerably between the recorded American results and South Africa. The USA reported 37% made infrastructural changes to improve water efficiency and only 3% changed watering practices compared to the 71.5% of South African participants who changed their watering practices. The methods that the horticultural industry has used to improve water efficiency is compared in Figure 6.3.

Using information from documents listed in Table 6.1, all of which mentioned water quality or quantity in some form and grouping the results from these to correspond to the groups used in Chapter 5, to categorise the methods used by the South Africa industry to use water more efficiently, enabled this comparison to be shown in Figure 6.3.

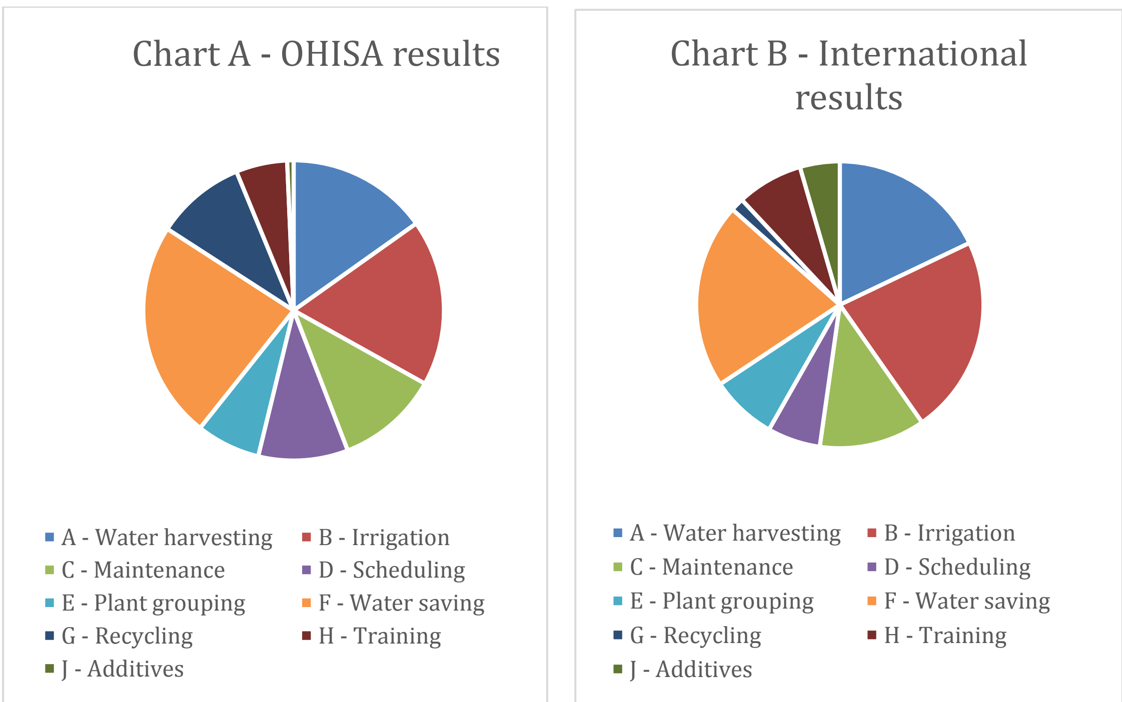

Figure 6.3: Combined suggestions of how water is used optimally in the ornamental horticultural industry

The trend of infrastructural changes was not isolated to the USA as these results show (Figure 6.3 and highlighted in Table 6.5). Internationally, irrigation and water harvesting scored higher than locally. Many of the growers and garden centre retailers from OHISA results showed that the greatest obstacle to retrofit their irrigation systems was the cost. In the Australian 2010 Water Management BMP, there is an example of a grower who had a 15–20-year-old irrigation system and used 22 - 26 megalitres per year with water from a dam. They retrofitted their irrigation system and had a water saving of 6.5 megalitres – a 27% reduction of water used and at the time had a water and operational savings of $831 per year (Nursery & Garden Industry Australia, 2010).

Table 6.5 Summary of the top methods used to improve efficiency of water use in the OHI

	International	**OHISA**
Irrigation	22%	18%
Water saving	21%	23%
Water harvesting	18%	15%
Maintenance	12%	11%

In keeping with Australia, their best water management practices recommended by the Nursery and Garden Industry Australia (NGIA) (2014) were comparable to those of South Africa in that both promoted efficient water use (water saving) then recycling and harvesting of excess water to decrease actual usage.

In investigating the individual practices to reduce water use within the industry, by comparing the local and international growers and retail garden centres, the following 10 methods are described most frequently by both groups (Table 6.6).

Table 6.6: Common practices for water efficiency

1	Rainwater harvesting
2	Run-off collection (gutters and channels)
3	Recycling water / managing wastewater
4	Irrigation efficiency: drip irrigation, types, and design
5	Reservoir and dam covers
6	Wind breaks

7	Water sensors
8	Monitoring or irrigation and watering
9	Maintenance of pipes, pumps, irritation, taps, nozzles
10	Plant grouping according to water requirements

Another interesting comparison although from different years is that in the USA there was much more overhead watering and a lot less hand watering compared to South Africa (Figure 6.4).

Each of these listed irrigation methods (Figure 6.4) have benefits and pitfalls and it is up to the individual workplace to evaluate these and determine which is most suitable for them, both in terms of plant varieties, staffing, and costs. The “other” in Figure 6.4 was flood tables which is used more readily oversees and only one garden centre retailer used it in South Africa just for their seedling section.

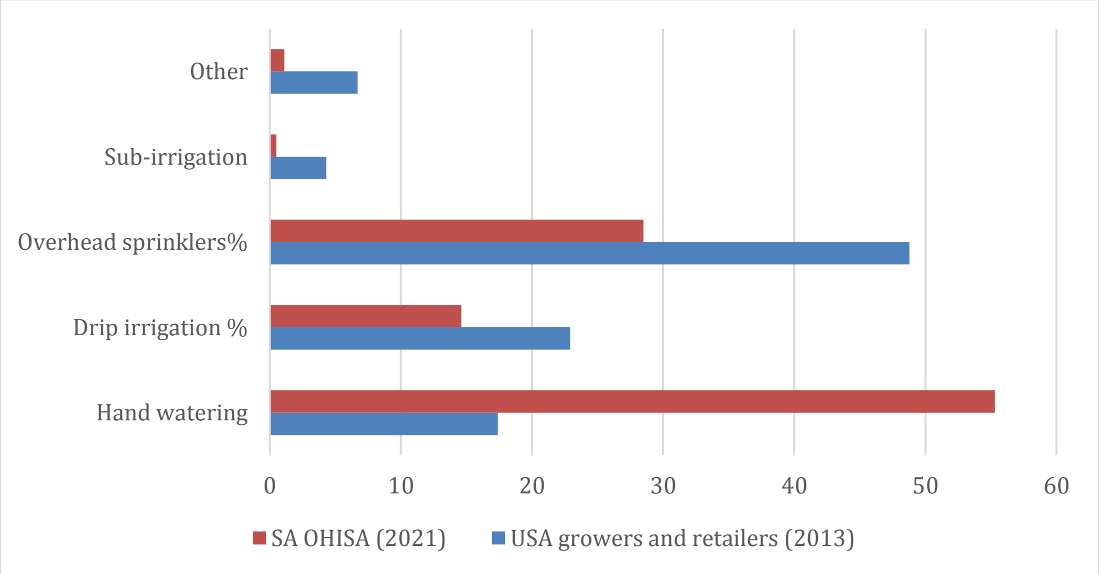

Figure 6.4: Irrigation method comparison between SA (2021) and USA (2013)

Referring back to Table 6.3 and SDG 6.4, it is noted that more than double the percentage growers in USA use groundwater compared to the 30.8% of the participants in the present study. The reason for this could be that this study included growers and garden centre retailers and many of these retailers are based in urban environments in South Africa and have restrictions placed on their access to groundwater and hence use harvested municipal water, rainwater or recycled water.

Target 6.6 of SDG 6 focuses on protecting our ecosystems, which is similar to SDG 15 that encourages conservation, restoration and sustainable use of natural habitats such as forests and preventing desertification and biodiversity loss. The manner in which the OHI negatively impacts this is by the loss of topsoil and soil erosion as a result of poor watering and irrigation practices (Fain *et al.*, 2000; Virginia Tech & Virgina State University, 2013; Lazzerini, Lucchetti and Nicese, 2016) and the Australian's examined *"efficient management of sediment and litter"* under water management. In this study, the researcher explored this, not as a separate category but rather as an impact of the industry, namely land degradation, which OHISA suggested that the industry does negatively contribute to. This problem is known as erosion control. From the site visits conducted in the present study, it was observed that most growers and retail garden centres do have water channelling paths or pipes to catch run-off water and recycle it, rather than let it cause erosion.

Run-off not only causes erosion but also affects water quality, as 25% of the combined growers and garden centre retailers in the study wrote that their business practices contributed to water pollution. The leaching of pesticides, fertilizers, and topsoil from the businesses in the industry is a concern. Some of the recommendations from other ornamental international horticultural studies include:

- Vegetated areas - the use of *"vegetation stabilizes"* and *"grassed waterways"* (Smith and Lopes, 2010),
- Wetland building (Nursery & Garden Industry Australia, 2010),
- *"On-site water treatment"* (Rideout *et al.*, 2011),
- *"Biobeds"* (Business 38) which is used experimentally in a few countries in the world with good results (Wolf, 2018).

In South Africa, one of the growers had a wetland (Business 22). Two of growers (Business 11 and 26), aerated the recycled water in their dams to improve the water quality without using additional additives.

When comparing information, several practices to reduce water use in the industry differ between OHISA and international members. These differences between the two could allow for possible future knowledge sharing and changing of practices (Table 6.7).

Table 6.7: Different practices for water efficiency

	Different practices to be water efficient	
1	Non damaged or broken pots	OHISA
2	Invasive species clearing on-site	OHISA
3	Underground drainage system	OHISA
4	Storm water management	International
5	Soil cover	International
6	Know water-holding capacity of substrate	International
7	Monitor the application pressure in irrigation	International
8	Use automatic rain shutoff	International

Some of the practices highlighted in Table 6.7 were mentioned in the semi-structured interviews with the growers and garden centre retailers. These participants indicated that they have the knowledge, but the application thereof was not yet shown in their business practices e.g., knowledge of water-holding capacity of substrate was mentioned by Businesses 14 and 38.

By implementing the suggestions discussed in Chapter 5 with the additional ones suggested from international practices (Table 6.7), the nurseries will not only improve watering efficiency but decrease fertilizer wastage and leaching which negatively affects the environment by causing water and soil pollution and this will also have a cost saving benefit.

Globally, it can be concluded that water quantity and quality is essential to the growing and selling of a quality plant. In the past, this natural resource has been wasted or polluted by the ornamental horticultural industry, but recent developments and regulations have resulted in practices changing to improve water use efficiency and associated pollution. With the implementation of some of the recommendations in the BMP associated with this research OHISA can make greater strides towards better water conservation especially in our water stressed country and assist in South Africa achieving the above-mentioned SDG's. It has been shown that OHISA needs to further improve water efficiency, even if it is one aspect at a time as the long-term return on investment both financially and environmental will be positive.

6.5 Discussion related to growth media

Following on from the importance of water and the environmental impacts that ornamental horticultural has on water quality, is the degradation, pollution, and natural resource exploitation of some of the ingredients of growth media which are used to grow a healthy plant. The advantages of using soilless growth media in intensive horticultural operations, urban agriculture, the production of specialised crops like hemp and cannabis has resulted in phenomenal growth of the industry (Gruda, 2022). Such growth and the difficulty in obtaining, extracting and processing the different growth media products has resulted in shortages which raised concerns in the USA (Jackson, 2021) and it was recorded as the second most important resource after water to OHISA (Figure 5.12).

The functions of a growth medium when growing a containerised plant are comparable to the functions of soil in an ecosystem (Figure 2.2) and in some cases soil is even used as part of the growth medium recipe (Figure 5.31 – topsoil and sand). The similarities include soil pH, cation exchange, texture, electrical conductivity, porosity which in turn affect the availability of nutrients and water and the ability for the substrate (soil or growth medium) to provide support, as discussed in Chapter 2. The difference is that when growing a containerized plant, the physical properties of the substrate must be able to provide a balance between air and water storage in a small space for the plant. Within this space, both chemical and biological process must be able to take place (Barrett *et al.*, 2016).

Despite soil not being mentioned directly in the Sustainable Development Goals, its conservation and use as described by the Soil Charter (Chapter 2) and the research and collaboration of soil scientists with other related disciplines is essential to achieve some of the Sustainable Development Goals (Keesstra *et* *al.*, 2016) namely SDG 2, 11, 12 and 15. The SDG's most relevant to the ornamental horticultural industry are shown in Table 6.8.

Table 6.8: The relevant SDG targets related to soil are:

Sustainable development goals	**International Literature Review of Horticultural Industry Practices**	**South Africa (Statistics South Africa, 2019)**	**OHISA (2021)**
2.1 Improve food nutrition and secure food availability by promoting sustainable agriculture.	The percentage of the world population which is undernourished has improved from 13.2% in 2001 to 8.9% in 2019 (Ritchie *et al.*, 2018).	In 2019, 6.5% of the South African population was undernourished	Growers and retailers have seen growth of vegetables, herb, and fruit production and sales each year. Sustainable home-grown edibles are a trend that keeps on growing. Swiss Chard seed is the top selling seed in the country. Most growers and even some retailers had vegetable gardens in the nurseries for the staff.
2.5 "By 2020, maintain genetic diversity" of agricultural products and share knowledge and resources to ensure sustainability thereof	The Global Horticulture Initiative in partnership with others including the World Vegetable Centre has better the lives of many by enhanced breeding of stable food crops and traditional ones, improved growing technologies and trained woman, subsistence farmers in food gardening	2.5.1: Number of plant and animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities (domesticated indicator): Plants: 35 604 (2015), 36 881 (2016), 36 814 (2017)	Seed manufacturers are constantly bringing back heirloom seeds for planting.

Sustainable development goals	International Literature Review of Horticultural Industry Practices	South Africa (Statistics South Africa, 2019)	OHISA (2021)
	(Keatinge, Virchow and Schreinemachers, 2018).		
12.2 By 2030, achieve the sustainable management and efficient use of natural resources e.g., soil and growth media components	15.2% of American growers in the study used certified organic growth media and 22.4% used waste products e.g., rice hulls as part of growth media ingredients (Dennis et al, 2010)	The main limitation faced by South Africa in reporting progress on SDG 12 is a general lack of indicator-specific reliable and verifiable data at national level.	Use sustainable growth media.
	Research showed that greatest amount of CO2 emissions is from potting-mix or growth media for container plants mainly because of peat used (extraction thereof) and transport to locations (Lazzerini, *et al.* 2016)		96% of the growers in the sample knew how much growth medium they used annually and 74% said that could not reduce the consumption thereof.
15.2 Promote sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase	Field grown plants require soil management strategies e.g., design, plant species variation, planting techniques, irrigation type, harvesting, fertilization and	Working for Land project run by the DEA to address degradation caused by overgrazing, soil erosion and poor development and agriculture	Prevent land degradation or reduce the impact of it when building new tunnels, sheds, and greenhouses.

Sustainable development goals	International Literature Review of Horticultural Industry Practices	South Africa (Statistics South Africa, 2019)	OHISA (2021)
afforestation and reforestation globally	pest control which can affect soil fertility and loss (Lazzerini *et al.* 2016)	practices. It promotes sustainable land use and conservation ethics.	
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought, and floods, and strive to achieve a land degradation-neutral world	In 2015, 33% of global soils were degraded. Poor and unsustainable agricultural practises have resulted in 52% of agricultural land soils to be partially or seriously affected (Kopittke, 2015).	15.3.1: Proportion of land that is degraded over total land area 10.71% (2014); the United Nations had a different figure of 78% based on data from 2015 (United Nations 2020)	Positively contribute to reforestation – growers and retail garden centres grow, sell, donate, and plant trees annually.

The international perspectives of this research show that the significance of soil is due to its positive properties e.g., it is a substrate for various biological functions, and cycles e.g., habitat provision, flooding control, nutrient cycle, filtering system, climate regulation, and carbon sequestration all of which are important. For industry and more specifically the ornamental horticultural industry, it provides an environment for natural resource development e.g., to grow (timber, food, plants) which in turn provides organic matter for compost and into which foundations can be constructed for buildings (Food and Agriculture Organzation (FAO), 2015). Broadly translated, SDG 12.2 is connected to the OHI because of the availability of the natural resources related to soil used as ingredients in numerous growth media recipes e.g., peat, coir fibers, vermiculite, and bark. Most emphasis has been placed on the extraction of peat which not only results in land degradation but also the release of carbon into the atmosphere thus contributing to climate change (Barrett *et al.*, 2016). In the United Kingdom, there is a movement to ban peat sales by garden centre retailers by 2024 and for growers to stop using it as part of their growth media blends by 2028 (Appleby, 2022). In South Africa Business 22 stated that they are "*trying to move away from peat as it is non-renewable and expensive, and distributors thereof are robbing the environment*."

Growth media was not mentioned as an industry indicator of concern in 2013 (Canadian Ornamental Horticultural Alliance (COHA), 2013), and this might be because peat was sourced locally in their country but in 2021, it has been reported as being an environmental concern (Aalbers and Morse, 2021). South Africa sourced peat from Canada but it now sources more peat from Lithuania (Pers. Comm, Oosthuizen 2020).

Apart from peat, there are various other ingredients that are used in different growth media recipes depending on what the growers and consumers are planting and growing. These substrate combinations also differ at the different stages of the plant's life cycle e.g., cuttings and seed germination have a different substrate to young plants and bedding plants as was seen during the site visits (Appendix 18).

Soil testing in America, Australia, Canada, Europe, and New Zealand was a big part of soil management not only for pollution monitoring but also checking nutrient levels e.g., nitrogen. Soil testing was only mentioned by five growers in the present study, and this is because these five submit annual soil samples to remain accredited growers for particular buyers.

The various solutions currently used by the international ornamental horticultural industry to decrease the environmental impacts of growth media component extraction and land degradation is tabulated below (Table 6.9). It is noted that a few of these practices are also recommended by OHISA (Figure 5.32) but under slightly different category names. They are discussed in more detail within the best practices manual.

Table 6.9: A comparison of practices for growth media use and reduced environmental impacts according to categories.

	International	OHISA categories
1	Soil health and quality	Storage and hygiene of growth media
2	Reuse of growth media	Recycling
3	Site selection of operation	Not mentioned by any participants
4	Soil erosion reduction by wind and water by planting and mulching e.g., grassed alleyways, nut shells covering beds	Soil saving
5	Soil testing and tissue testing	Training and trials
6	Soil amendments using waste from other industries e.g., peanut shells, rice husks	Recycling
7	Reduction in peat usage and replacing it with coir	Soil saving

Further analysis of international reports highlighted focus areas of some countries which is comparative to South Africa e.g.:

- Both New Zealand (New Zealand Plant Producers Incorporated, 2018a) and South Africa (King and Thobela, 2014) emphasised productive soils, free from contamination and improved fertility especially in terms of farming high value horticultural crops intensively. This pertains to SDG 2.
- Most countries are testing different growth media substitutes to reduce peat consumption - Canada (Aalbers and Morse, 2021), Italy (Lazzerini, Lucchetti and Nicese, 2016), Germany (Beccaro *et al.*, 2014), United Kingdom (Hillier Nurseries Limited, 2022, USA ((Dennis *et al.*, 2010) and South Africa
- Soil erosion was important particularly in Australia (Horticulture Innovation Australia and Nursery & Garden Industry Australia, 2018) and the UK (Hillier Nurseries Limited, 2022)
- Site selection was mentioned by research done by the University of Massachusetts (Smith and Lopes, 2010) and although important not by participants of OHISA.

There are several aspects where challenges for OHISA and international members exist on the same requirements for soil media but are addressed differently.

These are:

- Variety of products grown - most South African growers produced a wider variety of plant species (Figure 5.2) as the local plant purchasing population is small compared to the European and American markets where more specialist growers are found. This requires many different growth media recipes and ingredients.
- Certification of growth media: the local growth media manufacturers do not certify the growth media that they produce making it challenging to reliably grow uniform plants and have consistent nutrient and irrigation regimes.
- Sediment management: the legal requirements in other countries require strict soil erosion prevention plans but these are not enforced in South Africa.

These challenges contribute to the overall environmental impacts caused by the OHI, but by implementing steps to reduce the burden of growth media component exploitation and land degradation both locally and internationally, the industry can positively make a difference. This is highlighted using by-products from other industries e.g., rice husks, coco fibres, peanut shells, bark, and manure. Thus, the ornamental horticultural industry is setting an example and becoming part of a circular economy.

The next indicator is linked very closely to growth media, as in many instances the growth medium provides the conditions for the roots to be able to absorb the nutrients provided by fertilizers.

6.6 Discussion related to fertilizers

The importance of adding additional nutrients (e.g., nitrogen and phosphorus) in agricultural crop production is essential to feed the growing global population (Dawson and Hilton, 2011). This is true for horticultural plant varieties too (Wainwright, Jordan and Day, 2014), especially those grown intensively in containers. This type of growing has the potential to be environmentally damaging because of input resources needed (as explained above, energy, water, and growth media components) and waste products created e.g., leaching of fertilizers, plastic, or polycarbonate coverings. However, if policies are adopted and procedures implemented, then sustainable greenhouse horticulture can be achieved and these negative aspects can be reduced (Vox *et al.*, 2010).

Globally fertilizers have doubled and even tripled in price over the last two years which have affected growing practices (Voegele, 2022). One of the recommended methods to avoid additional costs is to improve the amount of fertilizer given to the plant, which will also result in less fertilizer loss to the environment. Nutrient management is an important factor in international ornamental horticultural businesses (Johnson, Mangiafico and Obropta, 2011b; Wani *et al.*, 2018; Darras, 2020a).

It is important to be aware of the global recommendations which are also mirrored in the national legislations which regulate fertilizer importation, sale and use within South Africa. The sustainable development goals and 4R principles of nutrient stewardship principles recommended by the International Fertilizer Association, are:

- Right source – fertilizer meets the needs of the plants
- Right rate – the amount applied is the correct dosage for the plant
- Right time – the nutrients are made available to the plant when it needs them
- Right place – the nutrients are available from a place where the plant can utilize them (Reetz Jr., Heffer and Bruulsema, 2015).

These are shown diagrammatically below (Figure 6.5) with the additional indicators related to sustainability.

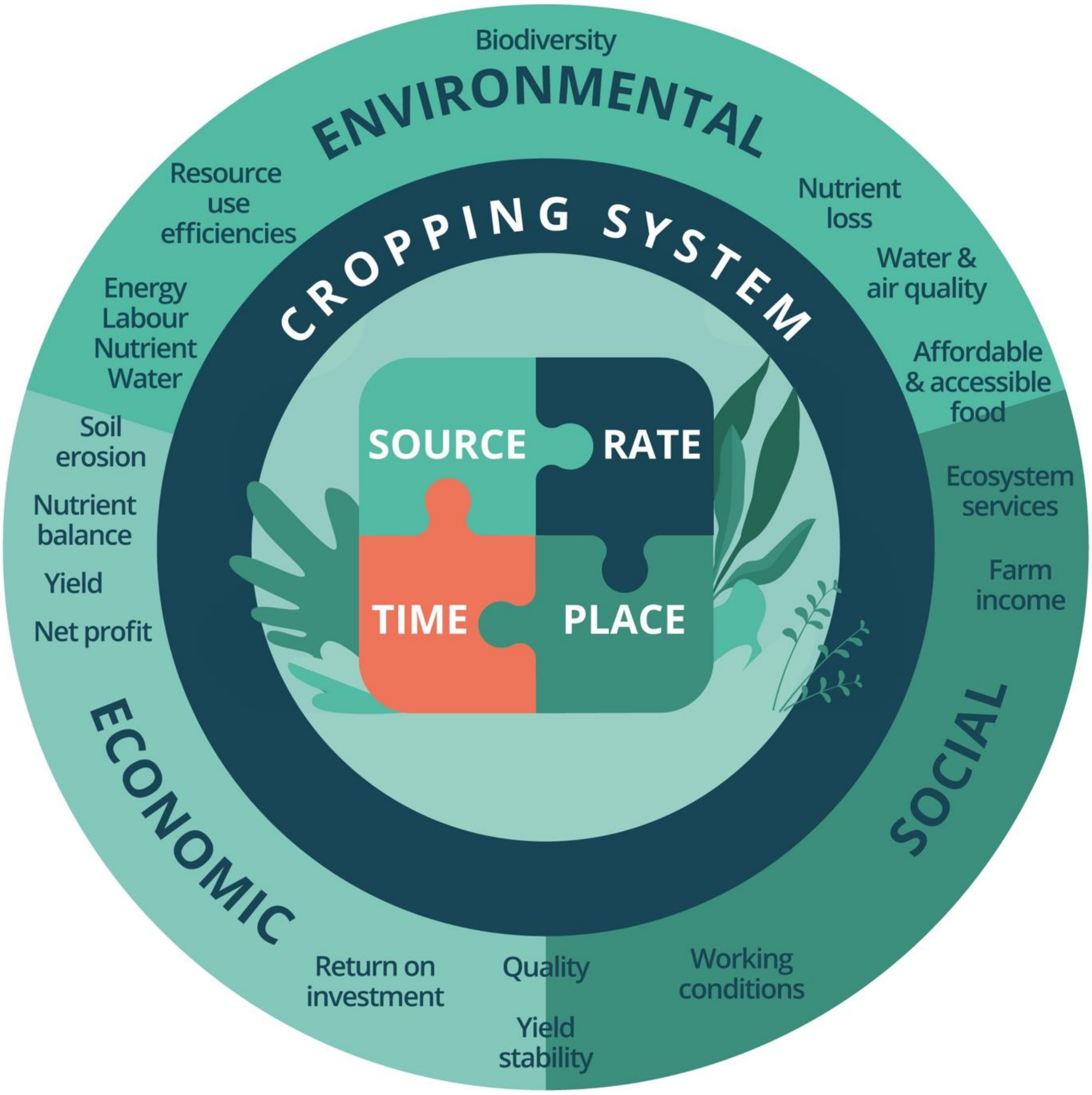

Figure 6.5: Performance indicators reflecting the social, economic, and environmental aspects of the performance of the cropping system. (IFA, 2009; IPNI, 2012. Adopted from Reetz Jr., Heffer and Bruulsema, (2015)) adapted by author.

The Fertilizer Bill, 2018 (South Africa) was promulgated to "ensure the manufacturing of safe and good quality fertilizers suitable for plant production and monitor the manufacturing of fertilizers to ensure that they play a critical role in food safety, human and environmental health, nutrition and food security". This illustrates the necessity of supplying the correct nutrients to the plants at the correct growth stages to reduce wastage. These recommendations, when correctly applied, will protect humans and the environment by working towards the following sustainable development goals. Allied with growth media, fertilizers are not directly mentioned in the SDGs but in terms of pollution and environmental damage to both the atmosphere, biosphere, and lithosphere they play a role. Consequently, the SDGs that fertilizers impact are SDG 3, 6, 7, 9, 12, 13 and 17. Those SDGs most relevant to the ornamental horticultural industry are listed in Table 6.10:

Table 6.10: A comparison of practices for fertilizer use and environmental impacts according to categories.

Sustainable development goals	**International Literature Review of Horticultural Industry Practices**	**South Africa (Statistics South Africa, 2019)**	**OHISA (2021)**
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	A study done on vegetables grown in greenhouses reported that N leaching into water was least damaging in high-tech greenhouses	High levels of nitrates South African groundwater which has the potential to end up non-treated drinking water can cause "infant methaemoglobinaemia" and even poisoning to livestock stock drinking it (Talma, Tredoux and Adelana, 2006)	Practice fertilizer saving principles and prevent runoff from fertigation systems ending in water courses. Use wetlands to minimise the effects of nitrate and phosphates leaching into groundwater as done by two growers.
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks and significantly	In Germany legislation regulates use of fertilizer and pesticides e.g., Plant Protection Act of 1986 and revisions thereafter (Griffin, 2010). Similar legislation has been applied	The main limitation faced by South Africa in reporting progress on SDG 12 is a general lack of indicator-specific reliable and verifiable data at national level.	Not allow chemicals and fertilizers to leach into soil thus polluting it.

Sustainable development goals	**International Literature Review of Horticultural Industry Practices**	**South Africa (Statistics South Africa, 2019)**	**OHISA (2021)**
reduce their release to air, water and soil to minimize their adverse impacts on human health and the environment	in the United States (Fulcher, 2016)		
	NO_2 emissions from fertilizers but variable depending on container size and type of fertilization method used (Lazzerini *et al*. 2016)		
14.1 By 2025 prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities including marine debris and nutrient pollution	No evidence of research into this apart from the leaching of fertilizers into groundwater and rivers	The main limitation faced by South Africa in reporting progress on SDG 12 is a general lack of indicator-specific reliable and verifiable data at national level.	Prevent fertilizers from leaching into water courses thus polluting it and resulting it eutrophication of rivers and seas.

The approach that the ornamental horticultural industry uses to achieve these targets is depicted in Figure 6.6. This is a culmination of the data collected from Table 6.1 which was then categorized into the same categories where the data using optimum fertilizer usage collected from the participants of OHISA, except for three categories, nutrient management, pollution, and teaching was recorded.

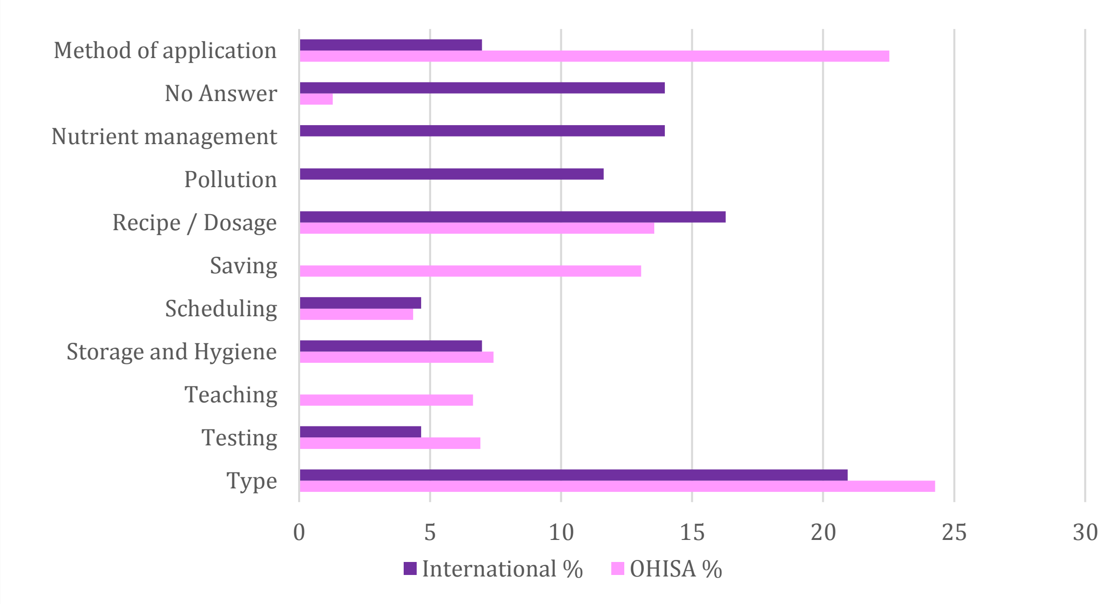

Figure 6.6: Comparison of optimum fertilizer use practices (%) by the international horticultural community and the ornamental horticultural industry of South Africa.

Internationally, the type of fertilizer used and the dosage of nutrients within the fertilizer are of greatest importance as these influence their environmental impact as is described in Table 6.10, SDG 3.9, 12.4 and even 14.1. Predominantly, excess nitrates and phosphates present in groundwater is causing pollution and affecting humans and ecosystems (Richie, 2021). Many of the international practices mentioned use controlled release fertilizers (Dennis *et al.*, 2010; Smith and Lopes, 2010; Yeager *et al.*, 2010; Johnson, Mangiafico and Obropta, 2011b; Lazzerini, Lucchetti and Nicese, 2016), although there is a movement towards organic fertilizer use to improve sustainability (Dennis *et al.*, 2010). The method of application e.g., fertigation via a Dosatron or within the irrigation systems or mixed into the growing media, are more numerous in South Africa than internationally as OHISA included hand fertilization and foliar feeding in addition to in-line fertigation or mixed into growing media as reported internationally.

The importance of scheduling fertilizer application was listed as being higher internationally and only a few growers implement it locally (Figure 6.6). The reasons for this could be the technological advances in greenhouse management applied globally, and consistent electricity supply (no load shedding). This is supported by the researcher noting during the site visits that only a few greenhouses had the facilities to be able to do this and as mentioned previously in this Chapter (6.3) only five of the participants tested their growth media for different element and mineral concentrations annually which also wouldn't be conducive to fertigation scheduling.

The categories from international data include nutrient management which could encompass all the categories from OHISA but as not specified, the researcher showed them independently. As with the pollution, the participants in OHISA were aware that fertilizers had the potential to cause pollution and took steps to minimize it, but there was not corresponding data to compare with the international studies. Lastly, in the present OHISA study, the researcher included the option of fertilizer-saving which highlighted actions that growers and garden centre retailers took to save fertilizer, but these procedures could have been included in nutrient management and so did not correspond to that which OHISA participants described and hence it too was considered separately e.g., "*err on the side of caution*", mulching, improved substrate requires less fertilization etc.

All ornamental horticultural industries prioritize the importance of the correct handling, transportation, and storage of fertilizers. This is usually governed by the country's regulations both in terms of environmental legislation and policy as well as the Occupational Health and Safety Acts and procedures (South African Government, 2018). These regulations are in place to protect humans and the environment e.g., ammonium nitrate, which provides nitrogen and ammonium for plants, is produced using anhydrous ammonia gas that can explode when exposed to air e.g., the Beirut explosion when a fire caused the detonation of 2750 tonnes of ammonium nitrate killing 218 people, injuring 7000 and displacing 300000 (Al Jazeera, 2022).

Soil and water contamination by leached chemical fertilizer use was another environmental concern globally (Lillywhite, 2014; Mack *et al.*, 2019) and 15% of the participants in this study mentioned that they might pollute the soil by the leaching of fertilizers. None of the participants mentioned that they had ever experienced a chemical spill which polluted the soil and groundwater. The economic costs associated with poor air and water quality causing environmental and human harm is billions of Euros each year as a result of excess nitrogen and phosphorus leaching into the environment (Sutton, 2011; Sud, 2020).

The establishment of reedbeds was researched in Australia to prevent excess fertilizer nutrients from ending up in the water. The results showed a 90% reduction of nitrates and a 96% reduction in phosphates (Nursery & Garden Industry Australia, 2014). Only one grower in South Africa had a reed filtration dam. There is an opportunity to learn from international counterparts or other local businesses e.g., SA Breweries in PE who used a reed filtration dam to reduce pollution of water before releasing it into river systems and thus help improve the water quality leaving the nurseries, as 25% of the participants felt that their business did contribute to water pollution.

Fertilizers and pesticides cause water, soil and air pollution which contribute to climate change and negatively affect fauna, flora and human populations and cost governments both economically, socially, and environmentally. Best management practices which can be applied in SA, have been described in the BMP. These will create implementable policies and procedures to minimise the detrimental effects of fertilizers. The use of pesticides will be discussed below.

6.7 Discussion related to pesticides

Globally, case studies have been conducted as to the life cycle assessment (LCA) of pesticides which revealed that pesticides are contributing to as much as ±70% toxicity in humans and 50% toxicity of freshwater ecosystems (Foong et al., 2022). This is why international regulations and treaties are in place to protect human health and minimise the impacts of pesticides on the environment.

On this basis, there are international conventions relating to hazardous waste and other chemicals which countries involved in this study are treaty signing members. These conventions include:

- *"Basel Convention on the Transboundary Movements of Hazardous Wastes and their Disposal Rotterdam Convention on Prior Informed Consent*

Procedure for Certain Hazardous Chemicals and Pesticides in International Trade" (Tully, 2013)

- *"Stockholm Convention on Persistent Organic Pollutants (POPs")* (Templeton, 2020)
- *"Montreal Protocol of the Vienna Convention"* (United Nations - Sustainable Development Goals, 2018)
- *"Minamata Convention on Mercury"* (signed but not yet ratified) (Coulter, 2016)

Aligned to these treaties are the following sustainable development goals (Table 6.11).

Table 6.11: The relevant SDG targets aligned to convention treaties and horticulture are:

Sustainable development goals	**International Literature Review of Horticultural Industry Practices**	**South Africa (Statistics South Africa, 2019)**	**OHISA (2021)**
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	The use of organic "plant protection products" in greenhouses resulted in "near zero" on the environment (Zhou *et al.*, 2021)	3.9.3: Mortality rate attributed to unintentional poisoning: 0.2 (2011), 0.4 (2013), 0.2 (2015) (unit: deaths per 100000)	There was a move towards biological pest control and / or organic pesticides but more in the retails compared to production operations
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials…	Most countries have pesticide legislation which is aligned to the International Code of Conduct on Pesticide Management (FAO, 2018)	The main limitation faced by South Africa in reporting progress on SDG 12 is a general lack of indicator-specific reliable and verifiable data at national level.	As mentioned under water resources the industry takes all measures to limit or ensure that no chemicals or pesticides end up in the water courses.

Sustainable development goals	International Literature Review of Horticultural Industry Practices	South Africa (Statistics South Africa, 2019)	OHISA (2021)
12 Ensuring the chemicals and waste doesn’t pollute air, water and soil thus affecting human health and environment.	In Germany legislation regulates use of pesticides e.g., Plant Protection Act of 1986 and revisions thereafter and promotes natural pest control (Griffin, 2010)		Agricultural pests Act 36 and related policy adoption (2010), which is to ensure that pesticides are used in a manner that reduces their negative effects on human health and the environment. Thus, the industry has to prevent chemical pesticides from leaching into groundwater or soil.

In striving to work towards the achievement of the SDGs in Table 6.11 some members of both the international horticultural industry and OHISA have created policies and procedures based on global recommendations and national legislation.

The international focus with regards to pesticide usage is on the legalities of pesticides use, storage, handling, and transportation as well as the safe disposal of containers and packaging. It also highlights the various different types of pests which affect plant production and sales, from mammals, to birds, insects, nematodes, bacteria, fungi and how to combat these causing as little harm as possible to human health and natural ecosystems (Smith and Lopes, 2010; Virginia Tech & Virgina State University, 2015; Horticulture Innovation Australia and Nursery & Garden Industry Australia, 2018; New Zealand Plant Producers

Incorporated, 2018b; Aalbers and Morse, 2021). This corresponds to the SDGs mentioned in Table 6.11.

As was done with the previous key indicators discussed, an analysis of the preferred strategies into plant protection products was conducted using the best management plans, papers and reports tabulated in Table 6.1. Most of the international best practices strategies included an integrated pest management (IPM) system (Smith and Lopes, 2010; Johnson, Mangiafico and Obropta, 2011a; Maxime *et al.*, 2014; De Silva and Forbes, 2016; Oxford Economics, 2018; Wani *et al.*, 2018; Aalbers and Morse, 2021) especially for production nurseries or growers.

Grouping the different application procedures from these results into related categories and ranking these categories according to their prominence is shown in Figure 6.7. From the literature review and study of these international practises it seems that a basic understanding and application of IPM principles is a minimum requirement of the international ornamental horticultural industry in comparison to the 50% of South African growers and 21% garden centre retailers who had knowledge of IPM practices which they applied in their businesses. In South Africa, aspects such as monitoring for pests and training which results in decision-making were mentioned separate to IPM strategies whereas internationally they are embedded in IPM procedures and not mentioned.

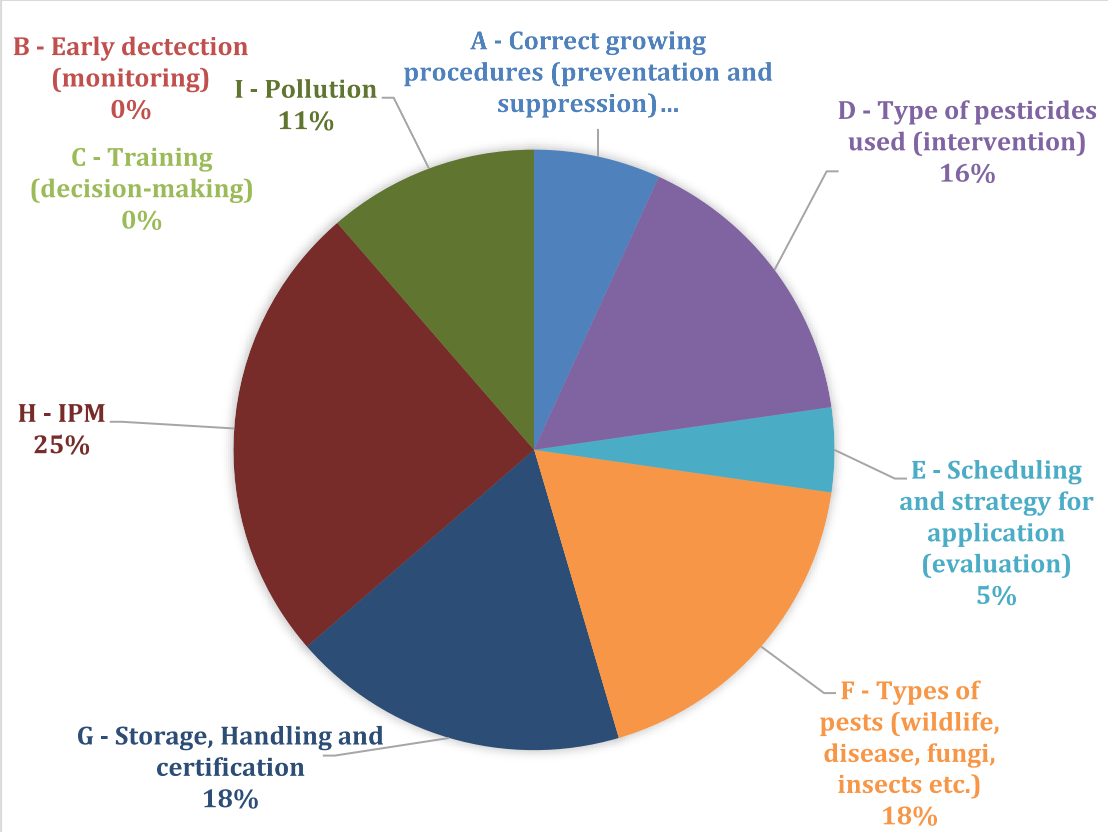

Figure 6.7: International strategies related to efficient use of pesticides and thus the reduction in environmental harm.

Both internationally and locally, the types of pesticides used and their associated active ingredients are becoming more and more important (Lazzerini, Lucchetti and Nicese, 2016). In certain countries the use of neonicotinoid is either banned or in the process of being banned (Havardi-Burger, Mempel and Bitsch, 2020). In support of moving to more sustainable options e.g., organic pesticides and biological pesticides are being tested and recommended (Dennis *et al.*, 2010; Lazzerini, Lucchetti and Nicese, 2016; Canadian Ornamental Horticultural Alliance, 2018; Aalbers and Morse, 2021). In South Africa, less than a quarter of the participants use biological pesticides and a similar but slightly lower number than this use natural pesticides (Figure 5.46). The reasons for this are the movement of containerised plants in and out of greenhouses making it difficult for populations of biologicals to establish themselves whereas they are more successfully used on mother stock (Business 5, 2021).

Pesticide pollution as described in previous Chapters and stressed in the SDGs is a real concern for all ornamental horticultural businesses and the implementation of IPM should minimise the excessive use of pesticides, but more tangible practices have to be applied to further reduce pesticide drift and run-off (Southern Nursery Association, 2013; Horticulture Innovation Australia and Nursery & Garden Industry Australia, 2018) and active steps have to be taken to protect pollinators (Griffiths, 2021) and the environment.

6.8 Discussion related to waste management and recycling

Most businesses, workplaces and homes create general waste such as paper, glass, plastic, electronic equipment, and metal (for example, old vehicles and equipment as well as electronic waste) but those which are specific to the ornamental horticultural industry are:

- Plastic pots, plastic bags, seedling trays and polystyrene trays
- Plastic for tunnels and greenhouses
- Woven plastic or weedguard for flooring
- Plant material
- Growth media
- Pesticides (Figure 5.50), fertilizers (Figure 5.41)

In 2010 a survey was conducted regarding sustainable production practices in numerous states within the USA, which showed that recycling plastic pots, composting of plant material were rated within the top five measures that growers undertook to lessen their environmental impact (Dennis *et al.*, 2010). These practices are still vital to improve the environmental sustainability of the ornamental horticultural industry. More recently, the recycling of all plastics, the use of alternative materials (including waste products e.g., wood chips) as a source of energy and experimenting with various renewable sources of substrates (including waste from other industries e.g., rice husks, tobacco dust, cotton gin trash and green waste) has been advocated (Darras, 2020).

As indicated in Figure 6.8, the participants from OHISA had similar results regarding plastic pots, plastic bags and growth media or substrate reuse (Figure

6.8). Water reuse was also very important. The reuse of waste products to provide energy was not considered by any participants in this research.

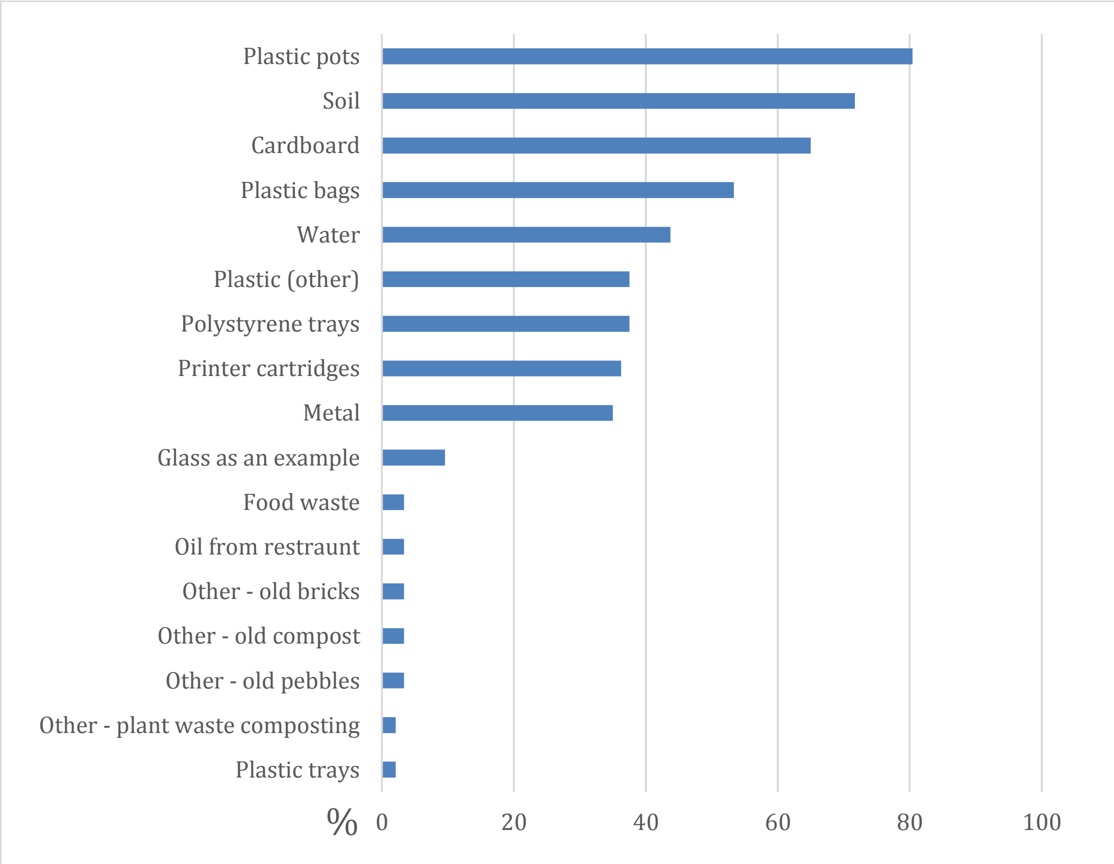

Figure 6.8 The combined results of recycling practices of OHISA participants

Plastic waste

It has been shown that the use of plastic by the ornamental horticultural industry is one of the greatest contributors to greenhouse gases because of the production of the plastic pots and packaging used by the industry (Lazzerini, Lucchetti and Nicese, 2016).

In Germany research showed that the use of plastics escalated from the 1970's and in 2010, although the material used had improved, the concern with regards to sustainability was ranked as medium to low (Griffin, 2010). These results have since changed with consumers looking for more biodegradable packing (Hall *et al.*, 2010; Nambuthiri *et al.*, 2015) which they say they are willing to pay more for but there is still a risk involved (Harris, Florkowski and Pennisi, 2020; Havardi-Burger, Mempel and Bitsch, 2020). Plants can be planted into two types of biodegradable pots, either those that can be planted with the plant, or those that must be composted. The planted variety is usually composed of compressed organic matter e.g., coconut fiber, manure, paper, peat, poultry feathers, straw whereas composted pots are made from “bioplastic” e.g., starch, rice hulls or polylactic acid (Castronuovo *et al.*, 2015). Another option is using recycled plastic from cooldrink or water bottles which are converted to liquid plastic and combined with biodegradable fibres such as cotton or vegetable starch or bamboo that can be molded into a pot. When these breakdown they have a smaller carbon footprint and leave less waste and residue compared to plastic pots (Nambuthiri *et al.*, 2015). The conversion to biodegradable pots has been slow (Harris, Florkowski and Pennisi, 2020) and in South Africa, there were no participants currently using this option as they currently prefer to recycle plastic pots similarly done by many other international horticultural businesses. Table 6.12 shows how the different types of plastics used within the industry can be reused.

Table 6.12: Plastic types used by the ornamental horticultural industry in the United States (green industry) (Association of Professional Landscape Designers, 2020)

PLASTICS USED IN HORTICULTURE				
Plastic	**Resin Identification Code**	**Pros**	**Cons**	**Recycled Uses**
High Density Polyethylene (HDPE)	#2	Rigid durable plastic used for outdoor trees and shrubs. Resists breakage, does not degrade quickly under UV light; thermally and chemically resistant.		Plastic timber, picnic tables, railroad ties.
Low Density Polyethylene (LDPE)	#4	Relatively inexpensive; used to cover greenhouses; mulching material.	Requires special recycling if in contact with pesticides; some companies offer wash line systems for cleaning.	Plastic composite lumber for decks; floor tiles; reusable grocery bags; compost bins and trash cans.
Polypropylene (PP)	#5	Plant containers for greenhouse production; durable; lightweight and resists breakage; not prone to leaching.	Yield losses are pretty high and standardized packaging in PP is low.	Typically not recycled.
High Impact Polystyrene (HIPS)	#6	Flats and trays for seedlings and small plants; inexpensive and lightweight.	Most often discarded or recycled rather than reused.	Can be recycled back into trays.

The above plastics are also used by OHISA members but their reuse and recycling of some of the products can be challenging. As shown in Chapter 5, more than 70% of the participants in this study recycle plastic pots. This is usually done by reusing them or donating them to schools, charities, and communities for reuse. One of the plastic pot manufacturers has recently managed to recycle the polypropylene pots successfully even if they are dirty and still have soil or other residues attached (Richard, 2022; pers. comm.) which was problematic in the past.

The amount of plastic used as greenhouse and tunnel coverings is also an environmental concern. Traditionally, glass greenhouses were used in Europe as they had a long lifespan and glass is biodegradable. With the improvement in plastic coverings for greenhouses and their cost-effectiveness, they have increased in popularity (Griffin, 2010). In South Africa, the tunnel plastic which usually needs to be replaced every 7 - 8 years on commercial farms is reused by schools and charities in the building of their own tunnels where they grow vegetables to share (Eckman, 2022; pers. comm.).

Growth media or substrate as waste

The production or extraction of traditional substates used by growers, particularly peat, resulted in a high release of CO_2 (Gruda, 2012) and so alternative sources needed to be found. These alternative waste sources as was shown in Table 6.9 together with the composting of plant material, provide the ornamental horticultural industry with the opportunity to showcase their ability to contribute to the circular economy and work towards achieving SDGs 11 and 12.

Table 6.13 Relevant sustainable development goals and their targets affected by waste.

Sustainable development goals	**International Examples**	**South African achievement (Statistics South Africa, 2019)**	**OHISA (2021)**
11.6 Reduce detrimental environmental impact of citizens in cities by focusing on air quality, municipal and other waste management strategies	Plastic used for pots contributes towards CO2 emissions (Lazzerini, et al. 2016) 80% of respondents use plastic containers. The lack of knowledge about biodegradable containers by both the growers and landscape professionals and costs are recorded as the slow usage of them by the industry (Harris et al, 2020)	Percentage of municipal waste generated and recycled (domesticated indicator) 1.3% (2015), 1.6% (2016), 7.5% (2017)	Opportunity for OHISA to apply nature-based solutions to improve air quality and showcase waste management strategies within the industry

Sustainable development goals	International Examples	South African achievement (Statistics South Africa, 2019)	OHISA (2021)
12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	Creating awareness and reducing waste of resources such as energy, water, paper, printing, travel and promoting recycling (HTA, 2022)	Specific objectives of the National Development Plan include absolute reductions in the total volume of waste disposed to landfills each year (SDG 12.5), increased waste recycling (SDG 12.5), development of green products and services (SDG 12.2), and carbon-pricing to reduce carbon emissions (SDG 12.C)	All growers in the sample participate in some form of recycling waste and reusing by-products, 92.3% of the garden centre retailers recycle, reducing the amount of waste that is sent to landfills

Each product manufactured or grown has a life cycle which traditionally was linear (Ogunmakinde *et al.*, 2021). By doing a life cycle assessment of a product one highlights areas to reuse, repurpose, recycle, etc., the product, to make the most of the original resources used and decrease the environmental impact. This change of mind set towards analysis of its life cycle has benefits but also has the potential to be over-simplified and lead to misleading data (Hellweg and Canals, 2014).

Figure 6.9 gives examples of how to change our thinking from linear to circular starting from the design and materials used in the manufacturing of the product to its last days and where it eventually ends up – this 9R framework has been adapted to include ideas from the ornamental horticultural industry to reflect on how adaptable products within the industry are towards circularity.

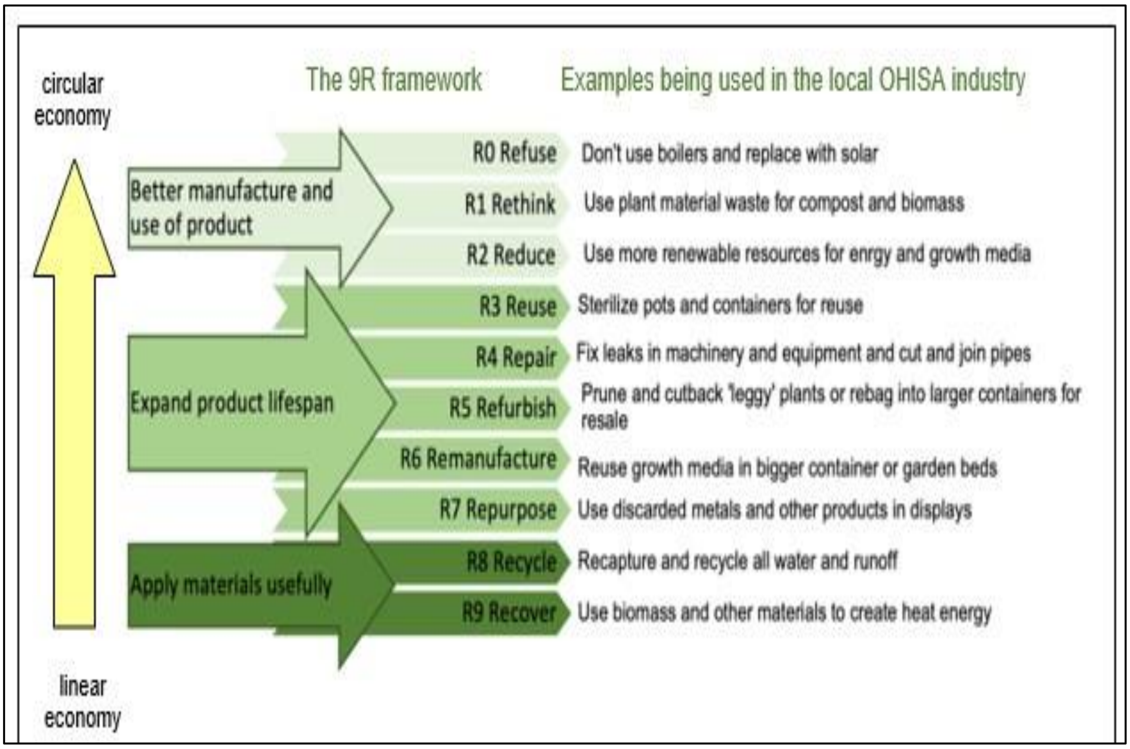

Figure 6.9. The 9R Framework. Adapted from Potting et al. (2017, p.5) cited in Kirchherr, Reike and Hekkert (2017)

Globally the decrease in the use of peat and its combination with different substrates from other industries' waste streams for growing various plant species has been investigated for many years. Examples of this include coir fibres, vermicompost, biochar, pine bark and nut shells (Noguera *et al.*, 2000; Barrett *et al.*, 2016; Alvarez *et al.*, 2017). These circular economic activities have not been isolated to ornamental horticulture in the northern hemisphere. In South Africa and Australia there is evidence of coir, horse manure, bark, timber etc., used by production nurseries (Nursery & Garden Industry Australia, 2014) as discussed in Chapter 5 of this thesis.

A decade ago in Europe, "the green nursery sector produced ±4kg of the residual biomass for each m^2 of the potted plants cultivation" (Sarri *et al.*, 2013). Ornamental horticultural businesses in Europe and United States were composting this plant and substrate waste for reuse (Dennis *et al.*, 2010; Bonaguro *et al.*, 2021) either into landscapes or growing substrates for other plants. The composting of organic matter by the ornamental horticultural industry has a positive environmental message because if it was not done, the waste would be added to landfills or incineration factories. There is minimal research available on the use of flower waste, which includes stems, leaves and flowers of herbaceous and woody plants. World-wide flower waste has been under-utilized as a source of biomass for green fuels and fertilizers although it is readily available throughout the world and more research is necessary to determine the efficiency of this type of waste re-use in a circular economy (Pereira *et al.*, 2022). The potential use of this waste as an energy source is critical as there are negative aspects of reusing growing media as described in Chapter 5 and reiterated in literature e.g., biological pathogens, high salinity, variable pH (Barrett *et al.*, 2016). In South Africa, although plant material and waste are being reused, they are not currently being used as an energy source.

The principles of circular economy and the life cycle assessment of products and plants is already being applied in the ornamental horticultural industry (Nienhuis and De Vreede, 1996; Darras, 2020a; Bonaguro *et al.*, 2021). Lazzerini, Lucchetti and Nicese, 2016, prefered the use of "surface unit" instead of a "product life cycle assessment" as they were comparing growing systems and businesses.

The issue of waste management has become more and more important both internationally and locally and this research has highlighted a few of the common practices of the ornamental horticulture industry. Sustainable waste management practices are explained in more detail in the best management practice manual.

6.9 Recommendations

Considering recommendations arrived at within each section above, it can be concluded that the best practices manual gives tried and tested ways and principles in which to make beneficial changes to an ornamental horticultural business. The question that may still need to be answered is, what is going to encourage members of the industry to make use of it?

The following recommendations can be applied to achieve this, as was done in other countries.

Recommendation 1: Have an accreditation scheme to improve overall sustainability within the industry. This has been done by Australian nurseries for many years e.g., the Nursery Production Farm Management System which includes:

- Nursery Industry Accreditation Scheme Australia BMP,
- EcoHort (environmental stewardship and natural resource management) and
- BioSecure (HACCP) (Biosecurity management) (Nursery and Garden Industry Australia Ltd., 2009; Nursery & Garden Industry Australia, 2014).

In South Africa certain businesses subscribe to these certification systems as they either supply plants and products to international businesses or they supply to chain stores such as Pick 'n Pay, Checkers and Woolworths, which have developed their own criteria of assessment which the growers have to meet to qualify to supply them e.g., Woolworths stipulates that their suppliers must adhere to "Farming for the Future" specifications.

Recommendation 2: For South Africa to insist that the best management practices become certified e, g., GlobalGap, Veriflora and MPS (already mentioned above).

Unfortunately, OHISA has no accreditation schemes governed by SAGIC or SANA but both SAGIC and SANA members must adhere to their respective constitutions e.g., the SANA constitution stipulates that no invasive species may be grown or sold in accordance with National legislation. Although biosecurity is being practised, would it not be better to acknowledge this in an accredited programme?

The Garden Centre Association runs the "Garden Centre of Excellence" competition which all SANA garden centre retail members are encouraged to enter as this sets benchmarks for different sections within the retail garden centres, improves standards, highlights garden centre retailing trends. It encourages environmentally sustainable practices e.g., alternatives to single use plastic bags as an option for customers, biodiversity information and water wise guidelines for customer etc. It would be advantageous for the competition to be adapted for growers to place more focus on sustainable development practices. In addition, OHISA could also develop separate accreditation schemes for growers and retail garden centres which would include the implementation of the best practices manual and thus improve the sustainability of the industry.

Recommendation 3: OHISA growers sign-up to be part of an Environmental Management System such as EcoHort, which focus on the key areas described above, if it highlighted sustainable growing achievements which could then be recognised by plant buyers and so promote more sales?

Recommendation 4: Invite industry role-players not affiliated to SANA and SAGIC to SANA trade days and SAGIC conventions to encourage them to become part of the industry. By increasing membership and affiliation, more companies and individuals will have exposure to the OHISA, best practices and training which will in turn allow they industry to grow and contribute more to the green economy especially if the recommendations above are implemented.

Recommendation 5: Encourage better communication between training and research institutions to ensure that both parties, institutions and OHISA are updated with latest trends and technologies within the industry. This is done internationally where international ornamental horticultural industries are staying abreast of current sustainability technologies and practices by funding and liaising with research intuitions and companies (Canadian Ornamental Horticultural Alliance (COHA), 2013; Maxime *et al.*, 2014; Lazzerini *et al.*, 2018; Bisbis, Gruda and Blanke, 2019; Isaak and Lentz, 2020; Gruda *et al.*, 2021; Nursery & Garden Industry Australia, 2021). In South Africa, the ornamental horticultural industry is perceived to be small, however this should not negate the need for further research into these key factors.

6.10 Conclusion

This chapter shows the progression of best practices manuals and best management practices with regards to the development of sustainability strategies and frameworks. In both Canada and Australia, priorities were highlighted and focused upon research, development, and implementation from these sustainable strategies. Thus, the Canadian Nursery and Landscape Association prioritised green infrastructure as a higher priority than implementation of best practices. Interspersed between these is the life cycle assessment of certain plant species as well as the life cycle assessment of ornamental horticultural businesses which too has been developed to ascertain and improve the overall sustainability of the plant, product, or business. South Africa can learn from these LCA's and adapt this knowledge and practice to our local industry as has been done in some of the BMP practices suggested.

Where possible, the present study compared the international practices cited in the literature and the actual practices implemented by the participants of the study in South Africa. There are many commonalities between the two, both in terms of methods to optimally strive towards environmental sustainability and better use of resources, as well as challenges faced. Although the reasons for the challenges are not always the same e.g., energy usage – South Africa experiences ideal conditions for growing plants compared to many countries in the Northern Hemisphere, but an energy crisis is still being faced.

Chapter 7: Conclusions and Recommendations

This concluding chapter presents a summary of the study, aligns the results and discussion to the research objectives and questions, and puts forward recommendations for OHISA to work towards achieving environmental sustainability. The significance of the research together with data from the from analysis of this research, points to current needs as well as future opportunities for further studies.

Sustainability is described as having three interlaced and integral pillars, namely social, economic, and environmental (Mensah, 2018). Population growth, pollution and consumption of natural resources are factors contributing to decreasing biodiversity and irreversible alterations to the planet (Ganivet, 2020). This highlights a need for improvement in environmental productivity and a shift towards more circular economic thinking and strategies using nature-based solutions. Sustainable development and striving to achieve its goals, is imperative for policy makers not only at an international and national level but also from a management level for businesses, industry (Fleurbaey France *et al.*, 2014) and individuals. This highlights individuals. This will be most effective should the aspects of knowledge, awareness and practices be aligned to this sustainable thinking.

The green industry of which OHISA is a part, has the resources available namely, plants, to provide nature-based solutions to various environmental challenges and contribute positively towards the green economy. The question which was the background to this study was, is the OHISA utilising natural resources e.g., water, soil and energy sources sustainably to produce and sell healthy plants. Using the KAP model the researcher investigated the knowledge, awareness (attitudes) and practices of those within the industry to determine if there was a need for intervention and adaptation to actually make the *“green industry”* green.

7.1 Introduction

The findings from this study show that OHISA because of business processes, certainly does affect our natural environment and makes use of limited resources, but within the industry, some steps have already been taken to reduce this impact. With the introduction and implementation of the BPM, further policies and procedures can be developed and influenced by OHISA and its members to work towards the achievement of many of the sustainable development goals pertaining to this industry. Thus, even though the industry is to some extent “green”, there is still a lot more that can be done to achieve or strengthen this.

7.2 Summary of Study

In summary, the results of this research reflect what OHISA has done with regards to environmental sustainability in their businesses and how this compares to international best practices. The nature and extent of current environmental awareness, knowledge and practices including environmental and / or resource management legislation and its application in the ornamental horticultural industry in South Africa was investigated.

Chapter 2 examined the natural environment such as air, water, land, and soil which is negatively influenced and exploited by humans and industry in the name of development. The relevant literature with regards to environmental challenges the world is currently facing was discussed and some of the causes thereof including pollution, climate change and population growth were also explored. This provided the background for the study and a global picture of environmental sustainability challenges and risks involved for humans, the ecosystems, countries, and businesses. Internationally, there have been numerous proposals, treaties, and research regarding the various ways in which actions can be taken and strategies suggested to mitigate these impacts and problems and provide solutions e.g., sustainable development, green economy, circular economy, nature-based solutions and green or environmental productivity.

This global picture was then narrowed down to focus on the environmental challenges faced by South Africa, South African businesses and then the ornamental horticultural industry. The condensation of the data and grouping of indicators both from global and local research, documentation, treaties, legislations, and practices, focused the researcher's investigation into six key areas namely: energy, water, growth media, fertilizer, pesticides, and waste which were also expressed as areas of environmental concern by the global ornamental horticultural industry.

A conceptual framework was used by the researcher to provide the backbone to the study. This approach was explained in Chapter 3. In conjunction with this conceptual framework, the KAP model offered a method which addressed the current knowledge, attitudes (if possible) and practices of the participants and together these tools provided the guidelines for the study. The KAP model was used to develop a questionnaire and categorise the data collected from the other research instruments discussed in Chapter 4.

In Chapter 4, the research design was described, and clarification was provided on the way that the relevant research instruments were chosen for this study. The focus was on qualitative research, and less on quantitative research, which is ideal for investigating sparsely researched issues (Bitsch, 2005) such as the sustainability of businesses producing and selling ornamental horticultural products from germination (growers) to sale (garden centre retailer) in South Africa (Havardi-Burger, Mempel and Bitsch, 2021). The OHISA was used as a case study and the individual businesses as sub-case studies in this research.

There were several advantages of the instruments chosen namely:

- The questionnaire gave the respondents the opportunity to focus their attention on the topic and matter at hand in their own time. The questions related to key indicators and addressed issues such as environmental legislation, their business management policies and their practical and sustainable implementation, and the obstacles faced by members in reducing the impact of the industry on natural resources and the environment

- The semi-structured interviews were conducted with the business owners or managers on-site which made the participants feel comfortable, and it was convenient for them, making it easier to share and convey the different aspects of their business practices. These positive attributes, particularly of participant observation in situ by the researcher, were suggested by Elwood and Martin (2000), and these interviews also gave the researcher the opportunity to clarify statements written in the questionnaires.
- The document analysis and fieldwork observations gave greater insight into the business practices, and this often complemented the questionnaire answers and interviewee responses making the data collected more reliable thus contributing positively to the triangulation of results.

7.3 Conclusions from results

7.3.1 Conclusions from Research Question 1

Question 1: *How has environmental legislation, management policy and their practical implementation affected natural resource sustainability?*

The environmental resources discussed in Chapter 2, namely air, water, and soil, are under threat and to decrease the negative effects of population growth, pollution and climate change on the availability and usage of these resources the researcher has shown how numerous international legislations and policies have been implemented globally to conserve and advocate the sustainable use thereof. South Africa has legislation to protect these natural resources too, e.g., the National Water Act (1998), the Soil Conservation Act (1946) and the National Energy Act to name a few which were also discussed in Chapter 2 and further aligned to OHISA in Chapter 5. It was shown that although this legislation exists, the implementation and regulation thereof is vital to ensure sustainability both locally and globally. This is not always done effectively hence updated recommendations and policy adjustments are made and deadlines are extended e.g., first was the Millennium Goals, then when these targets weren’t met sufficiently, it was adjusted to the Agenda 2030 (the Sustainable Development Goals) and natural resource depletion and still further adjustments have been made e.g., Agenda 2063 by the African Union. The study shows that Research Question 1 has been discussed and in conclusion, the resources remain at risk despite the global recommendations and treaties and the national legislations and policies thus, instead of having only a top down approach, the researcher suggests a bottom up approach. By improving the knowledge and changing the attitudes and practices of the individuals initially within OHISA using the best practices manual, then the greater OHISA business practices, it could ultimately be an example for other industries to follow suit.

7.3.2 Conclusions related to Study Objective 1 & Research Questions 2-3

The first objective of the study was to: "*identify the nature and the extent of the current goals, environmental awareness and knowledge including and / or resource management legislation, goals and policies of natural resources within the South African ornamental industry".*

Encompassed within Study Objective 1 were Research Questions 2 and 3 which were used to investigate the knowledge and awareness that the participants had relating to the environmental legislation, policies, and recommendations and how these affect their business practices.

The findings from Chapter 5 that focused on sustainable development and environmental regulations and impacts, showed that overall, the participants had an average of below 50% knowledge of environmental legislation both local and international. Only 5% of growers knew about the United Nations Sustainable Development Goals (SDGs) and no garden centre retailers had knowledge of them (although 11% admitted that they were unsure). These international SDGs were mirrored by the South African government in the National Sustainable Development Strategy which 11.9% of the total participants recognised.

It appears that if the regulations directly influenced their bottom-line and business management practices e.g., Plant Breeders Rights Act (2018), there was an increase in knowledge e.g., 70.9% knew this Act and 40% of the participants had heard of NEMA. Although their knowledge of the treaties, regulations and legislation was poor, this was not reflected in their business practices as shown by their answers to the "ways in which they optimise the use" of the key indicators being energy, water, growth media, fertilizer, pesticides and waste e.g., questions 23, 31, 39, 48 in the questionnaire, and business practices.

In answering Research Question 3, "*what environmental policies and practices are implemented by OHISA businesses in term of natural resource and impacts"* it was shown that a total of 87% of the participants were aware of the resources that they consumed which impacted on the environment such as electricity, water, fuel, fertilizer, growth media and waste generated (Table 5.2) but few had implemented policies to reduce their use thereof and minimise their effect on the environment. By using the proposed BPM (Appendix 20), the members of OHISA are given background information into the problems, activities to investigate these problems in their businesses and then templates to create policies, procedures, and practical solutions to mitigate their use of the natural resources and improve their environmental sustainability.

In the discussion, the natural resource that the industry is most dependent on is water. A lack of water has dire consequences for the industry, but the research did show that it also provided the industry an opportunity to show-case best practices to consumers if these are implemented correctly.

The next resource shortage that was of major concern for OHISA was growth media and this was followed by energy shortages such as load shedding and coal shortages, then soil contamination, local air pollution and lastly waste generation. These results reiterate the importance of Study Objective 1 but also demonstrate that the knowledge and attitudes that OHISA have regarding natural resource management, and practices that they implement are encouraging even though their awareness of the legislation was poor.

It is also important to note that indirect awareness was made apparent through the research observation, in that all the businesses had in some manner already implemented a range of practices to address the requirements of the legislation, goals and policies as part of their business practices. To avoid duplication of statements, these practices are discussed under objective two.

7.3.2.1 Energy

The intensive nature of energy used by the horticultural industry globally contributes to air pollution, greenhouse gas emissions and ecosystem degradation. The transition from fossil fuels to alternative energy sources such as solar power and wind energy in countries such as United States and Germany show an improved reduction in emissions and how the international industry is working towards the achievement of SDG 7.

Electricity was the greatest source of energy used by growers and garden centre retailers in South Africa. Results show that most growers (71%) and garden centre retailers (80%) are unaware of Sustainable Development Goal 7 which strives to provide “affordable, reliable, sustainable and modern energy for all” (United Nations Department of Economic and Social Affairs, 2015), while in excess of 80% of retailers and 60% of growers were unaware of the National Energy Act 34. Growers (54%) and retailers (40%) were most aware of the Carbon Tax Act 15 (Figure 5.15).

7.3.2.2 Water

Water availability was the most important natural resource affecting the ornamental horticultural industry both internationally and locally. The source of water varied from groundwater (boreholes and springs), used more extensively in the United States than South Africa, to surface water (rivers, dams, and reservoirs), municipal water and then rainwater harvested or recycled water, which 31% of OHISA used.

The awareness of the 2010 United Nations resolution regarding water is less known to both growers and retailers than the National Water Act. Results show that more that on average than 60% of OHISA participants were aware of the National Water Act (Act 36 of 1998), comprising 70% of growers and 53% of garden centre retailers.

7.3.2.3 Growth Media

Growth media used by most ornamental horticulturalists for growing in containers is soilless but the effects of the ornamental horticultural industry on soil degradation and contamination are detrimental and this is why the international horticultural industry has developed strategies to realize the SDG indicators corresponding to SDG 2, 12 and 15.

In South Africa, most of the participants knew very little about any of the Soil Charters, Acts, Norms and Standards in place to protect and conserve soil and land. These awareness levels were no more than 30% (Fig 5.29), which points to a huge gap in knowledge. As the retailers receive plants already planted and do not create and mix soils / media for planting their awareness levels of these legislations, goals and policies were not tested.

7.3.2.4 Fertilizer usage

The participants in the present study were slightly more aware of the Acts and Bill related to fertilizers. However, their absence of knowledge was not reflected in an absence of safe use and storage of fertilizers, practices which were well portrayed by all participants.

The awareness of the Fertilizer, Farm Feeds, Agricultural Remedies and Stock Remedies Act is not well known by the growers (less than 40%) and garden centre retailers (less than 30%). Awareness of the Fertilizer Bill 2018 was less than 35% for retailers and less than 25% for growers (Figure 5.36).

This points to a knowledge gap which could be strengthened through OHISA training as well as the implementation of a BMP manual within the industry.

7.3.2.5 Pesticides

Pesticides have been used in agriculture and horticulture to improve production yields and prevent losses from disease, insects, fungus, bacteria etc. (Tang *et al.*, 2021). Internationally, there are rigid requirements to adhere to protocols with regards to the use of pesticides (World Health Organization (WHO) and Food and Agriculture Organzation (FAO), 2014), both in agriculture and ornamental horticulture due to their potential to negatively affect human health and natural ecosystems by the release of polluting toxins into the air, water and soil (Nicolopoulou-Stamati *et al.*, 2016; FAO/WHO, 2018; Rasool, Rasool and Gani, 2022).

The use of pesticides in ornamental horticulture differs slightly from agriculture which focuses on improving production outputs. Ornamental horticulture strives to do that while consistently producing a quality, healthy plant which is free from blemishes (e.g., insect bite marks or signs of fungi etc.) and aesthetically pleasing (Bethke and Cloyd, 2009).

In adhering to international regulations and treaties, the South African laws with regards to pesticide production and use are strict. The awareness of the Agricultural Pests Act (Act No. 36) for growers was 62.5% and 47% of the garden centre retailers. This again points to a deficit in general awareness which would translate into possible non-compliance with these two acts.

7.3.2.6 Waste Management

The apex legislation in South Africa that addresses waste management is the National Environmental Management Act (Act no.59 of 2008). The awareness levels range from as low as 33.3% for growers to 57.1% for retailers (Figure 5.51).

The analysis of above leads to the following conclusions, that although OHISA awareness and knowledge of environmental legislation and regulations is poor, the behaviour and practices regards the key indicators in terms of environmental sustainability is better (as will be discussed in 7.3.3).

The above discussion indicates that the Study Objective 1 was appropriately addressed with regard to sustainability awareness and knowledge of resource management legislation, goals and policies in addition to Research Questions 2 and 3.

7.3.3 Conclusions related to Study Objective 2

The South African government highlighted nine key areas to move towards a green economy (Department of Environmental Affairs, 2018) which relates to the Study Objective 2: *"To contribute the green economy and optimum use of resources within the South African ornamental horticultural industry by identifying the nature and extent of current environmental business practices that promote sustainable natural resource management and development"*.

The Table 7.1 below shows the link association between the business practices and where OHISA can play a part in the nine key areas suggested by government (Chapter 2.3.2) and linked to the SDGs (Chapter 2.3.1).

Table 7.1 Key focus areas documented by the South African Government to move the country towards a green economy.

Key areas to move towards a green economy (DEA, 2018)	**Government strategies:**	**OHISA practices**	**SDGs**
"Green buildings and the built environment"	*Greening the urban environment and public spaces.*	This research showed how OHISA provided plants for government, landscapers, and consumers to assist them "*greening" their environment.*	3, 9, 11, 15, 17

Key areas to move towards a green economy (DEA, 2018)	**Government strategies:**	**OHISA practices**	**SDGs**
“Sustainable transport and infrastructure”	*Promote the use of non-motorised transport.*	Many of the staff live on their business properties or close to them - they can walk to work. At some OHISA sites bicycles and battery-operated golf carts are used to move around the farm.	9, 11
	Create and design infrastructure to enhance and not be detrimental to the environment e.g., using biomimicry principles	The study data showed that the structure and installation of greenhouses, tunnels and sheds using optimisation of natural lighting and using plants for temperature control and transpiration reduction.	9
“Clean energy and energy efficiency”	*“Expanding off-grid options in rural and urban areas”*	A few OHISA members use solar power and gas, but government initiatives and crime reduction would incentivise more to do so.	7
“Resource conservation and management”	*“National payments for ecosystem services”*	OHISA industry could become involved in eco-system improvement projects - and some already are e.g., they grow indigenous aloes to replace those which have been poached from the natural environment and donate them to be planted back in their original habitats.	13, 15
	“Up-scale “Working for …” programmes”	As an industry OHISA are already involved in the Invasive training programmes and projects such as “Working for fire”, “Working for wetlands” and “Working for water” are supported by the industry.	8, 13, 14, 15
	“Infrastructure resilience and ecosystems”	Using shrubs as wind breaks for infrastructure the industry can set an example for others to follow.	9, 11
	“Offset programme”	This was mentioned above and has a huge potential as the government has already asked	11

Key areas to move towards a green economy (DEA, 2018)	**Government strategies:**	**OHISA practices**	**SDGs**
		how many trees OHISA sell annually. If this information was known, it could be used to make informed decisions about the offset and improve South Africa's greening initiatives.	
	"Wildlife management"	Promote the correct use of pesticide and fertilizer to encourage biodiversity, within OHISA properties, nurseries and garden retail centres and in turn in the gardens and landscapes of their customers.	14,
"Sustainable waste management practices"	*"Waste beneficiation"*	Almost 50% of growers and 20% of retailers have waste management policies. Added to this all growers recycle or reuse certain waste products within their business and 92.3% of the garden centre retailers do the same. The range of products that are already recycled is vast (Figure 5.54).	1, 12
	"Zero waste community programme for 500 000 households"	Currently no evidence of this exists within OHISA however in support of this strategy, OHISA could support and teach communities in one aspect such as how to use their organic waste to make compost and thus grow food for themselves and produce less waste.	1
	"Agriculture, food production and forestry"	In many of the businesses the staff have their own vegetables gardens where they are growing food for themselves and their families. This could be promoted more. Already as an industry there has been a shift towards "grow your own" for consumers. Although on a small scale it is integral to sustainable agriculture especially since the onset of COVID.	2, 3

Key areas to move towards a green economy (DEA, 2018)	**Government strategies:**	**OHISA practices**	**SDGs**
	"Water management" -- the focus areas within this topic are:		
	"Water harvesting"	Some growers (>20%) and garden centres (>15%) do already do this, and others would be encouraged to do so through the BPM.	6
	"Alternative technology for effluent management"	Although as an industry, OHISA doesn't focus on effluent, the rinsing of pesticide waste from sprayers should be further investigated.	6, 14, 15
	"Reduce water losses in agriculture"	Many of the growers have changed their growth media to increase water-holding capacity thus making the plants sold more water wise. Hand watering and drip watering is practiced by many within OHISA which are both methods to reduce water losses (Figure 5.26). At both growers and garden centres water recycling is promoted.	6
"Sustainable consumption and production"	*"Industry specific production methods and industrial production technology changes"*	Some growers have done this to some extent e.g., using potting machine, improved irrigation, automated greenhouses (however mainly from an energy, finance and water saving perspective).	12
"Agriculture, food production and forestry"	*"Programme includes integrated sustainable agricultural production"*	Within industry there has been a shift towards "grow your own" for consumers. However sustainable agricultural food production was not the focus of this study.	2
"Environmental sustainability"	*"Greening large events and legacy (2010 Soccer World Cup, COP17*	The majority of growers and retailers have landscapers as their customer base (Figure 5.5) and to a lesser extent supply government as their direct customers (Figure 5.4).	4, 13, 15

Key areas to move towards a green economy (DEA, 2018)	**Government strategies:**	**OHISA practices**	**SDGs**
	flagship & Tourism)"	Government predominantly is landscapers as installation contractors. This would imply that OHISA are the predominant suppliers of plants for greening of large events and legacy events.	
	"Research, awareness and skills development and knowledge management"	This was not the primary focus of this study, although this study itself and the development of information and the BMP supports this strategy.	4

Based on the findings of this study as well as that tabulated above (Table 7.1) it can be concluded that the South African ornamental horticultural industry does align itself with the focus areas of the green economy development proposed by national government There are gaps within individual OHISA businesses that do not fully align to the green economy principles. This does point to a need for more focussed initiatives within the industry for those strategies that are appropriate to OHISA.

The above discussion indicates that the Study Objective 2 was appropriately addressed considering the association of the green industry to the green economy principles proposed by the South African government.

7.3.4 Conclusions related to Study Objective 3 and Research Questions 5 and 7

While gaining a better understanding to the knowledge and practices that OHISA implemented, the researcher was also educated about the challenges that are faced in working towards environmental sustainability. These findings highlighted the necessity for Study Objective 3: "*investigate the obstacles preventing OHISA from implementing environmental* *sustainability regulations, recommendations and best practices".* Again, these obstacles are discussed with regards to the relevant key indicators.

Associated with Study Objective 3 are Research Questions 4, 5, 6 and 7 which incorporate the obstacles and challenges the OHISA face related to implementing sustainable development practices and natural resource conservation and depletion.

The general lack of awareness of the many and varied government regulations as well as the SDGs and other policies as discussed in Chapter 5 is an obstacle to implementing the full extent of environmental regulations. This is despite a variety of positive initiatives in place with OHISA as discussed in chapter 7.3.1.

The obstacles which prevented the South African growers from using energy efficiently and implementing changes to achieve SDG 7 were cost, technical information, and infrastructure (Figure 5.21). The local garden centres showed that a lack of technical information and infrastructure was more of a challenge than the cost of using energy more efficiently (Figure 5.21).

Water shortages, droughts and water pollution have detrimental effects on OHISA, and the implementation of water restrictions causes serious constraints on the business (Chapter 5.2.3 and Chapter 5.5) but this is where innovation and training (implementing BPMs) and technology have been proven to minimise this challenge (Table 6.3).

Some of the obstacles to improving watering practices were human errors such as overwatering and watering the pathways when watering by hand, or not fixing leaking hosepipes or dripping taps immediately, forgetting the irrigation was still on or not turning off automatic irrigation when it has rained, time (not having enough hours in the day), old infrastructure and cost to retrofit, water restriction by-laws, lack of knowledge, water pollution, and financial constraints e.g. the cost to convert to drip irrigation (Chapter 5.4).

Growing media is an important commodity and demand for a good quality media, due its positive growing attributes, is continually increasing. The shortages thereof for both OHISA is a challenge. The greatest challenges for South Africa growers as raised in the semi-structured interviews being; inconsistency of growing media, soil borne disease, weed control, and sterilized media. Added to this is the inconsistency of chemical properties such as EC, pH, and the air fill porosity of the local growing media and thus in some cases they went as far as to import the product for specific plant varieties (Chapter 5.6).

The challenges related to optimum fertilizer application and usage that will not negatively impact the environment are few. The primarily obstacles identified are training and research, cost, infrastructure and application effectiveness (Figure 5.42). It is essential for the OHISA to overcome these challenges to reduce the potential negative environmental impacts of overfertilization on humans and habitats - land, water and marine.

One of the challenges that was mentioned repeatedly by the OHI is the disposal of expired pesticides and their containers. Over 30% of the growers use a chemical waste disposal company. More than 35% of the participants add these containers to the general refuse collection which has the potential to cause environmental harm. The rest indicated that they return them to the suppliers (Figure 5.50). An option for further study would be the implementation of biobeds in South Africa to reduce pesticide residue in the water and soils.

The most mentioned obstacles to enhance the efficiency with which OHISA uses natural resources such as water and electricity (coal) was the cost of implementing these changes. That is where the linking of the Study Objective 1 and 2 in this discussion would result in more favourable conclusions. From that mentioned above it follows that Study Objective 3 has been accomplished in the research in conjunction with Research Questions 4,5, 6 and 7.

7.3.5 Conclusion related to Research Question 8

Research Question 8 asks: "*How do the business practices of the industry have the potential to make a positive contribution or harmful effect to the environment, namely land, soil, water, or air?"* According to the results from the questionnaire (Table 5.6) the industry does contribute to environmental damage of the natural resources by polluting the air, water and soil in addition causing land degradation and using threatened resources such as topsoil and peat. It is by educating and implementing policies and change through the training and use of the BPM that these negative effects can be mitigated.

The OHISA is trying to have a positive contribution towards sustainability and natural resource use within the environment as shown below and it has a responsibility and an opportunity to educate and share these with their customers (as was highlighted in *"practical question 5" (page 158)).*

Many of these positive practices were observed but not yet documented as only 23% of the participants had an environmental policy but 48.7 % of participants wish to have one which they can use to make positive changes and document them. 28% of the participants see no need for an environmental policy but as the training and implementation of methods from the best practices manual show beneficial changes to other businesses as has been shown both locally and in other countries where best practices have been applied, they would be encouraged to change too.

According to Table 5.3:

- 83% of growers and 71% of retailers believe that selling plants which have minimal environmental impact is very important.
- 87.5% of the participants wish to prevent or regulate? (reduce) the pollution that they cause. This was highlighted by the fact that 63.5% of participants do not use coal for growing and selling plants, instead they use alternative sources of energy e.g., solar, habitats ideal for growing specific plants in terms of temperature, precipitation and humidity (Business 18, 25 and 21) and energy saving devices and techniques e.g., variable speed-drives on pumps, pumping water when local usage is at its lowest, turning off all electrical

equipment when not in use, LED lighting, using plants to regulate temperatures around tunnels and sheds (Figure 5.19 and 5.20).

In relation to research question 4, there is a positive attitude towards change in the consumption of resources, particularly electricity and water (Table 5.4) which are two of the major inputs and most constrained resources in South Africa of the participants at the time of the study.:

- most of the participants had implemented various strategies to optimize water use (Figure 5.27) which included water harvesting, more effective irrigation, better maintenance of equipment, grouping plants according to their water need (hydro-zoning), specific water saving technology and techniques including training and including water saving additives in growth media (Figure 5.28).

Monitoring natural resource use in terms of growth media was investigated and the methods that the growers used to limit wastage was:

- using specific growth media recipes for a variety of plant species, recycling of growth media, correct storage thereof and applying soil hygiene practices.

The leaching of fertilizers into ecosystems and contaminating resources e.g., water, soil, and land by the OHISA was limited by the following business practices (Figure 5.38) e.g.,

- using the most appropriate type of fertilisers for the specific plant's needs at that time of growth e.g., organic, or chemical, using the most effective application methods e.g., fertigation and reducing use of fertilisers by training and trialing.

Similarly, with pesticide usage (93% participants did use them) the participants focused on:

- monitoring and early detection to reduce the amount of pesticide used whether it be chemical, biological, or natural. The results showed that 50% of the growers implemented integrated pest management strategies to minimize the detrimental effects of pests on the plants (section 5.8).

garden centres do not use or sell pesticides higher than yellow bands which are harmful in nature and hazardous but if used according to the instructions on the are not extremely toxic or very hazardous.

The industry has and is highlighting the positive contribution that it makes providing nature-based solution to environmental problems e.g., planting more trees, shrubs and protecting grasslands into increase carbon sequestration and reducing air pollution or utilising waste from other industries in growth media recipes to be part of a circular economy.

7.3.6 Conclusions related to Research Question 9

Research Question 9 enquired about the *"the similarities and differences in the environmental sustainability factors influencing the ornamental horticultural industry both locally and internationally?"* This question has been answered throughout Chapter 6 as the comparison between South African and International ornamental horticulture industries was undertaken. Currently there is no holistic BMP for South Africa, some information exists in fragmented documents. When compared internationally a range of examples are available as shared in Table 6.1. and 6.3. Results from information/data gathered showed that both OHISA and International OHI struggle with similar aspects such as energy efficiency, optimal use of water, waste management etc. in their facilities. The production of the BPM for South Africa is one step towards closing the gap between the OHISA and the International OHI whilst support SDG's and national legislation.

7.3.7 Conclusions related to Study Objective 4

The progression of the research from the literature review to the local results of OHISA and the comparison of these to international practices culminates in the accomplishment of Study Objective 4: "*to develop a comprehensive manual using KAP principles for training on environmental sustainability and best practices for the conservation and management of natural resources within South Africa, targeted for growers and retailers".*

In the achievement of Study Objective 4, Research Question 8 had to be first answered,

An examination of the aforementioned discussions shows there is a need for knowledge sharing, attitude changing and skill development within OHISA in relation to the key factors, energy, water, growth media, fertilisers, pesticides, and waste associated to environmental sustainability in this study. This should finally result in a change in practices at both a grower and retailer business level.

The information from the participants, their business practices, researcher observation and the analysis of existing literature discussed in previous chapters of this study reveals how the researcher was able to obtain data to work towards Study Objective 4 and Research Question 9. This involved obtaining data, assessing the current OHISA situation (Chapter 5), analysing international best practice (Chapter 6) and based on this information, the compilation of a comprehensive best practice manual which was applicable to growers and garden centres within the OHI and more specifically those in South Africa.

The results obtained from the investigation of the six key indicators involved in OHI sustainability and the literature review were linked to the relevant sustainable development goals. The BMP provides the opportunity for knowledge and skills development. It also provides templates and activities which can be used for training of individuals within the ornamental horticulture business so that these persons can make changes to business policies and procedures with regards to natural resources use and their environmental impacts.

Appendix 20 illustrates the achievement of Study Objective 4.

Internationally it was noted that the motivation to improve environmental sustainability was shown to be certification which involved policy and practice evaluation e.g., GLOBALGAP (UK originally), Milieu Programma Sierteelt (MPS) (Dutch) and Veriflora (American) (Darras, 2020b) and EcoHort (Australia) (Australian Nursery and Garden Indstry, 2014). Locally, a few of the participants subscribe to Farming for the Future and Global GAP to be able to distribute their plants into different markets both in South Africa and abroad. In conjunction with initiating these programmes was the development of best practice manuals to provide guidance, procedures, and practical examples of how to implement changes to reduce the usage of natural resources, minimise environmental impacts and move towards sustainability. These issues interlink Study Objective 4 with Study Objective 1.

Policy development creates a need for procedures and practices to be documented and to be able to do this, knowledge and skills are needed. The participants rated the reasons they would be inclined to develop an environmental policy from a list the researcher compiled from international and local literature:

1. prevent or regulate pollution and environmental degradation (87.5%),
2. produce and sell plants which have a minimal impact on all aspects of the environment (77%)
3. reduce input costs (77%) and
4. save costs by improving waste management (76.5) (Table 5.3).

The greatest motivation being (1) by a margin of 10% and (2 – 4) were rated as almost equally important.

Only 23.3% of the participants had an environmental policy and of those that had only 50% had applied the recommendations contained therein. A further 48.6% wished to have an environmental policy and 28% felt that they had no need for one with most of the latter being garden centre retailers. A few of the garden centres believe that their businesses were too small (only two decision makers) for an environmental policy development. These results indicate the need for information on how to develop an environmental policy. International research and comments from those that have policies in South Africa showed that the growth and beneficial changes implemented because of the policy and procedures were worth it.

The aforementioned discussion indicates that there was a need for Study Objective 4 and this best practice manual has been compiled to support

SDGs, legislation and thereby improve the environmental sustainability of OHISA.

7.4 Weaknesses, limitations and deviations in data experienced during the research.

In addition to the limitations as discussed in Chapter 4.9 the following should also be noted. The sampling method namely purposive sampling a derivative of non-probability sampling was used by the researcher for the South African OHISA population (Creswell and Guetterman, 2019) which is considered to be a heterogenous population. The researcher did take steps to limit this lack of confidence by choosing different sized growers and garden centres with at least one participant from each province within the country, excluding Northern Cape. A total of 29.2% of the SANA OHISA growers and retailers population was sampled. The researcher also included non-SANA members, whose results were similar to SANA members when comparing their questionnaire answers and site visit photos. As a result, although the sample size and make-up might be seen as a limitation, it was not considered a weakness with regards the project as the researcher was searching for in-depth information from the smaller sub-case studies which produced valuable data (Rai and Thapa, 2015; Saunders, Lewis and Thornhill, 2016). It is therefore believed that this method chosen obtained the most appropriate in-depth results.

Some members of the allied trade in the industry (also members of OHISA but neither growers or retailers), who procure and produce chemicals and fertilizers, might have a greater environmental impact than those growers and garden centres covered in the research, due to the nature of their products. These Allied Trade members were not included in the study and therefore impacts from their businesses on any of the six areas of potential environmental impact are excluded and provide separate research opportunities.

An overarching limitation to the study is the size of the OHISA industry within the country compared to the human population size. This results in generalist growers as many growers in OHISA must grow at least 10 different varieties of plant species to be able to survive and so technological advances and speciality growing techniques are not acquired or practiced. Those growers that specialised and condensed their plant range used more advanced computerized systems and growing techniques to create uniformity in the varieties produced compared to the generalists.

This lack of technological advancement within OHISA should not reflect as a limitation for the study as it showed more cost-effective, simpler methods to achieve sustainability in line with the employment needs of South Africa. In addition, this is the reality of plant production and sales within the country and within this context, environmentally sustainable practices and procedures should be developed, honed, and implemented that suit the industry while still supporting SDG's and all appropriate regulations.

The lack of lifecycle assessment done within OHISA is a limitation, but this would be a challenge to implement as many growers produce a wide variety of plants in different sized containers, so to itemise out energy used per plant or even the water used would be extremely challenging. Also, many growers and garden centres do not itemise out measurements of electricity, water, fuel, and growth media per container but rather on an annual basis in terms of finances which would reflect quantities used. However, what could be possible, would be to produce generalised data for each nursery (wholesale and retail) based on their average production / sales data, linked to total of plants. This could be an opportunity for future research.

7.4.1 Bias reduction

The use of numerous instruments to complete the case study in terms of collection, analysis and interpreting provided a cooperative and thorough picture of real-life happenings (Yin, 2003; Stake, 2006; Merriam, 2009; Flyvbjerg, 2011). The strategy to combine the instruments such as surveys, interviews, focus groups (during pilot study), observations and others was used for triangulation which enhances the study (Harrison *et al.*, 2017) outputs and results.

In designing the questionnaire, steps were taken to minimise bias as similar questions were asked for each of the key indicators. This pattern was to make it easier for the participant to understand the questioning process and to complete it. There was a mix of qualitative and quantitative questions and although the researcher was looking for information about the business practices, the questions were not intrusive or of a sensitive nature. This resulted in a high return rate on completed questionnaires. Only one company asked the researcher to sign a non-disclosure form.

The layout of the open-ended questions, scale questions, tables to complete and other questions was structured to ease the participant's completion of them. The length of the questionnaire (35-45 minutes long) was an important consideration to avoid questionnaire fatigue. Only one of the respondents had a problem with the length and yet their final answers were still comprehensive and relevant. Thus, the researcher believed that questionnaire fatigue was not a problem.

The collected data were consistently captured from the research instruments and entered into an Excel spreadsheet. A second person checked the accuracy of all the data captured (Chapter 4.8.2). Data were also coded by two people separately and then they conferred. However, if 100% agreement was not achieved then the codes were discussed until both coders agreed fully (Chapter 4.8.2).

It is therefore believed that the methodology implemented and the process followed throughout the research process did not result in bias.

7.4.2 Verification of reliability and validity

With all the information the researcher made every effort to ensure the trustworthiness of the study by improving the:

- "Credibility" – spending hours on-site doing continuous observation, triangulation and confirming conclusions with participants (Tight, 2020). In one case the researcher had a semi-structured interview with the participant, the questionnaire questions were asked, and the researcher completed the questionnaire from the dictation of the participant's answers - these were then transcribed and returned to the participant for validation
- "Transferability" – the production nurseries or wholesalers provided the context for this study and by compiling the manual (BMP) the researcher will ensure that the information can be applied, and the methods used can be implemented by other researchers and ornamental horticultural businesses
- "Dependability" - the methodical accumulation of various types of data using different instruments improved validity (Tight, 2020)
- "Confirmability" – where bias has the potential to cause a problem with the results, the researcher has highlighted it and provided measures that were taken to minimise it
- "Audit trail" – all data collected (field notes, journals, transcriptions, videos, and raw data) were organized, stored, and analysed to determine its appropriateness in answering the research questions
- "Reflexivity" – notes and journal inscriptions were made when the researcher discovered new ideas or challenging opinions, ensuring a journey of personal growth and reflection.

The use of the mixed method approach was another way the researcher tried to improve and ensure the validity of the study by combining qualitative and quantitative approaches. Where the one approach fell short, the other strengthened the research. However, as mentioned above, validity is neither the combination of the methods nor the results from the experiments and examinations - it is the outcomes in terms of the explanations and conclusions from the research and how close to the truth they may be (Messick, 1995; Shadish, Cook & Campbell, 2002; Lissitz, 2009, cited in Mertens *et al.*, 2016).

7.5 Emerging suggestions and recommendations

This research is a start of the measurement of sustainability practices within the ornamental horticultural industry of South Africa. Once training has taken place and procedures and policies compiled then more detailed information can be obtained from each indicator to provide a more wholistic picture for the business management as how to take steps to improve environmental sustainability and in the long-term productivity and profitability.

The actual impacts of the OHISA on the six chosen environmental resources were not quantified in this study and should be considered for future study and the significance of each should be assessed to determine importance to address.

Further studies should then be conducted on cycle assessment of surface units as was done in Italy (Lazzerini *et al.*, 2018) or even specific plant varieties especially those indigenous to South Africa and compared to the LCA of them grown in other countries e.g., pelargonium (Bonaguro *et al.*, 2021).

Once the best practices have been implemented, a quantitative study into each of the key indicators to determine the actual use of natural resources could be conducted and peer reviewed between companies or during a focus group interview to determine improved sustainability measures to reduce the impact of the industry on the environment and reduce factors from the industry contributing to climate change.

As has been done in other countries, it would be a recommendation of this research to start a certification process according to certain sustainability criteria whereby businesses can measure their sustainability performance which would increase customer confidence within the industry as to being a "green" environmentally sustainable industry.

7.6 Contribution to knowledge / Significance of Study

The significance of this research has shown that, as in other countries, OHISA does impact the environment to a lesser or greater degree and that the representative members of the industry who participated in the study are aware of it (the calculation of the actual extent of the impact was not part of the study). The results from the study illustrate how the use of natural resources whether local e.g., bark, water, coal, or imported e.g., peat, coir, does cause environmental degradation and needs to be reduced to ensure sustainability of the resource. These results also show the practices implemented by the participants in the study to lessen the environmental impacts and decrease the contribution the industry makes to climate change in growing and selling a healthy plant. The discussion from OHISA was compared to other ornamental horticultural industries throughout the world and similarities highlighted and the few differences explained.

The contribution of this study is that the results form a baseline of knowledge and information regarding environmental sustainability within growers and retailers of OHISA. From this baseline future studies can further investigate the key factors in terms of improvement with additional data. The outcomes of the study, using the KAP model, have been used to compile a best practices manual for OHISA using both local and international procedures and recommendations. It is hoped that by OHISA staff working through the best practices manual, their knowledge related to the key indicators will increase, their attitude towards conserving the environment will be more positive and that the practices that they will be implementing within their workplaces will ensure environmental sustainability. This, in turn, will contribute positively towards environmental sustainability and make the industry more resilient to the impacts of climate change such as droughts, flooding, heatwaves and hailstorms and reduce its negative effect on the natural resources.

With each key indicator investigated, there were related obstacles which made it harder for the industry to decrease their impact or reduce the usage. Most frequently the costs, infrastructure and knowledge were the greatest obstacles identified. This, on the other hand, provides an opportunity to research, determine, and implement appropriate solutions within the South African context that also meet required standards and contribute to international SDGs.

These examples show some of the ways this research can contribute both to individuals and businesses within the ornamental horticultural industry regarding their understanding of government policies and thus their own development.

7.7 Additional opportunities for future research

Some of the more social sustainable development goals, which were not highlighted in the study could be part of future studies as they too are applicable to the ornamental horticulture industry in either a positive or negative way. These include no poverty (SDG 1), zero hunger (SDG 2), gender equality (SDG 5), reduce inequalities (SDG 10) and peace, justice, and strong institutions (SDG 16).

It would be beneficial research and produce a model that would determine generalised life cycle environmental impacts for OHISA / SAGIC members based on a range of inputs linked to resources used, and based on their average production / sales data, and then be linked to totals of plants. This could contribute to valuable environmentally sustainable information for the industry.

Another opportunity for future research is that *"everyone wants nature-based solutions but how do we do it and what type of information can we rely on?"* says Darby McGrath, PhD, Program Leader, Plant Responses and the Environment. "We want to fill those gaps with evidence-based research". The OHISA and / or SAGIC could fund research projects through the bursary programme that focused on research which was nature-based and providing solutions to the ornamental horticultural industry problems e.g., recommending which plants are most suitable for carbon sequestration in an urban environment.

7.8 Concluding remarks

During this study, the researcher has shown how population growth, industrial development, and agricultural and ornamental horticultural advancements have caused changes to the environment, not only due to resource use and land degradation but also pollution and contamination of natural resources such as water, land, soil, and air. Despite the many efforts being made to mitigate these effects and save the environment, the results of human manipulation of the environment and the integral cause-effect relationship have resulted in scientists being challenged to effectively remedy the past practices and / or prevent or predict potential problems.

To protect our environment in the future, requires not only the achievement of the sustainable development goals, but also scientific solutions and technological advancements with a greater knowledge and understanding of the inter-relationships between humans the environment. Humans need to become less materialistic and limit their production and consumption of products as well as population numbers (Huesemann, 2001). This together with a sustainable approach to life, business and pleasure.

The ornamental horticultural industry is part of a larger green industry, all of which use plants, resources, and hardware to beautify the environment – be it urban, rural, office parks, factories, home gardens, retail spaces, parks, and sports fields, for both government and private use. This creates a positive impression and, in some cases, provides “nature-based” solutions to specific environmental problems. However, it is important to always be aware of the natural resources used by the industry, to lessen the impact of their use and to rehabilitate those detrimental changes made to habitats and ecosystems when growing and selling healthy plants.

The present research addressed some of these issues and investigated the impacts of the ornamental horticultural industry of South Africa and the practices that have been undertaken to reduce these impacts. It also compared the focus of the South African and international ornamental horticulture industries. In addition, it has provided the tools in the form of a best practices manual for industry role-players to tackle the challenges and improve their environmental sustainability. This has been done in some other countries which has increased their trustworthiness with customers, enhanced relations with government and in the long term bettered their environmental sustainability and even their profitability.

Through this research the researcher highlighted these challenges focusing on the environmental capital which includes the availability and use of resources for raw materials to produce a healthy plant and then the possible degradation of these resources as a result. It also showed how ornamental horticulture can positively contribute to the built environment and not only use the stock of natural resources but add to it in a beneficial manner. The recommended solutions to improve environmental productivity and achieve sustainability, such as striving for a circular economy which creates green jobs using nature-based solutions were also researched.

The culmination of this research is about and for the ornamental horticulture industry in South Africa which although contributing to environmental problems, has the industry advantage of providing tangible solutions through carbon sequestration and biomass energy production, to become a zero or even better, a negative contributor to environmental degradation. The way to achieve this is to create environmental awareness about the problems the earth, South Africa and our local environments are facing and encourage an attitudinal and behavioural change towards the environment through the sharing of knowledge and skills by the implementation of the best practices in the manual.

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10.1007/s00038-017-0952-yORIGINAL ARTICLETime to harmonize national ambient air quality standardsMeltem Kutlar Joss1,2 · Marloes Eeftens1,2 · Emily Gintowt1,2 · Ron Kappeler1,2 · Nino Künzli1,2 Received: 4 October 2016 / Revised: 16 January 2017 / Accepted: 18 January 2017 / Published online: 27 February 2017 © The Author(s) 2017. This article is published with open access at Springerlink.comKeywords Air quality · Air pollution · Policy · Limit values · Standards · Particulate matterIntroduction.

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Appendices

Appendix 1: Sustainable development Goals (United Nations, 2015)

Appendix 2: Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development (United Nations General Assembly, 2020)

Sustainable Development Goal indicators should be disaggregated, where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location, or other characteristics, in accordance with the Fundamental Principles of Official Statistics.1

Goals and targets (from the 2030 Agenda for Sustainable Development) Indicators

The goals relevant to this study are highlight in using the same colours as those in Appendix 1. Those goals not aligned to the study have no colour and there indicators removed been removed. A full copy of the table can be found at (United Nations General Assembly, 2020)

Goals and targets (from the 2030 Agenda for Sustainable Development)	Indicators
Goal 1. End poverty in all its forms everywhere	
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2.1.1 Prevalence of undernourishment
	2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	2.5.1 Number of (a) plant and (b) animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities
	2.5.2 Proportion of local breeds classified as being at risk of extinction
Goal 3. Ensure healthy lives and promote well-being for all at all ages	
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	3.9.1 Mortality rate attributed to household and ambient air pollution
	3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)
	3.9.3 Mortality rate attributed to unintentional poisoning
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	
Goal 5. Achieve gender equality and empower all women and girls	
Goal 6. Ensure availability and sustainable management of water and sanitation for all	

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Proportion of population using safely managed drinking water services
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of domestic and industrial wastewater flows safely treated
	6.3.2 Proportion of bodies of water with good ambient water quality
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 Change in the extent of water-related ecosystems over time
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all	
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption
7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP
7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	
Goal 10. Reduce inequality within and among countries	
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
	11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
Goal 12. Ensure sustainable consumption and production patterns	

12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12.2.1 Material footprint, material footprint per capita, and material footprint per GDP
	12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
	12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1 National recycling rate, tons of material recycled
12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	12.c.1 Amount of fossil-fuel subsidies (production and consumption) per unit of GDP
Goal 13. Take urgent action to combat climate change and its impacts[4]	
13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change
	13.2.2 Total greenhouse gas emissions per year
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1 Progress towards sustainable forest management

15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development	

Appendix 3: Sustainable Development Timeline (adapted from International Institute for Sustainable Development (IISD), no date; Ghorbani, 2020).

1962	Silent Spring	Rachel Carson – toxicology, ecology and epidemiology. Agricultural pesticides causing damage to animal species and human health
1968	Biosphere – Intergovernmental Conference for rational Use and Conservation of the Biosphere (UNESCO)	Basic discussions about Ecologically sustainable development
1970	First Earth Day	National teach about environment
1971	Greenpeace	Formed in Canada
1971	Founex Report	Experts call for integration of environment and development strategies
1971	Polluter pays principle	Organisation for Economic Co-operation and Development Council says those causing pollution should pay the costs
1972	UN Conference on Human Environment	Stockholm – first time links between development and environment were discussed e.g. pollution and acid rain problems Establishment of many National environmental protection agencies and the United Nations Environment Programme (UNEP)
1975	CITES	Convention on International Trade of Endangered Species of Flora and Fauna established
1976	Habitat	First global meeting to link environment and human settlement
1980	World Conservation Strategy	Towards Sustainable Development released by IUCN – 4 factors affecting natural resource destruction: poverty, population increase, social inequalities, and international trade conditions
1980	Global 2000 Report	Recognizes biodiversity as critical to efficient functioning of the planetary ecosystem
1987	Our Common Future – Brundtland Report	Links together social, economic, cultural and environmental issues and global solutions ‘coining’ the term ‘Sustainable Development’ – environmental

		maintenance combining environmental protection, economic growth and social equity
1988	International Panel on Climate Change	Created to be responsible for the scientific process of global warming
1992	Changing Course	The Business council publishes book promoting sustainable development practices
1992	Earth Summit	Agenda 21 Action plan agreed to and
1994	International Conference on Population and Development in Cairo	Access to family planning for all and strengthening women's rights
1995	World Summit on Social Development	Heads of state meet to address poverty, employment, and social disintegration in all countries
1996	ISO 14001	Adopted as international standard for corporate environmental management systems
1997	1st World Water Forum	NGO's, governments, and international organizations meet to raise awareness and social importance of water
1997	UN General Assembly	Earth summit review and notices little progress made
1999	Launch of Dow Jones	First global sustainability index tracking leading corporate sustainability practices worldwide
2000	2nd World Water Forum	Water security noted as a concern for 21st century
2000	UN Millennium Summit and the Millennium Development Goals	Largest ever meeting of world leaders and set 8 Millennium Goals for 2015: combating poverty and hunger, fighting against disease, addressing primary education, environmental degradation and discrimination against woman and maternal health and infant mortality and global partnerships
2002	World Summit on Sustainable Development (Johannesburg)	Frustration at lack of progress and partnerships promoted
2002	Global reporting Initiative	GRI gives guidelines for how organisations should report on the economic, environmental, and social dimensions of their business activities
2005	Kyoto Protocol	Developed countries forced to reduce greenhouse gases and establish Clean Development Mechanisms for developing countries
2010	10th Conference of Parties to the Convention on Biodiversity (COP10)	Adoption of a strategic plan to preserve biodiversity and creation of intergovernmental Science-policy platform on Biodiversity and Ecosystem Services (IPBES)

2012	Rio + 20 Summit	UN Conference on Sustainable Development – Green Economy and institutional framework for sustainable development discussed
2015	2030 Agenda for Sustainable development	17 Goals adopted by all UN Member States to end poverty, protect the planet, and improve the lives and prospects for everyone everywhere
2019	Decade of Action	UN called for 2020 onwards to be the decade of action towards the sustainable Development Goals, calling on world leaders to mobilize financing, enhance national implementation and strengthen institutions

Appendix 4: Agenda 2063 of African Union linked to SDGs (The African Union Commission, no date)

Agenda 2063 Goals	Agenda 2063 - Priority Areas	UN Sustainable Development Goals
1. A high standard of living, quality of life and well-being for all citizens.	Incomes, jobs and decent work	1. End poverty in all its forms everywhere in the world
	Poverty, inequality and hunger	2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
	Social security and protection, including persons with disabilities	8. Promote sustained, inclusive and sustainable Economic growth, full and productive employment and decent work for all.
	Modern, affordable and liveable habitats and quality basic services	11.Make cities and human settlements inclusive, safe, resilient and sustainable.
2. Well educated citizens and skills revolution underpinned by science, technology and innovation.	Education and science, technology and innovation (STI) driven skills revolution	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
3. Healthy and well-nourished citizens.	Health and nutrition	3. Ensure healthy lives and promote well-being for all at all ages.
4. Transformed economies.	Sustainable and inclusive economic growth	8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
	STI driven manufacturing, industrialization and value addition	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
	Economic diversification and resilience	

Agenda 2063 Goals	Agenda 2063 - Priority Areas	UN Sustainable Development Goals
5. Modern agriculture for increased productivity and production.	Agricultural productivity and production	2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
6. Blue/ocean economy for accelerated economic growth.	Marine resources and energy	14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
	Port operations and marine transport	
7. Environmentally sustainable and climate resilient economies and communities.	Bio-diversity, conservation and Sustainable natural resource management.	6. Ensure availability and sustainable management of water and sanitation for all.
	Water security	7. Ensure access to affordable, reliable, sustainable and modern energy for all.
	Climate resilience and natural disasters preparedness	13. Take urgent action to combat climate change and its impacts.
		15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
8. A United Africa (Federal or Confederate).	Frameworks and institutions for a United Africa	
9. Continental financial and monetary institutions established and functional.	Financial and monetary institutions	
10. World class infrastructure crisis - crosses Africa.	Communications and infrastructure connectivity.	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Agenda 2063 Goals	Agenda 2063 - Priority Areas	UN Sustainable Development Goals
11. Democratic values, practices, universal principles of human rights, justice and the rule of law entrenched.	Democracy and good governance	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
	Human rights, justice and the rule of law	
12. Capable institutions and transformative leadership in place.	Institutions and leadership	16.Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
	Participatory development and local governance.	
13. Peace, security and stability is preserved.	Maintenance and preservation of peace and security	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
14. A stable and peaceful Africa.	Institutional structure for AU instruments on peace and security	
	Defence, security and peace	
15. A fully functional and operational APSA	Fully operational and functional APSA all pillars	
16. African cultural renaissance is pre-eminent.	Values and ideals of Pan Africanism	
	Cultural values and African Renaissance	
	Cultural heritage, creative arts and businesses	
	Women and girls empowerment	5.Achieve gender equality and empower all women and girls.

Agenda 2063 Goals	Agenda 2063 - Priority Areas	UN Sustainable Development Goals
17. Full gender equality in all spheres of life.	Violence and discrimination against women and girls	
18. Engaged and empowered youth and children.	Youth empowerment and children's rights	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
		5. Achieve gender equality and empower all women and girls.
19. Africa as a major partner in global affairs and peaceful co-existence.	Africa's place in global affairs	17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.
	Partnerships	
20. Africa takes full responsibility for financing her development Goals.	African capital markets	10. Reduce inequality within and among countries.
	Fiscal systems and public sector revenue	17.Strengthen the means of implementation and revitalize the global partnership for sustainable development.
	Development assistance	

Appendix 5 : Common list of NBS and respective grouped/paired NBS (considered similar or equal across projects) (Castellar *et al.*, 2021)

Projects	**URBAN GREEN UP (GU)**	**UNALAB Project (UNL)**	**NATURE 4 CITIES (N4C)**	**THINK NATURE (TN)**
NBS1	Floodable park	Infiltration basin; (Dry) Detention Pond		
NBS2	Grassed swales and water retention ponds	(Wet) Retention Pond		
NBS3	Rain gardens	Rain gardens		
NBS4	Grassed swales and water retention ponds	Bioswale	Swale	
NBS5	Electro Wetland	Constructed wetlands	Constructed wetland for wastewater treatment	Use engineered reedbeds/wetlands for tertiary treatment of effluent
NBS6	Green façade with climbing plants	Noise barrier as ground-based greening; Ground-based greening	Climber green wall	Climber green wall
NBS7	Hydroponic green façade; Green noise barriers	Façade-bound greening	Green wall system	Green wall system
NBS8	Vertical mobile garden	Mobile vertical greening / Mobile Green Living Room		
NBS9			Planter green wall	Planter green wall
NBS10	Green shady structures		Vegetated pergola	
NBS11	Green roof; Green covering shelters	Extensive green roof; Constructed wet roof	Extensive green roof	Intensive green roof/Semi-intensive green roof/Extensive green roof
NBS12	Green roof	Intensive green roof	Intensive green roof	Intensive green roof/Semi-intensive green roof/Extensive green roof
NBS13		Smart roof	Semi-intensive green roof	Intensive green roof/Semi-intensive green roof/Extensive green roof
NBS14	Natural pollinator's modules; Compacted pollinator's modules		Create and preserve habitats and shelters for biodiversity	Create and preserve habitats and shelters for biodiversity

Projects	URBAN GREEN UP (GU)	UNALAB Project (UNL)	NATURE 4 CITIES (N4C)	THINK NATURE (TN)
NBS15	Planting and renewal urban trees; Trees re-naturing parking	Single line trees; Boulevards	Street trees; Single tree	Street trees
NBS16		Green Corridors		Green corridors and belts
NBS17	Green resting areas	Residential park	Large urban public park	Large urban park
NBS18	Green resting areas; Parklets		Pocket garden/park	Pocket garden/park
NBS19	Arboreal areas around urban areas	Group of trees	Wood; Urban forest	Urban forest
NBS20			Heritage garden	Heritage park
NBS21			Private gardens	Private gardens
NBS22			Vegetables gardens	Community garden; Vegetable gardens
NBS23	Urban orchards		Urban orchard	Urban orchards
NBS24			Use of pre-existing vegetation	Use of pre-existing vegetation
NBS25	Community composting		Composting	
NBS26	Enhanced nutrient managing and releasing soil; Smart soil as substrate		Soil improvement; Structural soil; Mulching	Soil improvement and conservation measures; Incorporating manure, compost, biosolids, or incorporating crop residues to enhance carbon storage
NBS27			Soil & slope revegetation; Strong slope vegetation	Systems for erosion control
NBS28		Living Fascine; Living revetment; Revetment with cuttings (Spreitlage); Planted embankment mat	Vegetation engineering systems for riverbank erosion control	Systems for erosion control
NBS29	Hard drainage-flood prevention Unearth water courses	Reprofiling the channel cross-section; Channel widening and length extension; Daylighting	Reopened stream	Rivers or streams, including re-meandering, re-opening Blue corridors; Systems for erosion control
NBS30		Branches; Reprofiling/Extending flood plain area	Floodplain	
NBS31	Hard drainage-flood prevention	Diverting and deflecting elements		Systems for erosion control

Projects	**URBAN GREEN UP (GU)**	**UNALAB Project (UNL)**	**NATURE 4 CITIES (N4C)**	**THINK NATURE (TN)**
	Unearth water courses			
NBS32	Green parking pavements; Cycle-pedestrian green pavement			

Appendix 6: Overall view of the CRITINC (Critical Natural Capital) Framework (Ekins et al., 2003)

Natural Capital Characteristics																	
Bedrock/ geology																	
Atmosphere and Climate																	
Geomorphology					L												
Hydrology (surface)					e												
Soil					v												
Vegetation characteristics					e												
Flora, Faura					l												
Life Community																	
Ecosystem					1												Human made natural capital
		1	2	…	↓	1	2	…		1	2	3 …		1	2	3 …	
		Source Functions Sustainability Theme: Depletion				**Sink Functions Sustainability Theme: Pollution**			↑ L	**Life support Functions Sustainability Theme: Eco-system balance**				**Functions for human health and welfare**			**Culture, Social Structure Institutions**
	Total resource	State Matrix				State Matrix			e	State Matrix				State Matrix			
I-O table for resource per sector		Impacts A				Impacts B			v	Impacts C				Impacts D			
	Total pollutants								e								
Pollutants per sector	Co2….	Impacts A'				Impacts B'			l	Impacts C'				Impacts D'			
		Total depletion				Total pollution (themed)			2	Total depletion				Total depletion			
																	L
									↓								e
ECONOMIC SUSTAINABILITY		ENVIRONMENTAL / ECOLOGICAL SUSTAINABILITY															v
		Current situation				Current situation				Current situation							e
		Sustainability Standards				Sustainability Standards				Sustainability Standards							l
Economic M-SGAP		SGAP's (Physical)				SGAP's (Physical)				SGAP's (Physical)							3
↑	←←←←←←	Abatement, Avoidancem Restoration costs															
																	↓
		MULTI-CRITERIA ANALYSIS															
		ECONOMIC AND SOCIAL ASPIRATIONS															

Appendix 7: The natural capital indicators in the DPSIR framework. (Adopted from Olewiler (2006))

NATURAL CAPITAL	**Indicator**	**Direction**	**Data Avail-ability**
AIR QUALITY			
Drivers	Number of vehicles	Less is better	1
	Fossil fuel consumption by sector	Less is better	1
Pressures	Emissions of carbon monoxide, Sulphur and nitrogen oxide, particulates, volatile organic compounds	Less is better	2
State	Ambient air quality for above pollutants	Less is better	1-2
Impact	Number of cases of pollution-related disease	Less is better	2-3
	Loss of agricultural output due to pollution		
	Material damage		
Responses	Frequency of air pollution violations	Less is better	2
	Access to public transport	More is better	1-2
	Incentives to drive less (e.g. parking fees)	More is better	1-2
	Access to alternative energy sources	More is better	1-2
	Vehicle fuel efficiency regulations	More is better	
WATER QUALITY	**Indicator**	**Direction**	**Data Avail-ability**
Drivers	Water consumption by sector	Less is better	2
	Use of fertilizers by households and agriculture	Less is better	3
	Industrial usage of toxic compounds	Less is better	2
Pressures	Toxic emissions into water	Less is better	1
State	Drinking water quality (microbial)	Less is better	1-2
	Oxygen levels in water	More is better	1-2
	Ambient level of toxins/waste	Less is better	2
Impact	Number of cases of water-borne disease	Less is better	2
	Boil-water advisories per year	Less is better	1
	Loss of agricultural output	Less is better	2-3
	Habitat contamination	Less is better	3
	Beach closures due to pollution	Less is better	1
Responses	Water quality regulations and guidelines	More is better	1-2
	Water pricing	More is better	1
	Level of sewage treatment	More is better	1
LAND QUALITY	**Indicator**	**Direction**	**Data Avail-ability**

Drivers	Residential, commercial and industrial land usage		1-2
Pressures	Loss of natural areas	Less is better	2
	Solid waste disposal by sector	Less is better	1-2
	Density of buildings	More is better	1-2
	Loss of agricultural land	Less is better	1-2
Impact	Loss of aesthetic values	Less is better	3
	Loss of habitat and species	Less is better	3
	Erosion, siltation of waterways	Less is better	2-3
Responses	Protection of green spaces	More is better	2
	Zoning		1
	New construction vs building renovation		1-2
	Municipal expenditure on waste services	More is better	1

Note: In the availability column, 1 = data usually available, 2 = available only for sectors and more difficult to compile, 3 = limited availability of data and difficult to compile

Appendix 8: Approval letter from industry chairperson Paul Vonk on behalf of SANA Exco

CONSENT FORM

TITLE OF RESEARCH PROJECT

An Investigation into the Environmental Productivity of the South African Ornamental Horticultural Industry

Dear SANA President – Mr Paul Vonk   Date 21/03/2021

I am requesting permission to contact some SANA members for an investigative study with regards my research. I am studying the factors which influence the environmental footprint of the companies, namely energy, nutrients, pesticides, soil/media, water and waste usage. The outcome of the study will be a Best Practises Manual on how to increase their green productivity and thus create a more sustainable business model for the industry.

NATURE AND PURPOSE OF THE STUDY

SANA (South African Nursery Association) is active in many environmental issues either with government or other interested parties. It is referred to as the “green industry”, but little research has been done to investigate the actual environmental consciousness with regards to environmental sustainability of this industry and its role players. The motivation for this study is to explore the current awareness, use and conservation of the resources used in ornamental plant production and retailing businesses. This information will be compared with international practices for similar operations and agricultural practises already implemented in South Africa.

RESEARCH PROCESS

Questionnaires sent to a sample of SANA members

Semi-structured interviews with regards the above topic will be done with those members that are interested in contributing.

Those members who have already made changes to improve their use of these resources will be asked if the researcher would be able to invesagte their businesses in more detail in the form of a case study.

Using the results obtained from the above interviews, investigations and literature review, a manual with regards to environmental productivity will be compiled.

At a later stage those businesses which wish to implement certain aspects of the manual or up-skill their staff members will have the opportunity to send supervisors on a training course using the manual which will cover the six factors isolated for this study of environmental productivity namely: energy, nutrients, media/soil, pesticides, water and waste. Training of the staff members will include different techniques and teaching them about new technologies related to these factors and how to better conserve natural resources in their business.

The results of the study will be presented to SANA members.

CONFIDENTIALITY

The answers, opinions and facts given in the questionnaire are strictly confidential and no company's name or person's name will be mentioned unless the member has otherwise stated that they consent for their details to be shared.

WITHDRAWAL CLAUSE

Any member has the right not to complete the questionnaire and even if they complete the questionnaire and then have a change of opinion or answers and either would like to withdraw their questionnaire or change their answer this can be done within a three month period of them completing the questionnaire.

POTENTIAL BENEFITS OF THE STUDY

This research is important because South Africa has some natural resources that are being utilised beyond expectation and shortages are evident e.g. coal used to produce electricity. Other resources have always been scarce in South Africa e.g. water.

As a higher value is placed on natural resources due to the growing population, they become more expensive or less attainable for horticultural purposes and thus the ornamental horticultural industry would be negatively affected. This would reduce the attributes this industry brings to the South African economy and labour force. The purpose of this study is to investigate and encourage the sustainable use of water, energy, pesticides, soil and nutrients within production and retail nurseries or garden centres as well as the recycling, re-use and reduction of waste products.

On investigation of other industries, it might be a manner in which to assist companies gain greater funding or tax breaks for the green initiatives that they have or are undertaking and be a pathway to accrediting members within the industry e.g. the Green Flag Project, as the Green Industry Buiding Council does.

INFORMATION (Contact information of my Supervisor)

If you have any questions concerning the study, please contact Prof J. Dewar
College of Agriculture and Environmental Sciences
UNISA
Florida, South Africa
Email: Prof J. Dewar: johndewar65@gmail.com

CONSENT

I, the undersigned, Paul Adriaan Leonard Vonk (full name) have read the above information relating to the project and have also heard the verbal version and declare that I understand it. I have been afforded the opportunity to discuss relevant aspects of the project with the project leader, and hereby declare that I agree voluntarily to participate in the project.

I indemnify the university and any employee or student of the university against any liability that I may incur during the course of the project.

I further undertake to make no claim against the university in respect of damages to my person or reputation that may be incurred as a result of the project/trial or through the fault of other participants, unless resulting from negligence on the part of the university, its employees or students.

I have received a signed copy of this consent form.

Signature of participant: …...... ....

Signed at …Fourways………………… on …20 January 2020…………

WITNESSES..

G Olivier. and .W Appel

Appendix 9: Questionnaire given to recipients

UNISA university of south africa

Research project: An Investigation into the Environmental Productivity and Sustainability of the South African Ornamental Horticultural Industry

Dear   Date:

Your knowledge and experience within the industry is invaluable and as a researcher, I would like to draw on your expertise to determine the environmental awareness of our industry. Your contribution will assist the researcher to develop a Best Practices Manual for the industry on how to increase their green productivity and thus create a more sustainable business model.

Your decision to complete and return this questionnaire will be interpreted as confirmation that you have agreed to participate. All information will be treated as highly confidential and your identity and that of other respondents will not be disclosed unless prior permission is received.

If you have any questions regarding the research or related matters, please feel free to contact Cary Goodwin on 0827812710 (caryonsustainability@gmail.com)

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

For each question, please EITHER

insert a tick (?)in the relevant space(s),

OR

write your answer in the space provided.

If you feel you would like to elaborate on certain questions, please do. It can only enhance the value of the research.

Business background information

In which province is your business situated?

Eastern Cape (1)	
Free State (2)	
Gauteng (3)	
KwaZulu Natal (4)	
Limpopo (5)	
Mpumalanga (6)	
Northern Cape (7)	
North West Province (8)	
Western Cape (9)	

Which sector of the South Africa Nursery Association (SANA) does your nursery or garden centre belong too?

Allied trade, bulb and seed association (ABSTA) (1)	
Bedding plant growers (BPGA) (2)	
Garden Centre Association (GCA) (3)	
Growers (4)	
Non-SANA member (5)	

If you produce and / or sell plants which of the following do you specialise in? (Tick all applicable)

Annuals (1)	
Bonsai (2)	
Fruit Trees (3)	
Herbs & vegetables (4)	
Indigenous plants (5)	
Indoor plants (6)	
Perennials (7)	
Roses (8)	
Shrubs (9)	
Succulents & Aloes (10)	
Trees (11)	
Water plants (12)	

Which of the following categories best describes your customers?

	No customers in this category(1)	Less than 30% of customers in this category(2)	30-70% of customers in this category(3)	More than 70% of customers in this category(4)	All customers in this category(5)
Consumers (general public)					
Government departments					
Independent garden centres					
Landscapers					
Retailers (box and chain stores)					
Wholesalers (other nurseries or growers)					

Have you ever been pressurised by a customer to be environmentally sustainable?

Yes ☐ (1)   No ☐ (2)   Unsure ☐ (3)

If yes, give the details:

____

____

____

____

Environmental awareness

Which of the following general environmental declarations or legislation that apply to the ornamental horticultural industry are you aware of:

1983 – Conservation of Agricultural Resources Act, 1983

(Act No. 43 of 1983) [CARA]

Updated in 2013 Conservation of Agricultural 2013 Amendment Bill

1998 – National Environmental Management Act (NEMA)

1992 – Earth Summit – Agenda 21 (International)

2000 – United Nations Millennium Development Goals

2002 – Resources Development Act, 2002

(Act No. 28 of 2002)

– Green Economy Accord (National – South Africa)

– National Development Plan

2012 – National Strategy of Sustainable Development (2011-2014)

2015 – Sustainable development goals (International)

2018 – Plant breeders' Right Act 12 of 2018

– Plant Improvement Act 11 of 2018

– National Climate Change Adaptation Strategy

Republic of South Africa Version UE10

2030 – Vision Summit

Yes & how it applies to ornamental horticultural industry (OHI) (1)	No (2)	Yes, but unsure of how it applies to OHI(3)

For the purposes of this study, environmental management is defined as the methodical manner to find innovative, practical and sustainable ways for saving water, energy, and materials, while reducing detrimental environmental impacts such as pollution.

Using or referring to this definition:

Does your business have a written environmental management policy?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, has your business implemented this environmental management policy?

Yes ☐ (1) Year _ _ _ _ (If Yes) No ☐ (2)

If no, has your business considered introducing an environmental management policy? Yes ☐ (1) No ☐ (2)

Asses the importance of the following motivations for an environmental management policy:

	Not important(1)	Moderately important(2)	Very important(3)
Prevent or regulate pollution			
Improve your relations with regulatory authorities			
Selling plants which have minimal environmental impact			
Improve the environmental image of your business			
Create cost-savings in terms of inputs			
Cost savings in terms of waste management			
Other (please specify) -			

Are you aware of the usage of the following factors influencing your business's environmental performance?

	Yes(1)	No(2)	Not applicable (N/A) (3)
Water usage			
Growth media consumed			
Electricity consumed			
Fuel consumed			
Fertiliser usage			
Waste generated			

Do you think you can reduce your consumption of the following natural resources?

	Yes(1)	No(2)	N/A(3)	If yes, give an example
Coal				
Electricity				
Growth media				
Water				

Have any of your business activities resulted in the following:

	Yes(1)	No(2)	Unsure(3)	Not applicable(4)
Air pollution				
Soil contamination				
Landscape degradation e.g. soil Erosion or waste accumulation				
Water pollution e.g. fertiliser leaching				
Chemical spills				

If yes, give an example:

If no, give methods of how you prevent it?

____

____

____

____

To what extent do you think each of the following environmental impacts could negatively impact your business with regards to your plant production and sales:

	No negative impact(1)	Moderately negative impact(2)	Very negative impact(3)	Not applicable (4)
Water shortages				
Growth media shortages (e.g. topsoil, peat)				
Energy shortages (e.g. coal, oil, electricity)				
Waste generation				
Local air pollution				
Soil contamination				

When buying and/or marketing your plants and products, does your business habitually consider informing buyers or consumers of ways you have reduced your environmental impacts?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, explain how:

____

____

____

Environmental sustainability factors

To produce and/or sell a quality plant the following resources are used:

Water, Soil, Energy, Fertilisers and Pesticides sometimes with resultant waste.

WATER

Are you aware of the following resolutions and legislations with regards to water:

	Yes(1)	No(2)	Unsure(3)
United Nations General Assembly Resolution, The human right to water and sanitation 29 July 2010 (A/RES/64/292)			
National Water Act (Act 36 of 1998) which provides for water to be protected, utilised, developed, conserved, managed and controlled, in a sustainable and equitable manner			

What is your water source? (You can mark more than one)

Borehole (1)	
Dam/ reservoir (2)	
Harvested rainwater (3)	
Municipal (4)	
Recycled water captured (5)	
River (6)	
Spring (7)	
Other (please specify) (8)	

Do you have a written policy on water usage within your business?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, are you willing to submit it for comparison with others within the industry?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

List five practices that your business applies to optimise the use of water that could be included in a best practice's manual:

Indicate which method of watering you use? As a percentage (%)

Watering method	% of plants watered by this method	e.g.
Hand watering (Hosepipe)		65%
Hand watering (Watering cans)		2%
Drip irrigation		15%
Overheard sprinklers		18%
Capillary matting		0
Flood tables		0
Other (Specify)		0
		= 100%

Has your company taken any measures to reduce their water usage?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes to question 25, please mark relevant practise or method and include example/s

Example	Yes(1)	No(2)	Details of change
Changed growing media			
Example	Yes(1)	No(2)	Details of change
Changed watering practises			
Fog water harvesting			
Planted wind barriers to reduce transpiration			
Recycle water used			
Retro-fitted toilets and put in dual flush systems			
Training on efficient water practises			
Other -			

(1)

What obstacles are preventing you from using water more efficiently?

____

____

____

____

SOIL / GROWTH MEDIA – this section is to be completed by production nurseries only

	Yes(1)	No(2)	Unsure(3)
Are you aware of the following resolutions and legislations with regards to soil and growth media: World Soil Charter, 1981 (Revised 2015) improving governance of limited soil resources and ensuring healthy and productive soils for a food secure world			
Soil Conservation Act 45 of 1946 which was later replaced by the Conservation of Agricultural			
Resources Act 43 or 1983which consolidating all measures concerning soil utilisation and conservation			
National Norms and Standards for The Remediation of Contaminated Land and Soil Quality (2014) provides a national approach to the remediation of contaminated land by setting minimum standards for assessment of environmental protection measures			

Do you have policy on soil / growth media usage within your business?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, are you willing to submit it for comparison with others within the industry?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

List three practices that your business applies to optimise the use of soil / growth media that could be included in a best practice's manual:

____

____

____

____

What type of growing media do you use? (You can mark more than one)

Bark	
Coir	
Compost	
Garden soil	

Inhouse mixture	
Peat	
Potting soil	
Sawdust	
Topsoil	
Vermiculite	
Other (please specify) -	

Do you use different soil / growth media for different plant groups according to their pH, EC and air-filled porosity (AFP) requirements? i.e. do you have different recipes for different plants?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

Do you reuse your soil / growing media?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

What obstacles are preventing you from using your soil / growth media efficiently?

___

___

___

___

ENERGY

Are you aware of the following resolutions and legislations with regards to energy sourcing and usage?

	Yes(1)	No(2)	Unsure(3)
Sustainable Development Goal 7 access to energy and clean cooking, renewable energy and energy efficiency			
The National Energy Act 34 of 2008 allows for diverse energy resources to be made available and the promotion of efficient generation and consumption of energy and energy research			
Carbon Tax Act no.15 (2019 (IPCC Code 1A4c)) which includes the combustion of the following fuels: Anthracite, BioDiesel, Biogasoline, Diesel, Charcoal, Peat, Petrol and others which emission factors			

Do you have policy on energy usage within your business?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, are you willing to submit it for comparison with others within the industry?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

List three practices that your business applies to optimise the use of energy that could be included in a best practice's manual:

____

____

____

In the table below indicate which fuel sources are used for the different appliances, tools, machines and vehicles in your business

	Anthracite	Biomass	Coal	Diesel	Electricity	Gas	Methane	Petrol	Solar	Wind	Water	Other Specify
e.g. appliances					x							
Boilers												

Office equipment												
Generators												
Kitchen appliances												
Lighting												
Pumps												
Small tools e.g. weed eaters												
Sprayers												
Vehicles												
Trucks / tractors												
Underfloor heating in tunnels												
Air-conditioners												
Fans (												
Other												

41.To create the optimum temperature in specific areas for the production and / or selling of your plants, do you use an alternative to coal-produced electricity, e.g. (you can choose more than one.)

Biomass / Organic matter decomposition for heat generation
Gas Heaters
Heated water in under-floor piping
Hedging for cooling by reducing transpiration Misting for cooling

Open areas	Shade sheds	Tunnels

Oil Heaters			
Paraffin Heaters			
Shade netting			
Solar			
Thermal curtains			
Trees for shade and cooling			
Vermiculite			
Other – please specify -			

What obstacles are preventing you from using energy efficiently?

____

____

____

____

FERTILIZERS

Are you aware of the following legislations with regards to fertiliser usage within ornamental horticulture?

	Yes(1)	No(2)	Unsure(3)
The Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947) (Act No. 36 of 1947) provides for the registration and importation of fertilizers, farm feeds and sterilizing plants and certain remedies			
The Fertilizer Bill, 2018 to ensure that the manufacturing of safe and good quality fertilisers suitable for plant production; monitor the manufacturing of fertilisers to ensure that they play a critical role in food safety, human and environmental health, nutrition and food security			

Do you fertilize your plants? Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If not, why not?

Do you have a policy on fertiliser usage within your business?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, are you willing to submit it for comparison with others within the industry?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

List five practices that your business applies to optimise the use of fertiliser that could be included in a best practice's manual:

Are the fertilizers you use:

Inorganic (Chemical) ☐ (1)

Organic ☐ (2) or

Both ☐? (3)

Unsure ☐? (4)

How do you apply your fertilizer (you can choose more than one method?)

By hand ☐ (1)

Liquid (Dosatron or inline) ☐ (2)

Added to growing medium ☐ (3)

Other ☐ (4)

What happens to any of your excess or leached fertilizer:

It permeates into the soil (1)	
It drains into the groundwater (2)	
It is captured and reused (3)	
It ends up in water sources to be re-used (4)	

Other (5)

What obstacles are preventing you from using fertiliser efficiently?

____

____

____

____

PESTICIDES

Are you aware of the following legislations with regards to pesticide usage within ornamental horticulture?

	Yes(1)	No(2)	Unsure(3)
Agricultural Pests Act, 1983 (Act No. 36 of 1983) To provide for measures by which agricultural pests may be prevented and combated; and for matters connected therewith			
Adoption of pesticide management policy for South Africa (Notice 1120 of 2010) to ensure that pesticides are used in ways that lead to the minimisation of significant adverse effects on human health and the environment			

Do you use pesticides in your business? Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If not, why not?

____

____

Which type of pesticides do you use (you can answer more than one question)?

Biological ☐ (1)

Chemical / Synthetic ☐ (2)

Natural ☐ (3)

Do you use pesticides preventively ☐ (1) or curatively ☐ (2)?

Do you have an integrated pest management policy?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, can you explain the strategy and what methods are used?

How do you dispose of the pesticides and their containers that have expired or that you no longer use?

Dilute and pour into environment (1) ☐

Return empty bottles/containers to supplier (2) ☐

Add to general refuse collection (3) ☐

Call a chemical waste disposal company (4) ☐

Bury them (5) ☐

Other (specify) (6)

REDUCE / REUSE and RECYCLING OF WASTE

Are you aware of the following legislations with regards to waste accumulation and disposal within ornamental horticulture?

	Yes (1)	No (2)	Unsure(3)
National Environmental Management: Waste Act (Act no. 59 of 2008) (NEWMBA) protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development			

Do you have policy on waste management within your business?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

If yes, are you willing to submit it for comparison with others within the industry?

Yes ☐ (1) No ☐ (2) Unsure ☐ (3)

Do you recycle or re-use any products involved in the production and / or selling of your plants, which are either by-products or waste?

Yes ☐ (1) No ☐ (2)

65.If yes, mark the box with an ‘x’ and mention how you re-use/recycle it (a few examples are listed below):

Waste Product	Recycle	Explain how:
Cardboard		
Glass	[illegible]	Glass recycle bank
Metal		
Plastic bags		
Plastic pots		
Plastic (other)		
Polystyrene trays		
Printer cartridges		

Soil		
Water		
Other (please specify)		

If you re-use your products does it:

Create an income? ☐ (1)   RReduce input costs? ☐ (2) or Other ☐ (3)

If cost wasn't a factor, what 5 environmental management or infrastructural changes would you initiate in your business in the next 3 years and list in order of priority:

1

2

3

4

5

Thank you very much for taking the time to complete this questionnaire and share your valuable information. The results of this research will be communicated to you when the project has been completed.

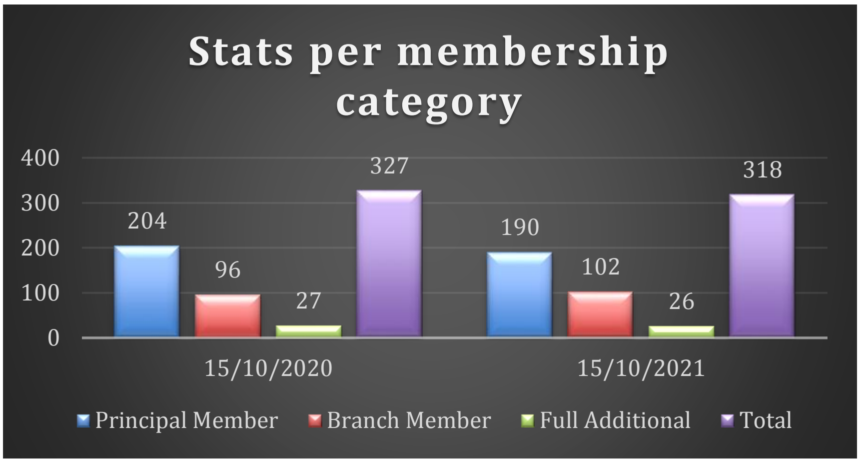
Contact person: Cell:

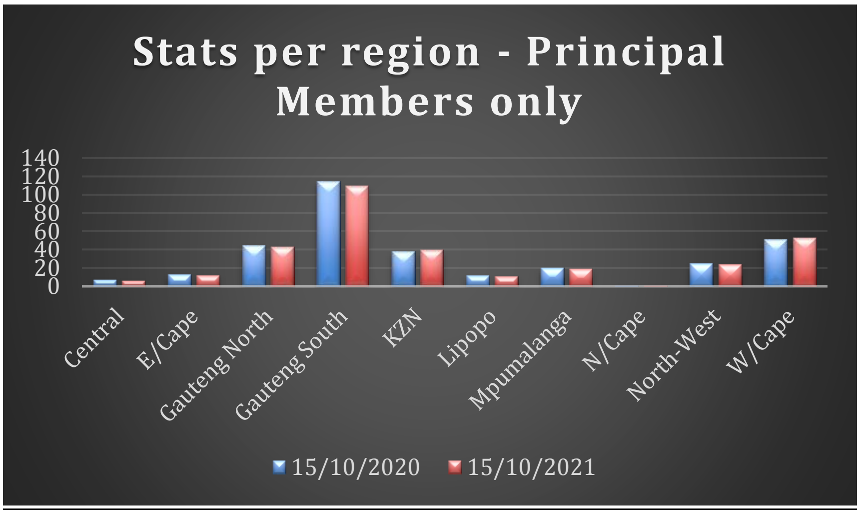
Business name: Date:

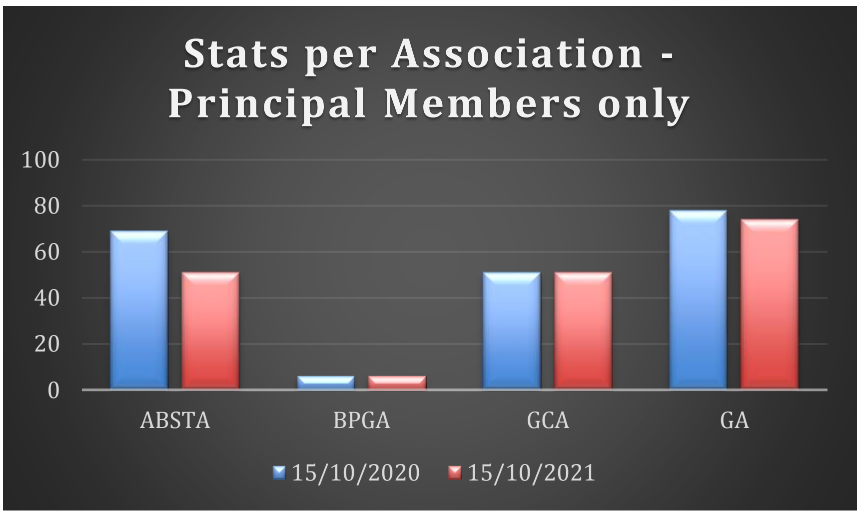
Email:

Appendix 10: SANA Membership information (Olivier, 2021)

<u>Membership Graphs</u>







Appendix 11: List of participants in the study

Growers or plant production nurseries		**Garden centre retailers**
3 Bushketeers Wholesale Nursery		Alma Nursery
Aquaflora Nursery		Builder's Warehouse
Arnelia farms		Cape Garden Centre
Avedore Wholesale Nursery		Colourful Splendour Garden Centre
Ball Straathof (Pty) Ltd		Concrete Creations CC
Bristle Cone Nursery		Eckards Garden Pavilion
Doonholm Nursery		Garden World Nursery
Elands Nursery		Greener Tidings Garden Centre
Green Earth Nursery		Heckers Garden Centre
Heuers Wholesale Nursery		Lifestyle Home and Garden
Honeywood Wholesaler		Montana Garden Pavilion
Klugro Wholesale Nursery		Plantland The Wilds Garden Centre
Ludwig’s Roses		Sebenza Garden Centre
LVG Plants (Pty) Ltd		Stodels
Magenta Nursery		Sunkist Garden Pavillion
Malanseuns Wholesale Nursery		Super Plants Tokai
Montana Wholesalers		The Aloe Farm
Ngena Succulent Wholesale Nursery		
Peebles Plants Wholesale plant grower		
Roos Nursery		
Sebenza Wholesale Farms		
Sittig's Grower Nursery		
Siyakhula Nursery		
Tuberflora Nursery		

Appendix 12: Photos from site visits related to energy factor within OHISA

Photo 1 and 2 - Viburnum hedge and soil berm

Hedging provides protection from the weather elements e.g., wind for the plants in the tunnels and greenhouses reducing the amount of

Photo 3 and 4 – Solar energy farm on site at a grower

This solar farm supplies some of the electricity used by the grower. They do still have a connection to ESKOM (Photo from Google Earth)

Photo 5 - Solar panels of garden centre

Use of solar power to provide energy from the panels on the roof

Photo 6 and 7 - Reading of solar energy

Solar energy reading sent to mobile farm to keep business owner informed (Business 8)

Photo 8 and 9 – Changed globes to be more energy efficient

Photo 10 – 14 – The use of opaque roofing increases light naturally

Use of natural lighting by changing roofing materials (Business 2, 17, 34, 19,

Photo 15 – 16 – Greenhouse insulation and screens for temperature control


Different roofing covers and side wall screens to provide protection and different light requirements of plants (Business 1, 5, 36)

Photo 17 – 18 – Mechanization of green houses


Greenhouse roof and sides are opened depending on temperature inside(Business 11 and 26)

Photo 19 – 20 – Alternative sources of energy to create optimum temperature


Using hedging to create protection windbreaks

Photo 21 – 22 – Shade nets protect plants from heat and hail


Shade nets are available in different colours and certain growers prefer white or platinum colour to the traditional green. They are also available in different percentages of strength e.g., 80% dark is better to create a shady environment for shady loving plants compared to 40% which is what most growers use to harden off their plants. 40% Shade netting is also used by most garden centres to create optimum light and temperature for plants, staff and customers.

Photo 23 – 24 – Frost cover used to protect plants in winter


Using frostguard to protect plants (Business 5, 12, 16)

Photo 25 – 26 – Frost cover used outside and inside greenhouses


Frost cover also is available in different strengths or thickness and most industry members use the 30g either white or green in colour.

Photo 27 – 28 – Material is used to prevent taps from freezing

These screens are usually seasonally installed (Business 20, 21, 15)

Photo 29 – 31 – Fabric or plastic screens around sheds for protection

Photo 32 – 33 – A lack of natural protection then requires screens

Material protection such as netting and matting (Business 18, 24)

Photo 34 – 35 – Lifting seedlings off the concrete floor

Seedlings lifted off floor and placed on sand and vermiculite bed or on heated water pipes for better root development as they maintain a more constant temperature and provide insulation from the concrete (Business 5, 12, 30)

Photo 36 – 37 – Lifting seedlings off the concrete floor

Water in pipes beneath tables used for maintaining moderate temperatures (Business 14)

Photo 38 – 39 – Using natural environment to provide shade

Trees providing a nature-based solution to regulate temperature for growing plants

Photo 40 – 41 – Boilers used for heating greenhouses in winter

Photo 42 – 43 – The use of coal to produce heat energy

The industry has to move towards a more sustainable source of heat energy e.g., photo 1 and 2 or biomass combustion and away from coal

Appendix 13: Photos from site visits related to energy factor within OHISA

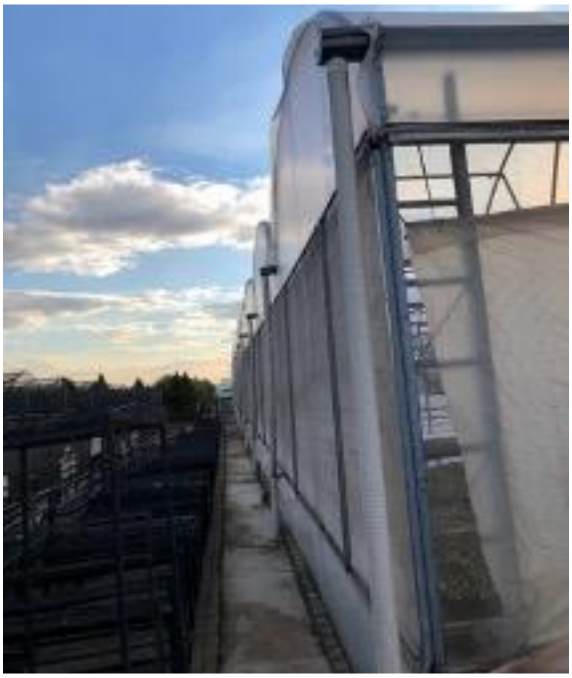
Photo 1 and 2 – Mulching of beds

Photo 3 and 4 – Mulching of soil on soil surface

The use of bark chips, wood chips, pebbles or crush on soil surface reduces loss of water from soil surface and maintains a cooler temperature for plant roots. It also reduces the amount of weeds that grow which compete with the plant (Business 31)

Photo 5 and 6 – Concrete channels to capture water

Photo 7 and 8 – Concrete pathways and channels



Concrete drainage channels to capture all runoff water (Business 5, 14, 22, 41)

Photo 9 – 12 – Gutters capture rain water for water harvesting

Gutters on building and greenhouses to capture rainwater (Business 8,15) either into tanks or channels flow in dams

In garden centres rain water harvesting tanks showcase water saving ideas to customers (Business 4,)

Photo 13 – 14 – Greenhouse insulation and screens for temperature control

Another very simple way of rainwater harvesting. Water to be used in nursery (Business 7)

Photo 15 – 16 – Irrigation examples – Hand watering

Both growers and garden centres do hand water (Business 5, 37)

Photo 17 – 18 – The use of hosepipes and sprayers

The hosepipe thickness and type of sprayers used by the different growers and garden centres are shown in these photos
e.g., Hose pipe rolled up safely to protect it being damaged by trollies (Business 2)

The sprayer nozzle attached to hosepipe varies depending on plants being watered and company preferences but does affect amount of watering being used (Business 6, 8) (above and below)

Photo 19 – 20 – Examples of sprayer nozzle

Photo 21 – 22 – Different types of drip irrigation used in the OHISA

Business 6

Photo 23 - 24 – Different types of drip irrigation used in the OHISA

Business 1

Photo 25 – 26 – More examples of drip irrigation

Different drip irrigation bigger bags of older plants (Business 24)

Photo 27 - 28– More examples of drip irrigation in different containers

Drip irrigation can be used in smaller pots with young plants, larger bags as well as hanging baskets. This was shown by the growers of the OHISA (Business 24 and 37)

Photo 29 – 30 – Drip irrigation in young, potted plants

Business 5 and 37

Photo 31 – Drip irrigation used in mother beds of plants

Business 30

Photo 32 – 35 – Example of capillary matting used to water plants

Root development using capillary matting

Business 26

Photo 36 – 37 Plant and container varieties watered using capillary matting

Photo 38 – 39 – Planting grouping

Succulents grouped in tables with metal drainage basin to capture excess water (similar to flood tables) (Business 19)

Photo 40 – 42 – Dams and reservoirs for collecting water

Dam covered to reduce transpiration (Business 6,7 20)

Photo 43 – 45 – Water tanks for collecting water

Water storage tanks – water comes from reservoir into tanks to be pumped for irrigation or gravity fed if topography of land facilitated it (Business 6, 9).

Water storage tanks – water comes from borehole into these tanks (Business 18), in drier region more tanks are necessary

Photo 46 – 47 Water tanks for collecting water

Water storage tanks – municipal water is used to filled these tanks as groundwater in the area is polluted and the water supply is irregular thus they need many tanks – emphasis how water dependent the nurseries are (Business 2)

Rainwater collection tanks (Business 34) for the garden centre within a retail shopping centre

Photo 48 – Dam with an plant covering

Aerating pond with plant cover (Business 11)

Photo 49 – 50 Dam for collecting runoff from nursery

Business 26

Photo 51 – 52 Customer education of waterwise plants and signage

Waterwise gardens – showing customers how to have a beautiful garden and still be waterwise (Business 19, 34)

Informing customers of how they can save water (Business 10 below or why business do what they do to save water (Business 11 above)

Photo 53 – 54 Customer education of waterwise plants and signage

Appendix 14: Photos from site visits related to growth media indicator within OHISA

Raw materials used by the OHISA in growth media formulations

Photo 1 – Different examples of heaps of growth media

An example of different growth media formulations from local suppliers e.g., mix 6 (front - 1) has a different ratio of bark, coir and potting to mix 8 (behind – 2) Then building sand (3) as a comparison (not to be used as growth media) and on the very right finely sieved potting soil (4) (Business 36)

Photo 2 – Different examples of heaps of growth media

Photo 3 - 5 – Different examples of heaps of growth media

An example of raw materials used to formulate ideal growth media for plants (Business 26) e.g., wood, decaying branches, sawdust, recycled growth media, compost, coir fibres etc.

Photo 6 – 9 Different examples of growth media

Circular economy - this grower uses the hydronic mix from local cucumbers farms and horse manure making their own growing mix make growth media (Business 20). Germinating seeds in small containers with a good growth media containing coir and then transplanting in bigger containers with their own mix

Photo 10 – Different examples of growth media components

Sawdust on the left from local horse farms – an example of reusing other industry waste and composting it (Business 9)

Photo 11 - 12 – Premium / imported substrates are kept in sealed bags

Many growers purchase pre-formulated mix (from local and international suppliers) specific to the stage of plant growth or for specific plants (Business 30, 36)

Photo 13 - 16 – Premium / imported substrates are kept in sealed bags




To maintain soil hygiene, the storage of growth media especially that which is imported (e.g., premixes, coir block, and peat) is very important. It makes financial sense to store and use it as sustainably (Business 5, 9, 14, 36)

Appendix 15: Photos from site visits related to fertiliser factor within OHISA

Preventing pollution by the leaching of fertilisers into the water or soil is very important to most members of the OHISA

The practices that the do to reduce or prevent this are:

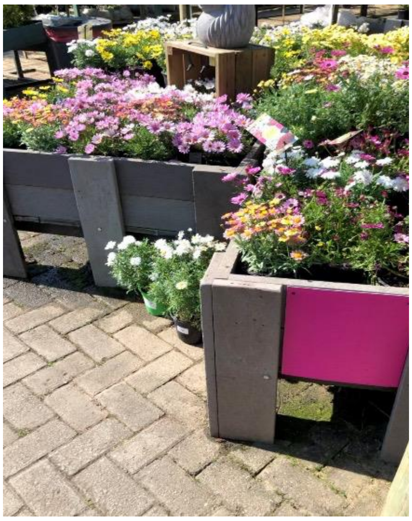
Photo 1 – 2 – Plastic under growing plants to prevent leaching

Plastic sheeting underneath plants to prevent leaching and weeds (Business 6, 26)

Photo 3 -4 – Material under growing plants to prevent leaching

Semi permeable flooring to reduce leaching and erosion, this is be covered with pebbles which also act as a filter but also improve the appearance (Business 21, 41)

Photo 5 - 7 – Plants on benches with concrete underneath



lants on tables and concrete floors to prevent leaching and allow for water runoff to be collected (Business 4, 10, 35,)

Photo 8 – 9 – Different fertilizer application methods


Organic, granular fertilizer by hand (Business 2) or chemical, granular fertiliser given by hand (Business 11)

Photo 10 – 11 – Different fertilizer application methods


Putting fertiliser (Slow-release) into the growing media (Business 26, 37)

Photo 12 - 14 – Different examples Dosatron to fertigate plants

Adding fertiliser to a 'Dosatron system' thus using a liquid application method (Business 2, 5, 22) Many of the growers have different fertiliser recipes for different plants and their growth stages – this is shown by the different tanks (most righthand photo) (Business 5, 20, 26)

Photo 15 - 16 – Using technology to monitor fertiliser levels in tanks and irrigation

The EC and pH of the fertiliser mix in the fertigation system is monitored by probes in the different tanks (Business 20)

Appendix 16: Photos from site visits related to fertiliser factor within OHISA

A few of the principles of integrated pest management are shown in the photos from the study.

Principle 1: Prevent and suppress disease and pests by growing a healthy plant using the correct ‘cultural’ habits of the plant e.g., growth media, light conditions, watering, temperature and taking the necessary steps to prevent pests and disease from entering greenhouses and tunnels

Photo 1 – Prevention of pests

Business 23 – Has foot baths with pesticide in to kill any bacteria on the soles of shoes

Photo 2 - 4 – Principle 2 – Early detection by monitoring

Monitoring using large yellow sticky cards. The wavelength of the yellow colour is proven to attract insects such as whitefly, thrips and aphids (Business 1, 5) (Insect Science, 2020)

Photo 5 – Monitoring pests present in greenhouses

Photo 6 – Monitoring pests present in sheds

Monitoring of pests using different coloured bands of tape (Business 26). It can be used inside greenhouses of outside in sheds. The blue sticky roll attracts Western flower thrips (Insect Science, 2020)

Photo 7 - 8 – Using yellow sticky cards in garden centres

One garden centre made their own example to show customers and another uses those sold by Insect Science

Photo 9 – 12 – Flowering plants with pollinators present

A lack of pesticide usage or using pesticide correctly is highlighted by prevalence of beneficial insects (Business 18, 3, 36, 37)

Photo 13 – An alternative or natural form of pest prevention

One grower used chickens as a form of pesticide as they eat the snails and caterpillars

Photo 14 – An example of a 'biobed'

One of the growers has made a type of 'biobed' not for the disposal pesticides directly but when cleaning pesticide residue from sprayers, it is done in this area so that the residues don't end up in the water system but rather seep into this tank but are filtered by the plants and different soil and gravel layers almost like a wetland would do.

Appendix 17: Photos from site visits related to waste factor within OHISA

Photo 1 and 2 – An examples of recycling at a garden centre

Showing customers at the entrance the importance of waste and recycling it. Highlighting how waste causes pollution is also necessary (Business 4, 10 above and right)

Photo 3 - 5 – Creating awareness within the workplace about waste

Reminding colleagues of what to recycle where (Business 15) and separating waste in greenhouses e.g., green waste for composting

Photo 6 - 8 – Re-using and re-purposing waste products

Reusing plastic and correx boards to separate trays going into germination room and protect newly planted seed from soil compaction (Business 5)

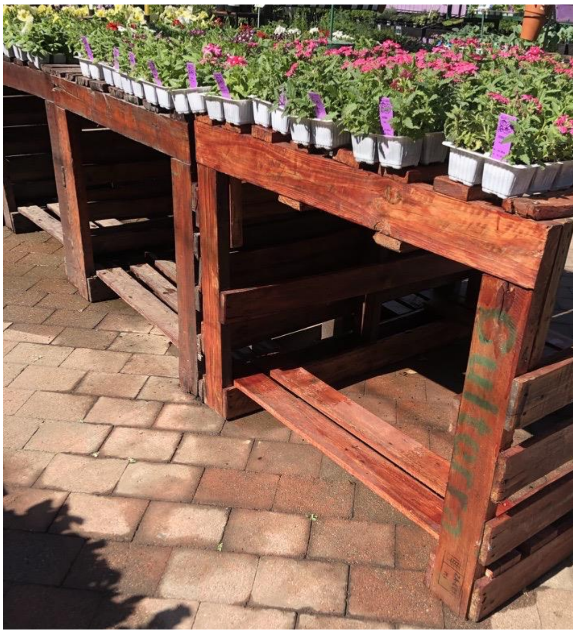
Photo 9 – 10 Re-using and recycling waste products

Recycling pots which have been used and sharing with customers (Business 17, 41

Photo 11 – Washing and sterilising pots for reuse

Business 18

Photo 12 – 13 – Repurposing products



There is a reuse for most things e.g., this team made stools from 128 polystyrene trays and taped them together (Business 5) and a garden centre made plant benches by upcycling the pallets that the compost is delivered on (Business 7)

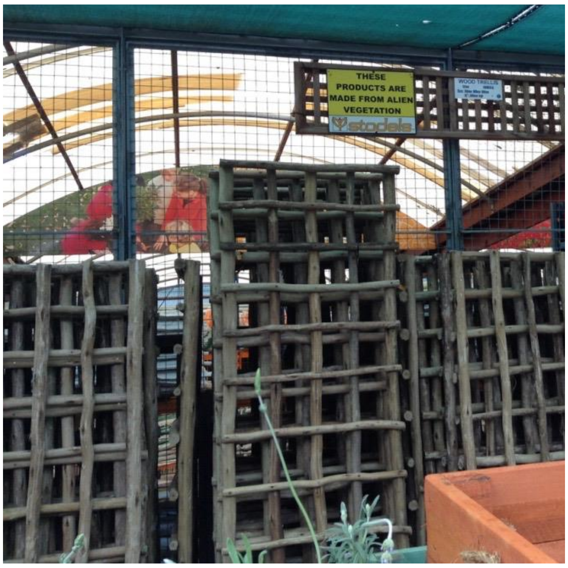
Photo 14 – Recycling cardboard and other waste to give to recyclers

Business 19

Photo 15 – Refusing to give customers plastic boot-liner

To make customers aware of single use plastic within the nursery industry some garden centres have stopped giving away plastic boot-liner to protect the customers' cars from the soil and dirt associated with the plants and instead sell multipurpose weed guard.

Photo 16 – 17 – Remanufacturing products



Promoting a circular economy by using invader trees branches and offcuts pole yards and manufacturing garden products e.g., stakes and trellis(Business 27, 41)

Photo 18 – Recycling metal into a display

Business 33 – Used an old car to create an interesting display

Appendix 18: Different substrates for different stage of plant growth

Extra fine (0-5mm) d	Fine (0-10mm)	Medium (0-30mm)
Young plants from seed	Seedlings	Potted plants

Appendix 19: Turnitin Report

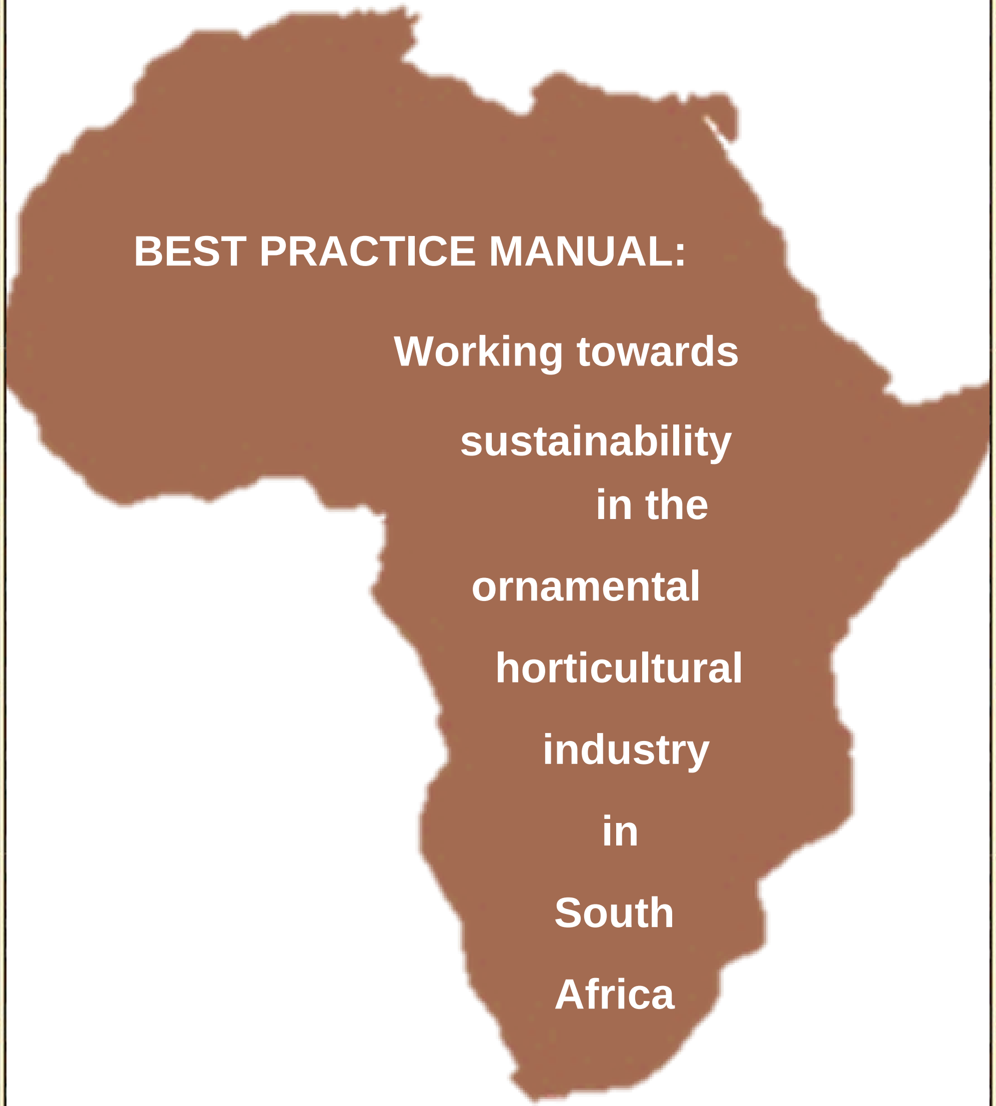
Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	C L GOODWIN
Assignment title:	Revision 1
Submission title:	An Investigation into the Environmental Sustainability of the...
File name:	Thesis_draft_15_no_photos.docx
File size:	42.41M
Page count:	519
Word count:	131,981
Character count:	786,811
Submission date:	30-Jan-2023 12:08AM (UTC+0200)
Submission ID:	2001771935

Appendix 20: Best Practice Manual



BEST PRACTICE MANUAL:

Working towards sustainability in the ornamental horticultural industry in South Africa

Module 1:

Best practice manual

Objectives of this manual

- to produce a resource that **provides scientific knowledge** about the nature and extent of *environmental problems* and *sustainability issues*, focussing on six factors pertinent to the ornamental horticultural industry (energy, water, growth media, fertilisers, pesticides, and waste). These are aligned to the 17 United Nations sustainable development goals and our country's nine key focus areas to achieve a green economy.
- to **create awareness** in ornamental horticultural businesses of the global and local crises regarding environmental issues, in order to cultivate a **positive attitude towards the environment** and a **willingness to change practices** to promote conservation and sustainability.
- to provide tools a) to **investigate the current situation** within ornamental horticulture businesses in terms of the key factors and the effect that they have on the environment, and b) to assist in **changing practices** to conserve natural resources, enhance environmental sustainability, and improve the bottom line financially.

How this "best practice" manual came about

Hello!

You might be wondering who I am and why I have compiled this manual.

My name is Cary Goodwin, born and raised in our beautiful country, South Africa. Both my parents started out as teachers but later began a production nursery growing colourful annuals, perennials, shrubs, grasses, and vegetables. After his studies, my brother joined the business and opened our first retail garden centre. I completed my first degree in agriculture, and then did a Masters in environmental education. I first worked as a teacher overseas, but came back to join the family ornamental horticultural business.

Ornamental horticulture focuses not only on plants but on people and the environment too. At present my family has one production nursery and two garden centres. The ornamental horticultural industry is referred to as the "green industry", which I once explained to a customer is about how to grow plants for food to eat, to beautify our environments, to create a better living space, and to lead a healthier lifestyle. Then I started thinking about the environmental impact that the ornamental horticultural industry in South Africa has when growing those plants.

In 2021 I set out to find what people within the industry knew about environmental sustainability e.g. sustainable development; environmental legislation, policies and treaties affecting our industry; natural resource usage within the industry; and pollution and degradation of land, water and air. The results of that investigation are reported throughout this "best practice" manual as case studies to show you what was happening in the industry and what measures and practices can be implemented to improve the situation and also improve the environmental sustainability of our industry.

Cary

Vision for the manual

If some of the recommended ‘best management practices’ in the manual are implemented by businesses within the ornamental horticultural industry, such businesses could:

- Use fewer natural resources and minimise the impacts of their business on the environment
- develop a structured, documented, and well-managed operation with better cognisance of both financial and environmental costs
- improve their business and the industry image by expending efforts on environmental efficiency and protecting the planet, whilst also improving productivity and profitability
- look for opportunities to reduce waste or reuse it in a circular way
- use the “green” movement to enhance the industry and encourage new

How to use this best practices manual

This best practices manual provides guidelines and tools for your business within the ornamental horticultural industry, to create your own environmental management policies and to implement some of the recommended practices to reduce your environmental footprint and become more environmentally sustainable.

Each business is different e.g., location, water sources, number of people working, and the way in which the business functions. I suggest that you go through the manual investigating which recommendations work best for you in your business. Due to the unpredictability of climate change and the different environmental problems in different parts of the country (such as droughts in the Western Cape and flooding in KwaZulu Natal) what works for one region or province won’t necessarily work for others.

This manual has information to share; activities to test that you understand what you have learnt; and activities and practical examples to apply this knowledge. The manual uses case studies from the research done in 2021 into the ornamental horticultural industry in South Africa, to give examples of what has happened within the local industry. Some of the practices recommended in the manual are already being implemented in South Africa and others still need be tried and tested within the local industry.

What to do once you have completed all the modules in this manual

Once you have completed all the modules and created policies for each of the different factors that influence the environment in which you work and its surrounds, you can combine them to form a *sustainability policy and procedures* document. This can be used to create awareness, increase knowledge, and change behaviour. With each factor, there is a basic cost analysis which can be conducted which will show year on year savings which can be made, as has been proven internationally.

The next step from here is to not only create awareness and change behaviour, but to make use of technology and machinery to actually measure the natural resources used in production and sales and find ways to reduce consumption whilst at the same time maintain profitability. This will assist your business to make better environmental decisions which in turn will create a healthier environment for all to work and live in and also increase favour with customers and most importantly improve sustainability within in your workplace both environmentally and financially.

Getting started

Module 1 is an introduction to the whole best practice manual, and explains the basic concepts of *environmental degradation*, *climate change*, and *sustainability of natural resources.* It goes on to provide information about **global** and **local South African efforts** to reduce environmental problems, and to promote conservation and sustainability. Throughout the module the 2021 investigation into the South African ornamental horticultural industry will be used to relate these ideas to what is happening and what could happen in this industry in this country.

- **Have you heard about *climate change* and *environmental degradation*?**
- **Do you think you, or the business you work in, impact on the environment in a negative way, possibly contributing to climate change?**

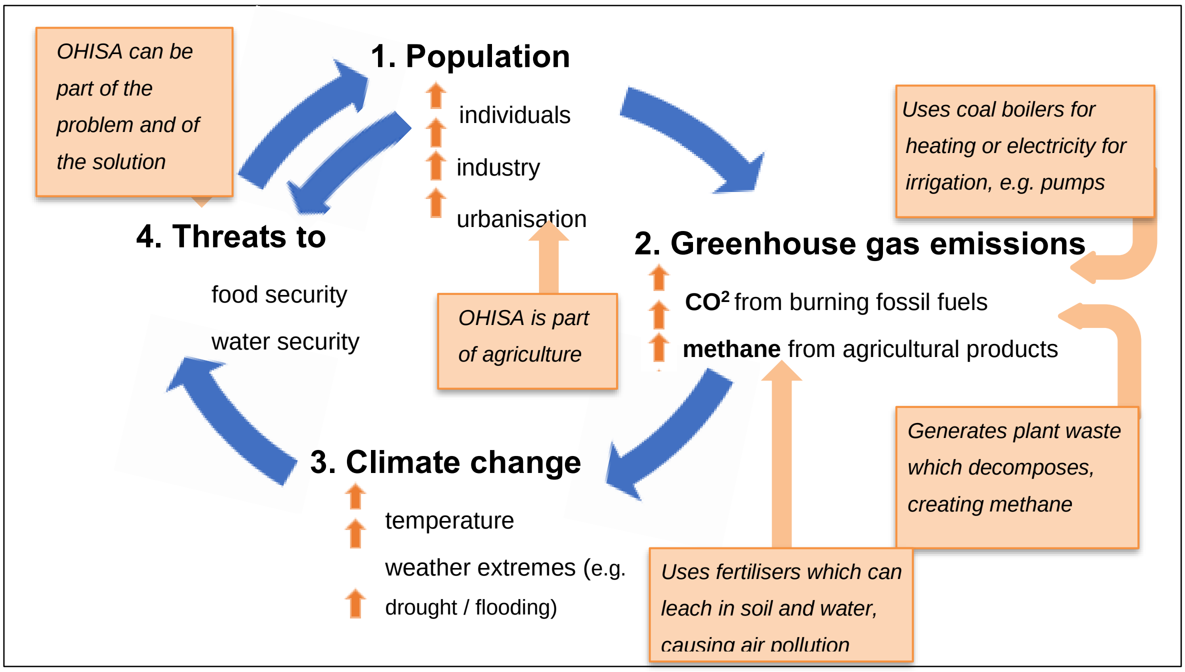
Climate change affects all of us, whether in our personal capacity or at our place of work. But all of us also contribute to climate change. We cook our food using energy from electricity, paraffin, gas, or wood; we travel by cars, taxis or buses that use petrol; and we use electricity or burn wood for heating – these things contribute to climate change. We cause environmental degradation by wasting water, building our homes near wetlands, and littering and creating waste which goes into landfills, and which doesn't always decompose, thus causing pollution.

How people affect climate change

The effects of the increasing population on climate change are shown in Figure 1.1, points 1 to 4.

1. As the population grows four factors change: the ***number of individuals on Earth*** *increases*; there is ***more industrialisation*** as technology develops; ***urbanisation increases*** as more people move to the cities seeking work; and there is an i***ncrease in agriculture*** in order to produce more food for the increasing population.
2. These increases can result in greenhouse gas emissions by increasing the three processes shown in point 2 in the diagram.
3. These in turn contribute to climate change with increased temperatures, more extreme weather conditions, and rising sea levels.
4. These factors can contribute to food shortages from crop failure; water shortages; and disease and sickness due to environmental degradation and pollution.

Figure 1.1 Adapted from a graphical description of population growth and climate change (Dodson *et al.*, 2020)



How the ornamental horticultural industry affects climate change

The ornamental horticultural industry affects many aspects of the environment by **using up natural resources** (e.g., water, components of growth media); **causing environmental changes (**such as destroying grasslands to install tunnels and sheds); and by **polluting the environment** in three common ways:

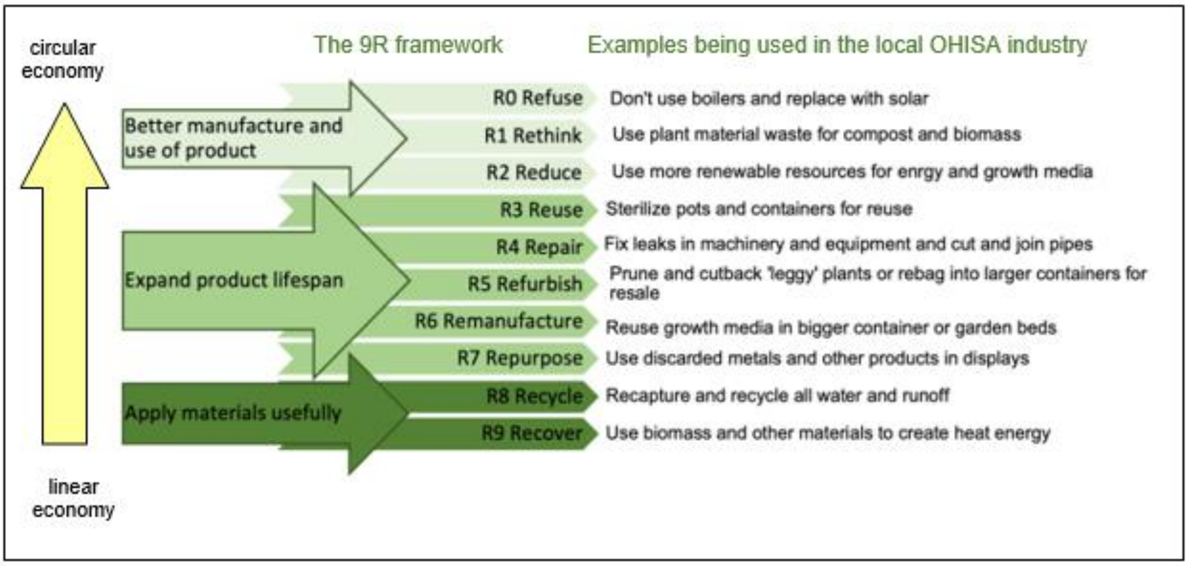
- **Water pollution** through leaching of fertilisers and pesticides into underground water
- **Soil pollution** from the creation of waste from packaging (e.g., trays or bags)
- **Air pollution** from heating and cooling of greenhouses and tunnels; from the exhaust fumes while transporting our products (plants); and by the release of nitrous oxide during the decomposition of plant material.

All these contribute to environmental degradation and climate change.

Positive changes the OHISA can or has implemented

The ornamental horticultural industry is in a fortunate position that although the production and sale of plants can contribute to environment problems, plants are part of nature-based solutions which can be used to solve some environmental problems. For example, by planting trees and hedges to control temperatures, planting groundcovers to prevent soil erosion; planting vegetables for food and health; and using the principles of a circular economy, the industry can contribute to sustainable development in ways represented in Figure 1.2.

Figure 1.2 The 9R Framework adapted from Potting *et al*. (2015) cited in (Kirchherr, Reike and Hekkert, 2017)



The figure shows that the ornamental horticultural industry has already started moving from a linear economy to a more circular one using the 9R principles e.g., reduce, reuse, repair etc. It gives examples that are currently being implemented by OHISA members in South Africa.

The benefits of the industry becoming environmentally sustainable include:

- Positive contributions to human health and lifestyles by improving the environment in which we work and live
- Better eco-system functioning;
- according to research, *"higher investment returns"* and *"long term profitability"* (Dunn and Dine, 2016).

Activity 1.1 ***What*** *do you understand by the word 'environment'?*

WHAT THE EXPERTS SAY

"*The complex of physical, chemical and biotic factors (such as climate, soil and living things) that act upon an organism or an ecological community and ultimately determines its form and survival*" (Merriam-Webster, no date) or

"*The biophysical, social and economic components as well as the connections within and between these components*" (The Department of Environmental Affairs, 2004)

Activity 1.2 *Explain what you understand by the term 'sustainable development'?*

WHAT THE EXPERTS SAY

"*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment and Development, 1987)

Environmental protection laws, treaties, and policies

Efforts to reduce environmental problems and to use sustainable resources have led to the development of legislation at international, national, and local levels, including in the ornamental horticultural industry.

INTERNATIONALLY

In the late 1980's members of the United Nations became concerned about the detrimental impacts the human population was having on the environment and whether these negative impacts would still allow *"future generations to meet their own needs"*. **Sustainable development** was proposed as a solution which focused on having a balanced relationship between the environment, economy, and society. Over time the reports and recommendations evolved, as various countries tried to follow the guidelines and found they needed further development. The original goals listed in *Our Common Future – The Brundtland Report* (1987), were soon replaced by goals from *Agenda 21* (1992), followed by the development of e*ight millenlium development goals (*2000-2015) and, most recently, the formation of 17 *sustainable development goals* from the United Nations (*Agenda 2030*)

The United Nations 17 sustainable development goals

In 2015, 17 goals were outlined in a document called *Agenda 2030 and* adopted by all United Nations Member States in an attempt to end poverty, protect the planet, and improve the lives and prospects for everyone everywhere. These sustainable development goals are often represented graphically as coloured icons numbered 1 to 17, usually with the same standard colours used for particular goals. Figure 1.3 shows (at the top) the commonest 17 icons that are used, and below that two alternative sets of icons (note the similar colours for particular goal numbers). Sometimes the wording changes slightly – for example, in some versions Goal 5 on "gender equality" has mistakenly changed to "gender quality".

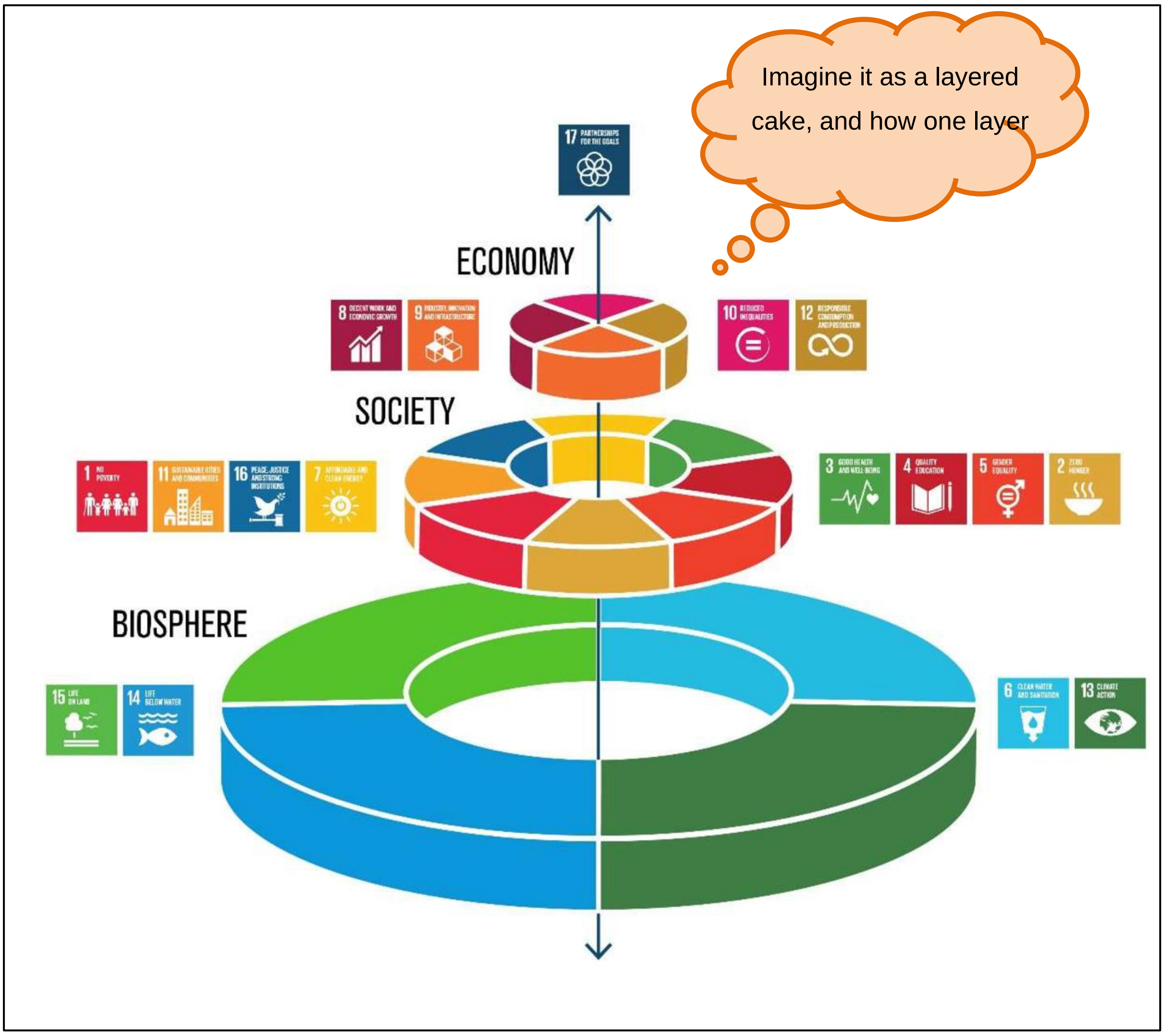
Figure 1.3 Different icons commonly used to show the 17 sustainable development goals, showing consistency of colours used

Activity 1.3 ***Did*** *you know that these 17 international goals existed and that many of them are followed in South Africa?* Indicate with a tick in the appropriate box.

Yes	
No	
Yes, but I am not sure how they apply in our industry	

Keeping track of 17 goals can be a daunting task. To make it easier, it helps to group them into three categories: ***biosphere goals***, ***societal goals***, and ***economic goals***. This manual focuses on the biosphere goals seen as the base layer in Figure 1.4. They are environmental goals and are relevant to horticulture. They underpin the societal and economic goals, so achieving these goals would positively influence the social and economic goals too. Likewise, if there is an improvement in the social and economic goals this would positively contribute towards overall sustainable development because they are all linked.

Figure 1.4 The layer-cake depiction of the three categories of the 17 sustainable development goals (Rockström and Sukhdev, 2016)**.** *Image adapted from Azote Images for Stockholm Resilience Centre*



NATIONALLY IN SOUTH AFRICA

An investigation of the South African ornamental horticultural industry

The case studies shown in pale yellow textboxes throughout this manual report on an investigation I conducted during 2021 and 2022. A detailed questionnaire was sent to 130 South African Nursery Association (SANA) principal members (bedding-plant growers, growers, and garden centres), of which 41 were returned by growers and garden centre owners or managers. All provinces except the Northern Cape were represented. I then visited 26 production nurseries and garden centres in Free State, Gauteng, North West, Mpumalanga and Limpopo to observe and conduct informal interviews.

The case studies in this manual report on the findings of this study, based on the sample described above. They illustrate both the state of the industry at the time (what people in the industry knew about sustainable development and were implementing in their businesses) and what they thought needed to be done in the future. The ideas of experts in the industry learnt from the participants are used to supplement advice from international experts and are reported in this manual.

CASE STUDY

Of the 41 Ornamental Horticultural Industry of South Africa (OHISA) members surveyed during 2021-22 the majority were not aware of the INTERNATIONAL sustainable development goals.

- **70% were unaware of *Agenda 21*** (the United Nations 1992 action plan towards sustainable development subscribed to by many nations, including South Africa)
- **86,5% were not aware of the 17 sustainable development goals** published in 2015 as a "*blueprint to achieve a better and more sustainable future for all by 2030*" (United Nations, 2015).

Awareness of LOCAL legislation

But to what extent were members of OHISA aware about LOCAL environmental legislation documents?

South African legislation for conserving our natural resources

INFORMATION BOX

South Africa has put laws in place for the conservation and use of our natural resources:

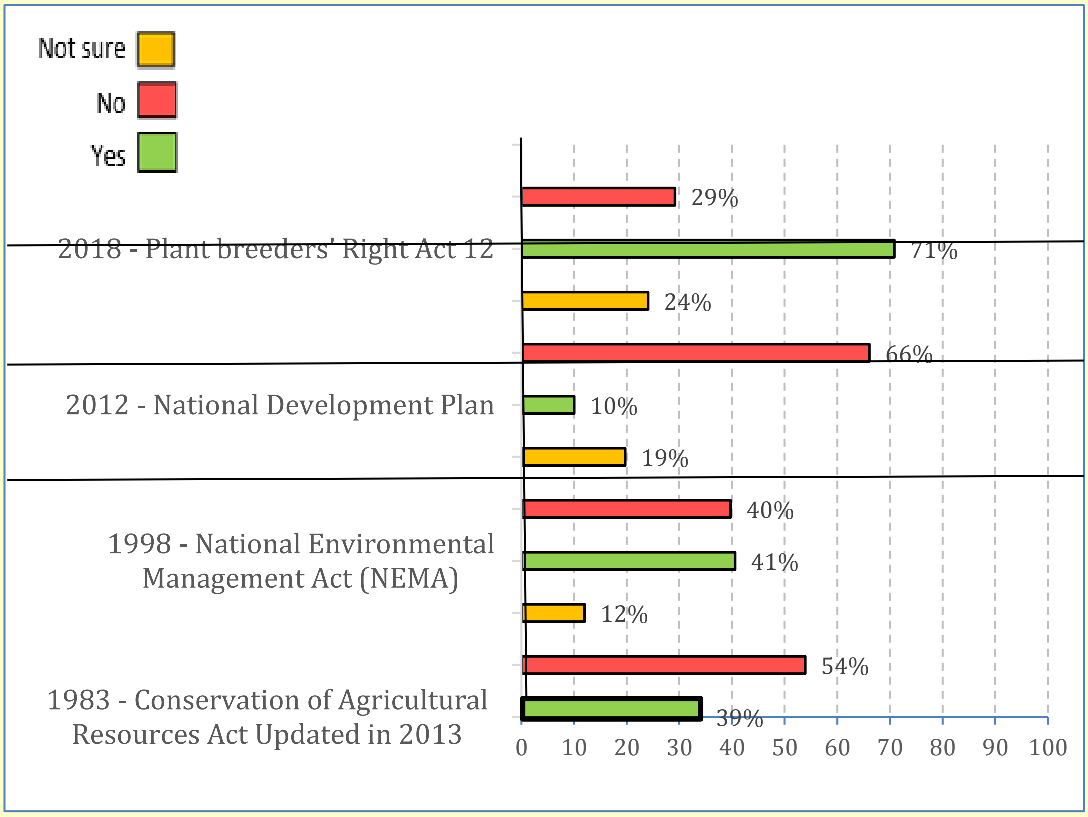
- 1983 – *Conservation of Agricultural Resources Act* (CARA) (Act No. 43), updated in 2013
- 1998 – *National Environmental Management Act* (NEMA)
- 2002 – *Resources Development Act* (Act No. 28)

In response to the international guidelines and achievement of the sustainable development goals South Africa has formulated and started the implementation of the following:

- 2011 – *Green Economy Accord* (National – South Africa)
- 2012 – *National Development Plan*
- 2015 – *Vision Summit 2030*
- 2019 – *National Climate Change Adaptation Strategy*

CASE STUDY RESULTS

This graph summarizes the percentage of the respondents who said they were aware of 4 of the 12 documents listed in a question in the 2021-22 research in South Africa in the OHISA industry. These four items are shown because other research suggests that although businesses often show low awareness of the majority of the global and local legislation documents, treaties and goals, the laws that directly affect their business were better known and tended to be adhered to.



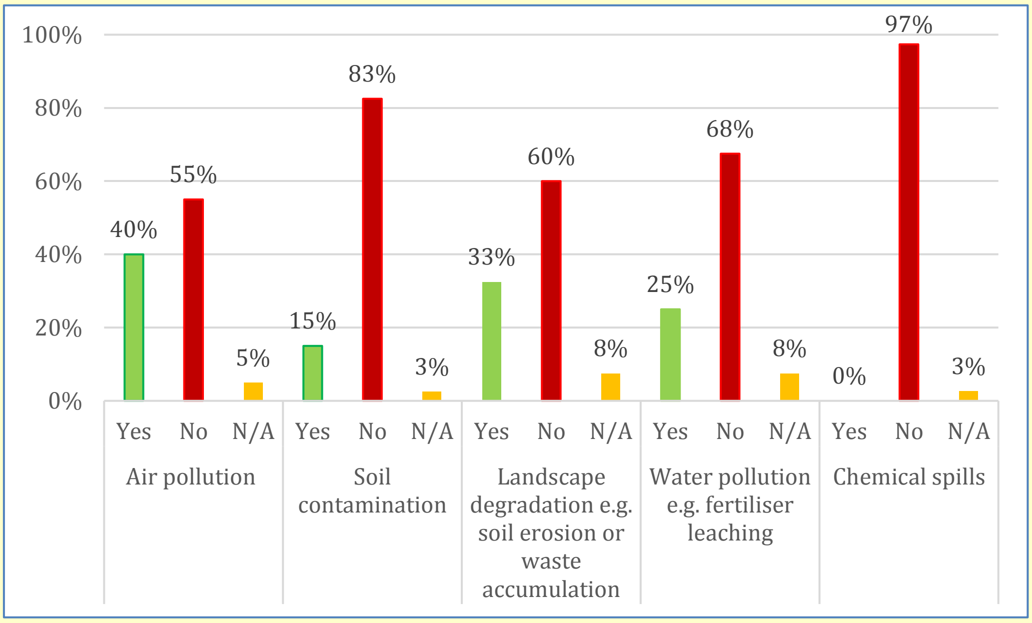
The graph shows that few participants were aware of the *National Development Plan* and *Conservation of Agricultural Resources.* If a business has to follow the advice in these documents, they first need to get hold of the documents and read them to see what advice they give. However, the 2021 research did show that the respondents were are more familiar with the those legislations which directly influence their business e.g., breeding (*Plant breeders' Right Act*) and selling plants (*NEMA),* because these document affect the profitability of the business.

Acknowledgement of the impact of horticulture businesses on the environment

The 2021 research also assessed the environmental impacts of the ornamental horticulture industry in South Africa by asking the participants if they thought their business had contributed in any way to the following: air pollution, soil contamination, landscape degradation, water pollution and chemical spills.

CASE STUDY RESULTS

The graph shows the frequency of responses when asked whether they thought their businesses impacted negatively on the environment.



Their answers showed that:

- A high percentage of respondents did not think their business impacted negatively on these six environmental factors, particularly in the case of chemical spills and soil contamination.

The industry has indeed not recorded any chemical spills they feel affected the environment.

The most frequent cases where respondents DID think they their business impacted on the environment were:

- **Air pollution** from boilers and vehicles, followed by **landscape degradation** when constructing a nursery site, building sheds or tunnels, digging dams, etc.
- Only a small percentage believed they polluted **water** and even fewer felt their business **contaminated the soil**.

These environmental impacts, as well as other factors such as **population growth** and **pollution,** can have negative impacts on the businesses within the ornamental horticultural industry. It is therefore important that everyone working in the industry becomes more aware of what is meant by *environmental degradation*, and whether (and in what ways) their business might be contributing to such problems.

The relationship of YOUR business with these environmental factors

The two activities on the following page will help you to think about how your business might affect the environment, and also whether the environment might have an impact on your business.

In each activity consider the factors and the question carefully, and then tick the boxes that best apply to your business. If the factor is not relevant or does not apply to your business, then tick the "not applicable" box for that factor.

Activity 1.4 *Do you think YOUR BUSINESS* influences *the environmental factors listed in the table below?*

	Yes	No	Unsure	Not applicable
Air pollution				
Soil contamination				
Landscape degradation e.g., soil erosion or waste accumulation				
Water pollution e.g., fertiliser leaching				
Chemical spills				

If "yes" give an example of how your business affects the environment.

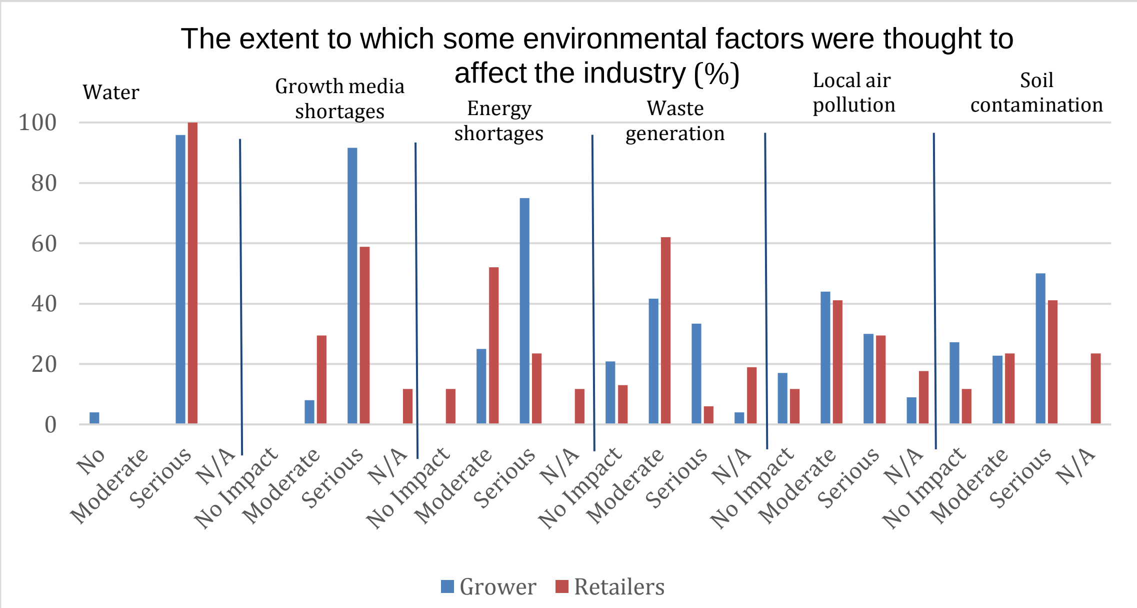
Activity 1.5 *What effect do you think the following ENVIRONMENTAL FACTORS could have on YOUR BUSINESS (either in terms of plant production or plant sales)?*

	No impact	Some impact	Heavy impact	Not applicable
Water shortages				
Shortage of growth media (e.g., topsoil / peat)				
Energy shortages (e.g., coal, oil, electricity)				
Waste generation				
Local air pollution				
Soil contamination				

The case study results show how the GROWERS and the RETAILERS in the South African research study believed the environmental factors impacted on their businesses. The findings for the growers and retailers are shown separately, as their opinions show interesting differences associated with the different types of businesses.

CASE STUDY RESULTS

Gowers and retailers were asked "To what extent do you think each of the following **environmental factors** could negatively impact your business with regards to your plant production and sales?"



- Based on the percentage of respondents saying the problem was "serious", two factors (**water shortages** and **local air pollution**) showed very similar responses for growers and retailers, highest for the impact of **water shortages** (above 90% of respondents seeing it as serious, with only about 40% of them seeing local **air pollution** as serious). The only grower who said that water shortages did not affect his business, specialised in succulents.
- **Shortage of growth media** was reported as seriously affecting more growers (>90%) than retailers (about 60%). Retailers who said they were affected indicated that organics (growth media) make up a large proportion of their sales and that shortages would affect their income.
- **Energy shortages** were reported to affect most businesses, but more growers (nearly 80%) said this was a 'serious' problem, while most retailers (just over 50%) saw it only as a moderate problem. Those who said energy shortages had *no impact* or *was not applicable* are using solar energy to generate electricity.
- The impact of **waste generation, local air pollution** and **soil contamination** affected all the participants in the study but to different degrees, with soil contamination being seen as 'serious' by most.

Helping YOUR business to take some action

This research suggests that these impacts do affect the ornamental horticultural industry within South Africa to a lesser or greater degree, so it is hoped that by working through this manual the industry can become more resilient to these impacts and reduce their impact on the natural resources.

The South African ornamental horticultural industry has been proactive in some regards and many nurseries have already made changes to their business practices, resulting in a reduced impact on the environment. What is interesting is that these changes were usually initiated because of their cost- saving opportunities and the necessity to improve business practices to keep the businesses going, rather than with the environment in mind.

Activity 1.6 *List THREE things your business has done to become more environmentally sustainable.*

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_
_
_
_

CASE STUDY RESULTS

Some examples of changes already being made some horticultural businesses in the country were provided by people who completed questionnaires or interviews for the 2021 study were:

- Converting from electricity (coal-generated) energy sources to solar energy, in the business
- Putting covering over dams to reduce evaporation
- Adding aerators to dams to reduce impurities in the water making irrigation easier
- Changing growing media ingredients from non-renewable resources e.g., peat to renewable resources

There are still many other ways that the ornamental horticultural industry can make a difference to their environmental impact and resource consumption and reduce operational costs, not only in terms of the key factors of the study but also the encouragement of positive planting and nature-based solutions to try and offset negative environmental impacts.

The South African government has highlighted 9 key areas in which to move towards a green economy (Department of Environmental Affairs, 2018). These are linked to some of the United Nations sustainable development goals, as shown in the last column of the following table. By using these as guidelines, the ornamental horticultural industry can associate itself with these focus areas (if they haven't already) and can grow as an industry. It might also assist them to be looked at favourably by the government. It could also be an opportunity to get rebates or incentives for the changes that they make.

Key focus areas documented by the South African government to move the country towards a green economy (DEA, 2018), the sustainable development goals targeted and how OHISA has contributed

Key area	Government strategies:	OHISA industry initiatives	SDGs
"Green buildings and the built environment"	Greening the urban environment and public spaces.	This research showed how OHISA provided plants for government, landscapers, and consumers to assist them *"greening" their environment.*	3, 9, 11, 15, 17

Key area	**Government strategies:**	**OHISA industry initiatives**	**SDGs**
"Sustainable transport and infrastructure"	Promote the use of non-motorised transport.	Many of the staff live on their business properties or close to them and walk to work. At some OHISA sites bicycles and battery-operated golf carts are used to move around the farm.	9, 11
	Create and design infrastructure to enhance, not harm, the environment e.g., using biomimicry principles	The structure and installation of greenhouses, tunnels and sheds using optimisation of natural lighting and using plants for temperature control and transpiration reduction.	9
"Clean energy and energy efficiency"	*"Expanding off-grid options in rural and urban areas"*	A few OHISA members use solar and gas, but government initiatives and crime reduction would incentivise more to do so.	7
"Resource conservation and management"	*"National payments for ecosystem services"*	The OHISA industry could become involved in eco-system improvement projects - and some already are e.g., they grow indigenous aloes to replace those which have been poached from the natural environment and donate them to be planted back in their original habitats.	13, 15
	"Up-scale "Working for …" programmes"	As an industry, OHISA is already involved in invasive training programmes and projects such as "Working for fire", "Working for wetlands" and "Working for water".	8, 13, 14, 15
	"Infrastructure resilience and ecosystems"	Using shrubs as wind breaks for infrastructure the industry can set an example for others to follow.	9, 11
	"Offset programme"	This has a huge potential as the government has already asked how many trees OHISA sells annually. If this information was known, then it could be used in similar ways to census documentation to make informed decisions about the offset and South Africa wouldn't be known as one of the most polluted countries but rather that they greened so many areas to try to reduce the effects of pollution.	11
	"Wildlife management"	Promote the correct use of pesticide and fertiliser to encourage biodiversity, not only in the national parks but in OHISA nurseries and garden retail centres and in turn in the gardens and landscapes of their customers.	14
"Sustainable waste management practices"	*"Waste beneficiation"*	Some garden centres and growers are already making use of recycling to earn an income or to help others make ends meet, but this area has room for expansion in the industry.	1, 12
	"Zero waste community programme for 500 000 households"	OHISA could teach people how to use their organic waste to make compost and thus grow food for themselves and produce less waste.	1

Key area	Government strategies:	OHISA industry initiatives	SDGs
	"Agriculture, food production and forestry"	In many of the businesses the staff have their own vegetable gardens where they are growing food for themselves and their families and this could be promoted more. Already as an industry there has been a shift towards "grow your own" for consumers which is a small scale of integrated sustainable agriculture especially since the onset of COVID.	2, 3
	"Water harvesting"	Some growers and garden centres already do this, and others could be encouraged to do so.	6
	"Alternative technology for effluent management"	Although OHISA as an industry doesn't focus on effluent, the leaching of pesticides and fertilisers must be investigated.	6, 14, 15
	"Reduce water losses in agriculture"	Many of the growers have changed their growth media to increase water-holding capacity thus making the plants sold more water wise. At both growers and garden centres water recycling is promoted.	6
"Sustainable consumption and production"	*"Industry specific production methods and industrial production technology changes"*	Some growers have done this e.g., using a potting machine, improved irrigation, automated greenhouses.	12
"Agriculture, food production and forestry"	*"Programme includes integrated sustainable agricultural production"*	As mentioned above, many of the nursery staff have their own vegetable gardens where they are growing food for themselves and their families. Also previously mentioned is a shift towards "grow your own" for consumers.	2
"Environmental sustainability"	*"Greening large events and legacy (2010 Soccer World Cup, COP17 flagship & Tourism)"*	The green industry was included in the greening of stadiums and surrounds for the 2010 World Cup and continues to support other government initiatives to improve the urban environments by planting trees, shrubs, and perennials to green and beautify these places of events and legacy.	4, 13, 15
	"Research, awareness and skills development and knowledge management"	There is also an established bursary fund and allocation of internships within the industry which promotes research.	4

Getting started on your own business plan for sustainability

This manual is a starting point for the industry to move towards sustainability. As the strategies are implemented and each business becomes more confident in their environmental productivity practices, it is hoped that actual figures can be shared more widely, for example, in terms of energy and water usage, or rand value per product produced, and resultant waste. These can then be used to set benchmarks towards which the industry could strive.

The rest of the modules in this manual focus on the six different factors investigated in the 2021 study. The sections in the manual for each factor follow the same pattern, addressing, for example:

- The impacts and problems caused by the industry
- The related sustainable development goals
- The South African legislation and strategy reports.

However, the activities, ideas, and strategies suggested are dependent on the information that was available in 2021 and will also vary for each business. Therefore, when using the manual you should adapt the activities and suggestions to suit the needs of your business, or to change environmental policies and practices that you might already have.

Once the background information in the bullets above has been understood, your business can develop a basic policy for each factor, using the ideas, plans and best practices tried within the ornamental horticultural industry both locally and internationally. The individual policies associated with each module can be combined to provide a total policy for the business, indicating the implementation of strategies and achievable solutions to improve the environmental productivity of the business and of the ornamental horticultural industry.

A suggested set of steps to follow to develop and implement changes in your business includes:

Step 1: Choose one or more **environmental officer(s)** within your business who have a passion for the environment and already show positive behaviours towards the environment. They will more easily identify with some of the practices and set an example for others to follow with regards to change.

Step 2: Identify the status of the current environmental policy or practices that are documented within your business using the following **checklist**:

Do any of the **policies** have standard operating procedures (SOP) accompanying them?

- Level 1: If you have no written policies – start at the beginning to write policies and standard operating procedures for implementing the policies
- Level 2: If your business has some written policies that need updating and implementation strategies
- Level 3: If your already have suitable policies and use them within all business structures see if there are small ways in which you could add to or improve them.

Step 3: **Implementation:** Depends on the answer of Step 2. Are your starting from scratch or changing policies from what you learn from the manual?

Step 4: Record and review: When developing a policy, you could use the information from the 2021 research study to give reasons for your policy development e.g. *due to the global energy crisis, global warming, climate change, legislation, cost-saving etc. research into the state of the ornamental horticulture industry in 2021 shows how few South African ornamental horticultural businesses have an environmental sustainability policy and implement it*.

The case study on the next page shows that few businesses have environmental sustainability policies, despite them believing they needed one.

CASE STUDY

Results from the 2021 study revealed that only 34.8% of the grower participants in the study had environmental policies and of that one 50% of those with a policy actually apply them. Fewer of the retailers had an environmental policy (11.8%) and only half of those that had one used it. This suggests that the development of environmental policies for the industry is needed. They need to be tailored towards the industry members for ease of application and operation so that these numbers can increase.

56% of the growers and 42% of the retailers said they wished they had an environmental policy, but only about 35% of the growers and 12% of the garden centres had one.

What are the benefits of having an environmental sustainability policy?

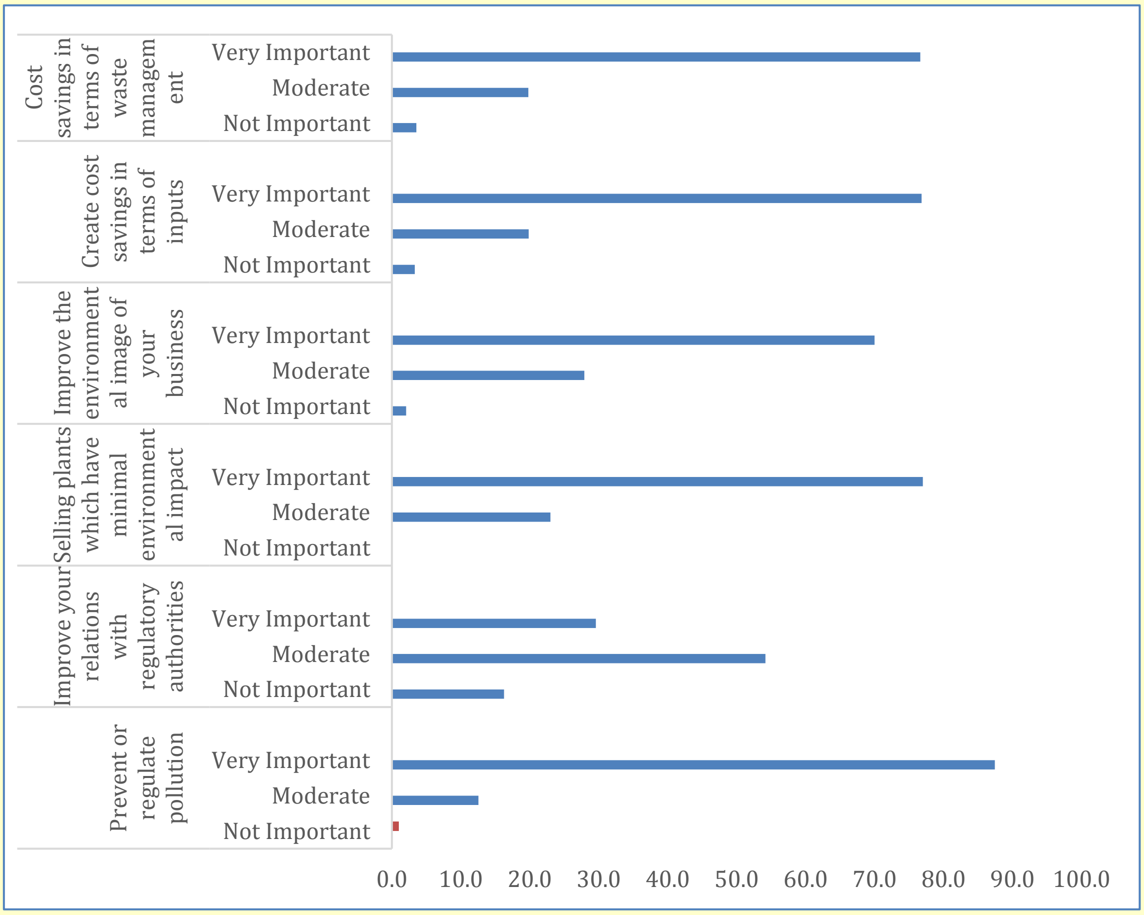
Think carefully about why you think such a policy might be desirable (benefit your business), before providing the reasons asked for in this activity.

Activity 1.7 *List TWO reasons why your business might benefit from having an environmental sustainability policy document.*

What reasons were suggested by the growers and retailers who completed the questionnaire in the 2021 study, and how important did they consider each to be?

CASE STUDY

Graph showing the percentage of respondents indicating how important they considered each of the following factors to be as reasons to motivate businesses to have a policy on environmental sustainability.



When asked to choose which of six listed reasons were important motivations for having such a policy the respondents chose the following (from most frequent to least frequent).

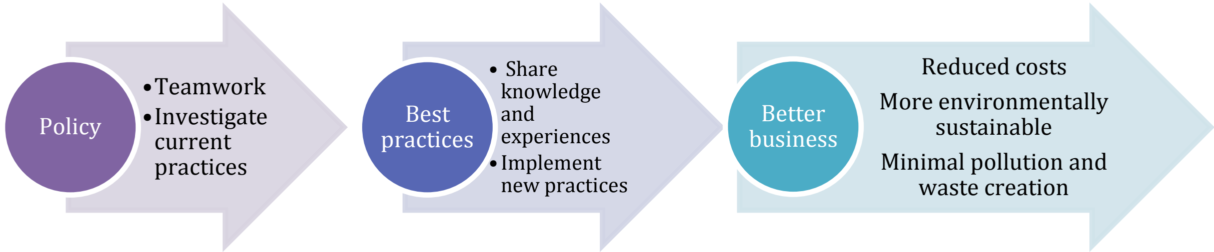
- To "*prevent or regulate pollution"*
- To "*sell plants which have a minimal environmental impact*" and "*creating a cost saving in terms of inputs*"
- "*Cost savings in terms of waste management*" and
- "*To improve the environmental image of your business*"

The reason chosen least often was:

- To *"improve your relations with regulatory authorities".*

From this information it can be deduced that creating environmental policies which can be applied in the business can reduce costs and improve environmental sustainability as mentioned above – thus it makes good business sense!

Once your policy has been written then your team needs the tools to be able to adopt and implement it and this is done through the best practices described in this manual.



Tips for creating a "best management practice" policy

There are certain criteria to be fulfilled to create a useful best practice manual. Using the following guidelines given by the Food and Agriculture Organisation of the United Nations, (2015 and 2009) can help to develop a suitable policy for your business.

- Find solutions to problems which are achievable
- Create a positive impact on those within the business
- Be environmentally, economically, and socially sustainable
- Provide education, training and technology which make learning interesting and applicable
- Allow for participation of all in decision-making and actions to give a sense of stewardship towards the greater good of the company, individual and environment
- Provide an opportunity to reduce risk and improve productivity and profitability.

The application of the best practices in your business needs to be reviewed frequently, and the results recorded to be able to objectively evaluate your policy and to make recommendations or changes to it. The template below could be used as an example of how this can be done. Copy it into your own document so you can expand it to fit your information in. Using the template, the environmental officer in your business has the guidelines to give a meaningful report to the supervisor and company management with regards to the various environmental indicators and their use and the impact the company has on them.

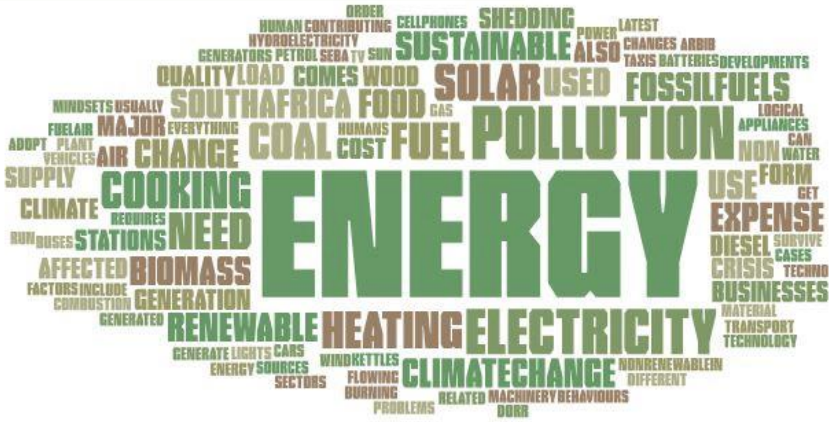
Adapted from "Documenting a good practice" (Food and Agriculture Organisation of the United Nations, 2015)

Best Management Practice for *(add name of your business)*		
Date:	*List names of those involved (e.g. Environmental Officer)*	
Type of document *(Tick the most relevant choice)*	☐ Worksheet ☐ Standard operating procedures ☐ Policies guidelines ☐ How to … (training guides)	☐ Review document (monitoring report) ☐ Information sheet ☐ Educational poster
Target Audience *(tick relevant boxes)*	☐ Worker ☐ Team leader ☐ Supervisor ☐ Manager	☐ Manager ☐ Workplace owner ☐ Other
Section on workplace	*List, e.g. admin, planting, selling, logistics, spraying etc.*	
Purpose of document		
Workplace address		
Contact details		
Area within workplace most appliable	*Inside, outside, delivery bay, hothouse etc.*	
	Describe initial situation and problem	

Document structure	*Explain good practice being addressed*
	Include time schedule
	Explain risks to be addressed
Stakeholders and partners	*List those involved and benefitting from best practice implementation*
Methodological approach	*Explain workplace practices and process to be addressed and adapted*
Validation	*Explain monitoring and recording changes both positive and negative*
Impacts	*(Describe environmental, economic, and individual impacts)*
Innovations employed	
Success factors	
Constraints	
Lesson learned	
SD goals targeted	
Repeatability	*Explain other areas in workplace where this could be adapted or repeated*
Conclusion	Evaluate the impact and usefulness
Related websites / resources	*List*

Module 2:

Energy sustainability



Do you think we have an energy crisis in South Africa?

Yes ☐ No ☐ Unsure ☐

WHERE DOES OUR ENERGY COME FROM?

Everything we do requires energy!

Humans need energy to survive, which we get from **food.** We need energy to cook the food e.g., electricity, wood, or gas. The cars, buses, and taxis we use need energy to run e.g., fuel. Our lights and our appliances e.g., kettles, TV, cellphones all use energy.

In South Africa energy usually comes from electricity, 93% of which comes from **coal** (which is used to generate electricity in power stations). We also need energy in the form of **fuel** for our vehicles, machinery, and generators: this fuel could be in the form of *diesel, petrol*, or *batteries.* Other sources of energy include the **sun** (solar energy), **wind** (in some cases), **hydro-electricity** (electricity that is generated from flowing water), and from **biomass combustion** (the burning of plant material).

ENERGY-RELATED PROBLEMS

Air pollution and climate change

The generation and use of energy are major factors contributing to pollution and climate change. While there are major technological changes associated with energy that is used in different sectors such as transport and food supply, human mindsets and behaviours have to change in order to adopt the latest technology (Arbib, Dorr and Seba, 2021) so that developments can be accelerated. Globally, air quality is affected by energy usage and in South Africa we have very poor air quality. The main contributors to pollution are coal-powered electricity generation stations and the fuels used for cooking and heating (wood, coal fires and paraffin) (International Assistance for Medical Travelers, 2020).

The increasing expense

In the 80's, 90's and early 2000's energy in South Africa was reasonably priced and reliable. Towards the end of the last decade, energy costs have increased exponentially, and the supply has become very unreliable.

Running out of energy

Electricity shortages have resulted in 'load shedding' in South Africa which started in 2008. This has affected not only our every-day lives but also businesses, development, agriculture, and the economy. Many businesses have been forced to close, and countless people have lost their jobs.

Now THINK AGAIN about the question:

Do we have an energy crisis in South Africa?

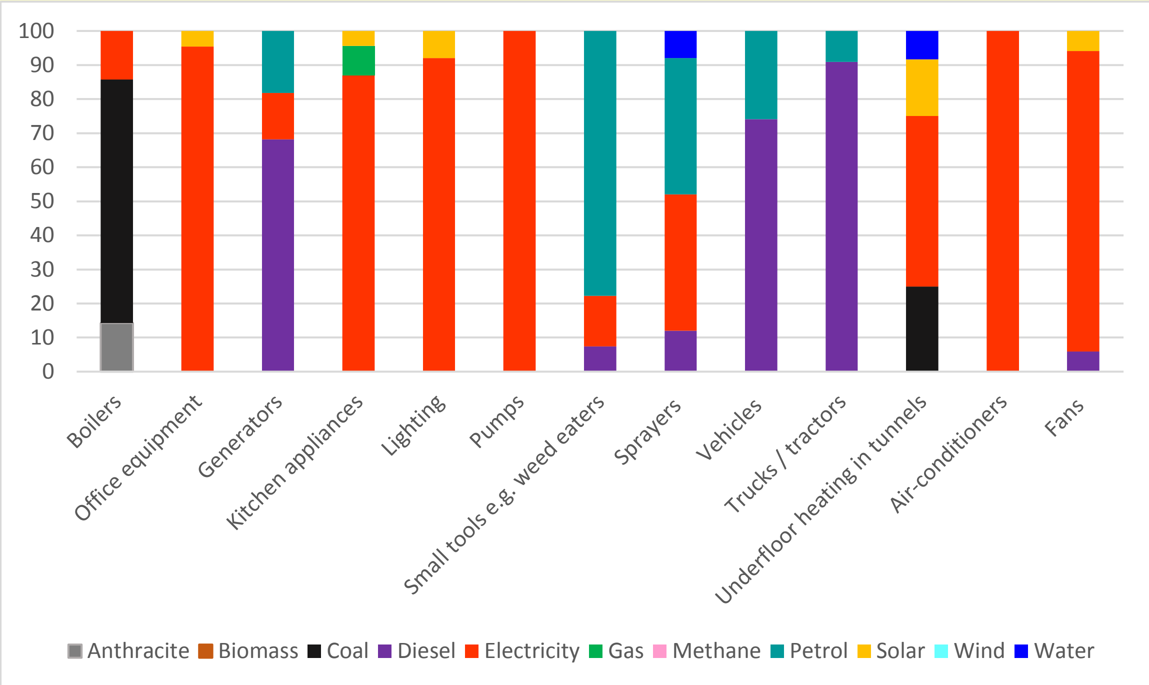
DO YOU THINK THIS MIGHT AFFECT YOUR BUSINESS?

Activity 2.1 *How has the energy crisis in South Africa affected your business?*

The chances are the business you work in has been affected by energy shortages. The price of diesel and petrol is constantly increasing, making deliveries more expensive. Loadshedding is affecting your computers in the office or the point-of-sale systems at the tills (e.g., the card machines won't work). The irrigation systems also function less effectively because the timing is no longer accurate due to power cuts. With the power off you are unable to pump water from the borehole and reservoirs. You might have got generators or invertors to assist keeping things working but these cost money and so the price of the plants you sell must increase. All these challenges are due to energy shortages, and they affect the bottom-line of the business and the morale of those working there. This provides the opportunity for each business and person to change their attitude, to become more energy efficient and to rely less on non-renewable energy sources such as coal, and to increase their knowledge about renewable energy sources such as solar energy, and how best to use them in their business and daily lives.

CASE STUDY RESULTS

The respondents in the 2021-2022 study of the ornamental horticultural industry were asked which fuel sources they used in their business for the different appliances, tools, machines, and vehicles. The following graph summarises responses from the GROWERS in the sample.



- 71% of growers that required heating to grow their plants still used boilers which used coal or anthracite
- 100% of pumps were electric and 88% of the fans in greenhouses were run on electricity
- 95% of all office equipment used electricity
- 87% of all kitchen appliances used electricity

You will see that the colours that dominate in the graph show an almost exclusive use of non-renewable resources (red for electricity, purple for diesel, teal green for petrol, and black for coal). As the ornamental horticultural industry looks towards alternative sources of energy these would be areas of the business they would need to focus attention on.

These are not favourable statistics in terms of sustainability so what can we do to make a difference and change them? An environmental policy with regards to energy usage of the South African Nursery Association is essential to provide guidelines towards achievable targets aligned with those of sustainable development goal 7 and local policy, which promote energy saving and reduce the impact the industry has when using non-renewable resources. Let's change these statistics so that we as an industry can work towards SDG 7. Renewable energy generation is an option not only to alleviate these challenges but also to reduce the effects of climate change in the country.

Responses to energy-related problems

What has been achieved so far in working towards sustainable energy-related solutions at international, national, and local levels?

INTERNATIONAL (GLOBAL)

INFORMATION BOX

The most relevant international initiatives encouraging countries and companies to implement policies and practices to improve energy usage are targeted by the United Nations sustainable development goals, especially SDG Goal 7 (providing affordable, reliable, and clean energy for all by 2030). There are 5 targets under sustainable development goal 7. Those most relevant to the ornamental horticultural industry are Target 7-2 (to increase substantially the global percentage of renewable energy); Target 7-3 (to double the improvement in energy efficiency by 2030); and Target 7-A (to promote access to research, technology, and investment in clean energy). In addition, some of SDG 12 targets relate to energy: Target 12 targets (the sustainable management and development of natural resources by 2030).

Despite energy-related problems that exist globally, a number of positive practices are making a difference worldwide:

- In 2020 29% of global power was generated by renewables, mainly hydropower.
- Solar energy was the fastest growing source of electricity generation in 2020 in the United States.
- In 2019 the renewable energy sector employed 11.5 million people. If each country had to strive towards limiting the temperature increase to below 2ºC according to the Paris agreement this could grow to 18 million jobs.

- If the recommended energy-efficiency policies were adopted throughout the world there could be a 40% reduction in carbon emissions even without developing new technology (United Nations Department of Economic and Social Affairs (UNDESA), 2021).

Information in first three bullets above suggests a positive move towards renewable energy worldwide, over time.

NATIONAL (IN SOUTH AFRICA)

South Africa, one of 195 countries in the world, ranked 14th in terms of greenhouse gas emissions in the world in 2021, largely because of its coal-powered electricity generators (statista.com/statistics/486073/ co2-emissions-south-africa-fossil-fuel-and-industrial-purposes). This is a disappointing statistic considering that South Africa has so many opportunities for energy conservation and savings, especially with the use of renewable energy sources such as **solar power**, **wind energy** and **biomass** energy, all of which are considered to be 'clean' energy sources. They in turn would reduce carbon and SO_2 emissions (Merven, Hartley and Arndt, 2019). 'Biomass energy' is the term used to describe any fuel derived from plants or animals, usually by the process of combustion.

South Africa's geographical location, topography and size provide numerous opportunities for renewable energy resources e.g.

- wind power along the coastline
- solar power in the flat, dry interior
- biomass energy using waste from forestry and sugar-cane plantations along the tropical, east coast (Department of Environmental Affairs, 2018). Biomass can be used for heating applications (such as wood stoves) or electricity generation by combustion in a power plant, as for burning coal.

INFORMATION BOX

South African legislation to improve energy sustainability

The regulations and policies that South Africa has in place to manage energy and the burning of fossil fuels which contribute to greenhouse gases include two important government "Acts":

- The ***National Energy Act 34*** of 2008, which allows for diverse energy resources to be made available; for the promotion of efficient generation and consumption of energy; and for energy-related research.
- The ***Carbon Tax Act no.15*** **(2019)** which allows for a tax to be charged on CO_2 emissions that contribute to greenhouse gases, for example, the combustion of the following fuels: anthracite, biodiesel, bio-gasoline, diesel, charcoal, crude oil, municipal wastes, natural gas, paraffin, peat, petrol, white spirit, wood, and others fuel types. The intention of this act is to impose financial penalties so that large contributors to greenhouse gas emissions are encouraged to start taking remedial action.

In 2019, in an effort to meet 'Sustainable Development Goal 7', South Africa was able to secure a $10.8 billion investment into the renewables sector through the *Renewable Energy Independent Power Producers Procurement Programme* (REIPPPP) (Radebe, 2019) and $8.5bn in 2021 to effect the conversion from coal to renewable energy sources (Deonarain, Pickup and Hunt, 2021).

The latest sources of energy that are being investigated in South Africa are imported liquefied natural gas, local natural gas in the form of coalbed methane and shale gas. Coal is still important as part of the 'energy-mix' not only for providing energy but also jobs and investment opportunity (Radebe, 2019). In the United States the cost of the renewable technologies associated with wind and solar energy have dropped by 39% and 82% respectively because of demand, resource availability, costs, government and businesses policy decisions and global and national regulations (Centre For Climate and Energy Solutions, 2021). This highlights the amount of money that South Africa had

INFORMATION BOX

South Africa (Statistics South Africa, 2019b)

- **14.6%** of energy used by South Africa in **2013** was from renewable energy sources
- **26.20%** of energy used by South Africa in **2015** was from renewable energy sources
- South African economy was **more energy efficient in 2015 relative to a 2011 baseline** (the lower the ratio the better) – unit of measurement is energy supplied unit / economic output: 2.07 TJ /million rand (2011), 1.89 TJ /million rand (2015)

available to transition away from coal to more environmentally friendly, renewable energy sources that are also better for human health. This is gratifying, especially as energy costs are increasing due to the depletion of oil and coal reserves, which *Working for energy (Biomass Energy)* is a project of the Department of Environmental Affairs (DEA) which is investigating the use of biomass to produce different forms of energy.

Research has been conducted on the use of renewable resources in Africa. **Solar energy** (using photovoltaics with solar cells that convert LIGHT from the sun into energy, and **concentrated solar power [CSP]** that uses mirrors to concentrate ENERGY from the sun), **wind power, hydroelectricity, biogas production** and **biomass combustion** were investigated, with solar power, wind and CSP being preferred for further development and implementation in South Africa because the technology is available and it has favourable financing options (Naicker and Thopil, 2019). However, there will need to be policy changes from government to encourage and fund development for infrastructure, and training to increase the knowledge and skills required to further develop and maintain the solar power and CSP framework.

LOCAL (THE ORNAMENTAL HORTICULTURAL INDUSTRY IN SOUTH AFRICA)

Numerous environmental risks in the horticultural industry are associated with energy consumption, including:

- Air pollution and resultant health issues for employees and neighbours.
- Air pollution which can damage plants both physically and in their growth habits.
- Light pollution from consistently leaving lights on unless for security purposes, especially in unused spaces.
- Secondary loss of habitat and biodiversity from the conversion of grasslands, forests and even farmlands into coal mines to produce electricity.
- Waste accumulation from coal and anthracite used in boilers.
- Oil spills from vehicles and machinery not maintained optimally or when used by careless or untrained users.

These risks suggest areas to target business goals when trying to move towards greater use of sustainable energy sources.

Although the horticultural industry is experiencing energy-related power problems, the results of the 2021-22 study (Goodwin, 2023) show that stakeholders working in the industry generally have a poor knowledge of various international and national goals targeting energy sustainability.

CASE STUDY RESULTS

Only 21% of respondents to the questionnaire were aware of the United Nations' international sustainable development goal 7 on making clean affordable energy accessible to all, whilst 71% said they had not heard of it.

There were low levels of awareness of the two important South African legislative acts described earlier.

	Aware of it	Not aware
National Energy Act 34	20%	74%
Carbon Tax Act	47%	49%

- **Are these two acts relevant to your business?**
- **Have you experienced the effects of air pollution?**

With more knowledge about the detrimental effects of air pollution on human health and the environment, do you think you are likely to change your energy-related habitats, not only at work but home too. We have all been frustrated because of load shedding but has this made you more aware of how much electricity you use? Has this awareness created an attitude of needing to become more energy-efficient? Have you actively taken steps to reduce your dependency on electricity or reduce your usage of fossil fuels as an energy source (both at home and at work). If you are not sure where to start, let this manual help you.

In this module you will find information to help you make decisions about becoming more energy-efficient in your business. The information is not found just in information boxes like the one below.

- Useful information that you can apply is also found in *normal text.*

- The *activities* and "*think about it"* boxes have been designed to help you think about matters, and plan towards becoming more energy efficient.
- The *case study boxes* in yellow reveal what others in the ornamental horticultural business are experiencing and thinking – you can use results to see where others are experiencing similar problems, or not. This might influence decisions you make.
- Some of the points in the text have references written after them. At the back of a module is a reference list for the articles, should you wish to read further on a specific matter.

INFORMATION BOX

Energy in the ornamental horticultural industry is used mainly for 1) temperature control and light to grow healthy plants; 2) for electricity to power the pumps, irrigation, and offices; and 3) fuel to run machinery, equipment, and vehicles.

Plants need light for photosynthesis and the amount of light they receive affects how fast plants grow and for how long they stay active. In South Africa we have many hours of sunlight all year long, which provides optimum growing conditions.

The effect of light on plant growth is determined by three factors:

Intensity (how strong the light is):

- Light intensity influences the manufacture of plant food, stem length, leaf colour and flowering. When grown in too much shade, most plants, get elongated (spindly) stems, with light green leaves.

Duration (how long the sun shines):

- Some plants only flower when days are 11 hours or less (short day plants) e.g., chrysanthemum, rice, soybean, onion, violet, Christmas cactus, and poinsettia.
- Other plants only flower when days are longer than 11 hours (long-day) plants.
- There are also day-neutral plants that are not sensitive to day length at all.

Quality (the type of sunlight)**:**

- Plants need mainly blue and red light for photosynthesis and for flowering; they also need infra-red light.

The surrounding air temperature (i.e., the ambient temperature) for plant growth in South Africa is also ideal for most months of the year although our winter night-time temperatures in certain provinces decreases below optimum, which results in growers having to use energy to heat tunnels and greenhouses. In general, most plants grow best between 21° C and 26° C (daytime temperature), and between 15° C and 20° C (during the night).

Cool night-time temperatures are more desirable for plant growth than high temperatures. Lower night-time temperatures help the plant:

- recover from moisture loss
- intensify flower colour
- prolong flower life

Very hot or very cold temperatures may cause:

- plant stress
- inhibited plant growth
- damage to the leaves

Activity 2.2 ***Conduct*** *an ENERGY audit of your business, using this checklist.*

Rate the areas of your business where you could become more energy efficient using the checklist below. Carefully consider the four categories of energy efficiency and tick the boxes that best describe your situation for each aspect of the business listed in column 1.

For example: Under "irrigation" your pumps may be old (and hence not energy efficient*) or you might use your pumps only at non-peak times (*slightly energy efficient*) or have a variable speed drive on the pump (which monitors the water pressure needed and adjusts the pump functioning accordingly e.g., if less water is needed then pressure sensor on the VSD (Variable Speed Drive) causes the pump to slow down and thus uses less energy), or if you are using a solar pump (you have* reached sustainability *for your pumps, in terms of energy supply).*

A second example is Plants on concrete floors (not energy efficient)*; Plants on sand covered with weedguard* (slightly energy efficient); *Plants on tables with sand or concrete underneath (Energy* efficient within constraints of the business); *Plants on tables and water heated pipes run below the table and there is a concrete floor with sand on top beneath table* (energy sustainability achieved).

	Our business is probably at this level of energy efficiency ….				
	Not energy efficient (it needs attention**)**	**Slightly energy efficient**	**Energy efficient in constraints of the business**	**Energy sustainability achieved** (no fossil fuels used)	**Not applicable**
Irrigation					
Pumps					
Production					
Sowing machines					
Potting machine					
Soil mixer					
All done manually					
Dispatch and Deliveries					
Trucks /delivery vehicles					

Tractors					
Golf carts					
TLB (Heavy duty machinery for earth moving)					
Forklifts					
Modified trolley					
Property maintenance					
Blowers / mowers					
Weed eaters					
Sprayers					
Tunnels and Greenhouse					
Boilers					
Heaters					
Fans					
Wet walls for cooling					
Underfloor heating					
Lighting					
Cooling					
Protection from wind					
Temperature control					
Flooring					
Offices					
Computers, printers, copiers					
Microwave					
Fridges					
Kettles					
Coffee machines					
Urns					
Lighting					
Gas appliances					
Generator					
Wiring					
Growing areas and plant sales and sections					
Hedging					
Trees for cooling					
Shade netting					

Other					

Developing a sustainable-energy policy

The background provided in this module illustrates the necessity for developing your own energy conservation policy in order to 1) reduce energy-related problems that affect the environment and cause climate change; 2) move towards the use of sustainable energy sources; and 3) reduce expenses associated with energy use in the horticultural industry. In what ways can you USE what you have learned to see where changes and savings can be made in your business?

You should already have completed the checklist to identify which areas in your business use energy and whether it is being used efficiently. Your next task would be to identify exactly what energy sources you are using for different aspects of your business. Then decide whether the TYPE of energy you are using involves fossil fuels or renewable energy.

Activity 2.3 **Tick** ***in the relevant boxes to indicate w***_hich type of energy sources are used for different purposes in your business._

	Anthracite	Biomass	Coal	Diesel	Electricity	Gas	Methane	Petrol	Solar	Wind	Water	Other (specify)
e.g. Appliances, kettle					✓							
Boilers												
Office equipment												
Generators												
Kitchen appliances												
Lighting												
Pumps												
Small tools e.g., weed eaters												
Sprayers												
Vehicles												
Trucks / tractors												
Underfloor heating in tunnels												
Air-conditioners												
Fans												
Other (specify)												

Activity 2.4 ***Make*** _a list of any by-products that are produced from these energy sources in your business. Add (in brackets) examples where you USE any of these by-products in your business. e.g., heat generated from compost production_

If you do produce by-products in your business, do you recycle them?

Yes ☐ No ☐

State which ones you re-cycle:

Activity 2.5 If *you do re-cycle, the explain how. (e.g., the water from the air-conditioners for the office runs back into the drainage system to water the plants)*

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1.1.1.3 **Activity 2.3** *Make a list of any by-products that are produced from these energy sources in your business. Add (in brackets) examples where you USE any of these by products in your business*

e.g. heat generated from compost production

Now that you have determined the source of energy used, let's see how much it costs to energise your business. To complete the following exercise, you would have to access to information from documents such as electricity bills, invoices, or receipts etc. If there is insufficient space to answer, copy the table into a new document and increase the size for your purposes.

Activity 2.6 Calculate *how much your business spends each month, using the records of expenses of the last year.*

Source of cost:	Equipment usually using this resource in the business	OHISA industry statistics (based on the 2021 research)	Jan	Feb	Mar	etc. …	Annual cost
Electricity bills	Pumps	100% of the pumps in the businesses used electricity					
	Sowing machines						
	Potting machine						
	Soil mixer						
	Other						
	Fans	88% of fans in tunnels used electricity					
	Lighting	100% of the lighting used electricity					
	Office equipment	95% electricity					
	Kitchen equipment	87% used electricity 4% used solar energy 9% used gas					
Diesel receipts	Trucks and tractors	91% used diesel					
	Smaller vehicles	26% used diesel					
	Generator						
Garage invoices	Company cars	74% use petrol					
	Blowers & weed eaters	78% of small tools and equipment use petrol					
Coal invoices	Boilers	71% of growers who need heating for plant production use coal					

Energy-saving ideas from the 2021-2022 ornamental horticulture industry research

INFORMATION BOX

There are many low-cost options to promote energy saving and moving towards renewable resources for energy.

Using alternative energy sources, such as solar energy:

- Solar panels for generating heat, or linked to inverters to store energy
- Solar geysers

Energy-saving ideas for pumps:

- Installing a variable speed drive on pumps to optimize electricity usage
- Use pumps between 11h00-04h00 when electricity costs at the lowest
- Turn off pumps when not in use

Electrical equipment:

- Make sure you have meters on electrical distribution boards
- Have timers on your distribution board (DB) to control electricity usage e.g., lights, pumps, air conditioners and irrigation

Energy-saving ideas for watering:

- Use gravity for water and irrigation
- Use a furrow system to channel water
- Use climatic conditions to control watering to only when it is needed

Becoming more aware:

- If not necessary do not switch it on
- Consciously limit your use of energy
- Use cold water only to avoid energy use on geysers
- Generator used only when necessary

Equipment:

- Danish trolleys & tail-lifts for more efficient handling and transporting of plants

Maintenance of vehicles:

- Vehicles serviced & maintained regularly so they operate more efficiently

Saving energy for lighting:

- Energy saving lights & skylights, use low energy bulbs, LED lighting
- No lights on or use indoor lights only when needed
- All lights on sensors that turn off lights where there is no movement

Energy-saving for heating and cooling of greenhouse, tunnels, and sheds:

- Underfloor heating to heat area only around plants & not entire greenhouse
- Hothouse heated by sun energy
- Insulation in roofs
- Insulation using double layer plastic and green house screens for temperature control
- Control temperature using wet pad & fan
- Use low energy geyser elements

Scheduling use of energy:

- Use solar heating during day and electricity between 22:00 & 03:00 (cheaper rate)
- Pump water only when needed, or pump in off-peak hours
- Use timers on boreholes, pumps, and geysers to limit usage and automate irrigation
- Pump at most efficient times & only when necessary (i.e., observe weather patterns and expected rainfall, evaporation rates and cloud cover)
- Using several hosepipes at the same time
- Reduce the amount of irrigation and pumping you use

Remember that you do not have to do all of this at once!

Activity 2. 7 Indicate *whether you could implement the following changes (yes /no) and how*

Type of cost reduction	yes	no	By doing what?
minimize usage			
reduce costs			
create awareness			
change behaviour towards energy usage			

The table in Activity 2.7 (spread over four pages) gets you thinking about tangible changes that you can make within your business to improve your energy efficiency. It focuses on different areas of the business so you can investigate them each independently. You can work with others to decide if a change could be made. Think about WHY and HOW you will make the change by placing ticks in the relevant boxes under “purpose for change”. Depending on the answer to these questions suggest where you can change – yes, I can implement change by creating awareness and training on how to do the job and complete the roster all which has low costs.

Activity 2. 8 Carefully *consider each area of your business and complete the table.*

Areas of business	Possible alternative energy	How to make change	Can I make the change?	Purpose of change: minimize usage	reduce costs	create awareness	change behaviour (say	Cost
Irrigation								
Pumps		Switch off pumps when not in use	Yes					None
		Maintain pumps in good working order and clean regularly				✓	*Training*	Low
		Use solar pumps						High
		Place tanks and water sources higher than where water is needed to allow gravity to do the work of the pump						Medium
		Aerate the water to rid it of algae and impurities which making the pumping thereof easier						Medium
Production								

Sowing machines		Turn off when not in use				✓		None
		Use efficiently						
Soil mixer		Mix according to a recipe and the amount needed per time e.g., better time management and use of resources both labour and materials					*Training*	Low
Potting machine		Purchase premixed growing media most suitable to plant varieties you are growing						Medium
		Use efficiently and if cost allows look for models that do multiple containers using less manpower						High
Areas of business	**Possible alternative energy**	**How to make change**	**Can I make the change?**	**Purpose of change** minimize usage	reduce costs	create awareness	change behaviour (say	**Cost**
Dispatch, deliveries, and vehicles								
		Have a maintenance programme e.g., check air filters and replace, make sure tyres are balanced and at the correct gauge					*Training*	Low
		Have a designated area for vehicle and equipment maintenance and storage, preferably with a concrete floor to prevent oil spills and fuel leaks that can affect soil and ground water						Low, a concrete slab
		Use the most suitable vehicle for the job or delivery e.g., not a 4-ton truck for a 1-ton delivery (fill the truck to do more than one delivery in the same area)						High (if you need to buy)
Trucks and delivery vehicles		Plan routes to be time and fuel efficient.					*Training*	None
		Use the smallest vehicle for the task at hand.						(cost of training or employing logistics person)
		If budget allows upgrade to more fuel-efficient models and those with technology to reduce carbon emissions.						
		Educate drivers to drive efficiently thus reducing idling and riding of the clutch.						
T r		Have a maintenance and service plan.						Low

		Ensure drivers are trained to drive safely and correctly.						
		Have the correct size tractors for the needs that you require.						
Golf carts	Battery-operated rather	Use bicycles to move around farms.						Low
TLB		Have a maintenance and service plan.						Low
		Ensure drivers are trained to drive safely and correctly.						
Fork-lifts		Have a maintenance and service plan.						Low
		Ensure drivers are trained to drive safely and correctly.						
Property maintenance								
Blower/ Mowers	Battery operated rather than diesel						Train those working with equipment to use, clean and	Low
Weed Eaters								Low
Sprayers	Manual or battery							Low

Areas of business	**Possible alternative energy**	**How to make change**	**Can I make the change?**	**Purpose of change**				**Cost**
				minimize usage	reduce costs	create awareness	change behaviour (say	
Tunnels and Greenhouse								
Heaters	e.g., gas, paraffin	Biomass / organic matter decomposition for heat generation						Low
Wet Walls	Water	Use recycled water and not potable water for cooling tunnels and green houses						Low
Cooling	Plants	Hedging for cooling to reduce transpiration						Low
Protection for wind	Plants and shade-netting							Low
Shade netting		Used for covering tunnels and sheds for cooling						Medium

Temperature control		Painting of tunnels with white PVA to reflect heat in summer						Low
		Thermal curtains						Medium
		Use vermiculite layer as part of flooring to add better insulation						Low
		Recycle polystyrene trays e.g., 128's for 406's to put other trays on top of in tunnels for insulation and better drainage						No cost - recycling
Fans	Electric , wind	Misting for cooling rather than fans						Medium
		Tunnels opening to allow natural drafts for temperature control e.g., cooling						
Underfloor heating	Water and pumps	Place piping in and under compost or storage areas which can heat up during the day, thus having naturally heated water in pipes which will then run into underfloor heating						Medium
Lighting		Use natural lighting where possible or shade netting most suitable to plant variety being grown e.g., 40% green / black for hardening off. 40% mixed white and black for growing; 80% for shade loving plants						Medium
Boilers	Use solar energy	Convert to solar energy to heat water for underfloor heating of tunnels and green houses.						High (return on costs - long term)
		Ensure tunnels and greenhouses are maintained and insulated to maintain temperatures						Security a problem in South Africa
Offices								
Computers, printers,		Set power saving and energy saving modes to conserve energy when not in use or turn off				✓		
Areas of business	**Possible alternative energy source?**	**How to make change**	**Can I make the change?**	**Purpose of change**				**Cost**
				minimize usage	reduce costs	create awareness	change behaviour (say	
Kettles		If boiled and not all water used pour heated water into flask for next person to use						None
		Have lunch breaks at similar times so that kettle is boiled less frequently						

Micro-waves		Have solar cookers for warming food							Low
Coffee machine		Saves having to boil kettle so often							Low
Urns		Saves having to boil kettle so often especially for larger teams							Low
Wiring		Check for overloading, corroded parts, and faulty installation colour?							Low
Lighting	Con-vert to LED lights	Turn off all lights when not in use							Low
		Have sensors which switch on lights when someone enters an office or bathroom but when there is no movement, lights go off							Medium
Fridges		Use the most energy efficient one as possible							Medium
Planting trees and hedges		Use plants to provide natural cooling and temperature control in offices and buildings instead of air conditioners							Low
Growing areas and plant section									
		Put plants together with similar water and temperatures needs						Plan-ning	None
		Have the germination room near to the sowing room so less energy e.g., tractors or labour is needed to move trays from one area to another						Plan-ning	Low
		Have potting machine near to where the soil is kept or mixed again to decrease transport costs within the business						Plan-ning	Low
		In summary: Plan site for the shortest distance to be travelled between tasks						Plan-ning	Low
		Use conveyor belts and trolley to move more plants more efficiently from one area to another							Medium
Other									

Studies have shown that it is not only the use of technology, infrastructural changes and system changes that improve a company's environmental impact, it is also the buy-in and attitude change towards the environment of those involved. By setting an example, having reminders around e.g., a sticker on the light switch to say please turn off, people are more inclined to work towards a positive environmental change where it becomes a part of their life and not something extra.

Are you now ready to create your energy policy document for your business and see how best you can conserve energy and achieve SDG 7 (use the following table to help you as shown in Part 1 of the manual for a similar table for the whole business – THIS one applies to an energy.)

Activity 2.9 ***Draw*** *up an ENERGY policy document using this template to guide you*

Title	*Best Management Practice for Energy use with the Production area of the Nursery*	
Date	Business address	Contact details
Stakeholders and partners	*List those involved e.g., environmental officer:*	
Section on business	*List (e.g., admin, planting, selling, logistics, spraying etc.)*	
Type of document *(Tick the most relevant choice)*	☐ Worksheet ☐ Standard operating procedures ☐ Policies guidelines ☐ How to … (training guides)	☐ Review document (monitoring report) ☐ Information sheet ☐ Educational poster
Target Audience *(tick relevant boxes)*	☐ Worker ☐ Team leader ☐ Supervisor ☐ Manager	☐ Manager ☐ Workplace owner ☐ Other
Purpose of document		
Relevant area in business	*List (e.g., Inside, outside, delivery bay, hothouse etc.)*	
Document structure	Description of initial situation and problem	
	Good practice being addressed	
	Time schedule	
	Risks to be addressed	
Stakeholders and partners	*List those involved and benefitting from best practice implementation*	
Methodological approach	*Describe business practices and process to be addressed and adapted*	
Validation	Monitoring and recording changes both positive and negative	

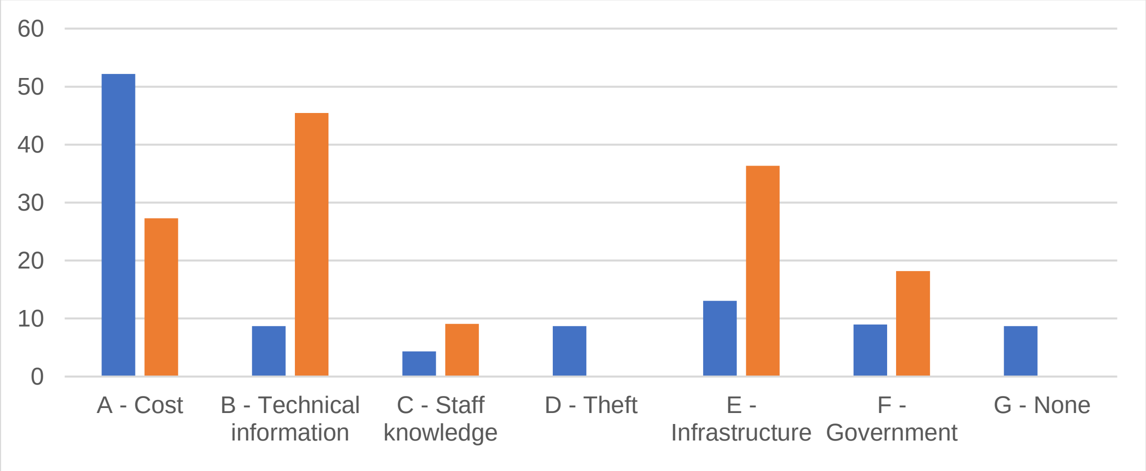
Impacts	Environment
	Economical
	Individual
Innovation	*List new technologies applied*
Success factors	
Constraints	
Lesson learned	
Targeted SD goals	
Repeatability and adaptability for other areas in business	
Conclusion	Impact and usefulness
Contact details	
Related websites	
Related resources	

Potential problems when trying to achieve energy efficiency

When developing and applying an energy-efficiency policy be aware they you may encounter obstacles along the way. Do not feel discouraged – others have also identified difficulties. Keep a positive attitude and try to find ways to overcome obstacles. The following case study shows some obstacles that were experienced by members of the OHISA in the 2021-2022 study, when trying to achieve energy efficiency.

CASE STUDY RESULTS

The respondents in the 2021-2022 study of the ornamental horticultural industry identified the following difficulties when they tried to implement energy efficiency policies in their businesses.



Activity 2.10 ***Did*** *you have the same obstacles as others in the industry or were there new ones that are preventing you from using energy efficiently? List them.*

Now you have finished working through this module on energy, review the objectives and indicate those you believe you have achieved, by ticking those **completed**).

ENERGY OUTCOMES checklist

	Become aware of the energy crisis globally and the consequences of irresponsible energy generation and resultant pollution	
	Gained knowledge about the energy use within your workplace	
	Created an energy conservation, use policy and prevention pollution policy for the different parts of your workplace	
	Shared the policy with others for feedback	
	Implemented the policy and got more feedback	
	Created an opportunity for behaviour change within your workplace	
	Reduced the energy-related input costs within your workplace	
	Improved your environmental footprint by responsible energy use and conservation of energy	
	Helped your fellow co-workers and peers become more environmentally friendly	
	Developed and applied a strategy to update policies annually to maintain environmental sustainability within your workplace	

Module 3:

Water sustainability

South Africa is a semi-arid country with an average rainfall of 465mm (Department Water Affairs and Sanitation, 2018). Water is a scarce resource and an evaluation by the *European Environments Agency* puts the water stress level of South Africa at 41.38%. This means the demand for water for a particular period is 41,38% more than the available amount of water. This is because the fresh water available has been reduced due to the drying-up of aquifers (porous rock or ground saturated with water) because of over-utilization of water from rivers and streams, and a declining water quality. The water quality has declined because of increased nitrification, higher salt content, pesticides, and organic matter pollution (European Environments Agency 2019). In 2018, 40% of our dams, rivers, and aquifers had poor quality water caused by pollution and the destruction of river catchment areas. The major contributors to this pollution are the **agricultural sector** (pesticides, irrigation return flows, fertilizers), the **industrial sector**, the **mining sector** and **urban areas** (Sustainable Development Goals – Country Report 2019). In addition, the water-use efficiency needs to be improved for all users.

In order to improve water-use efficiency in your business you would first need to conduct a water-use audit, to see how and where you are currently using water. This would allow you to pin-point areas where you could make improvements to conserve water.

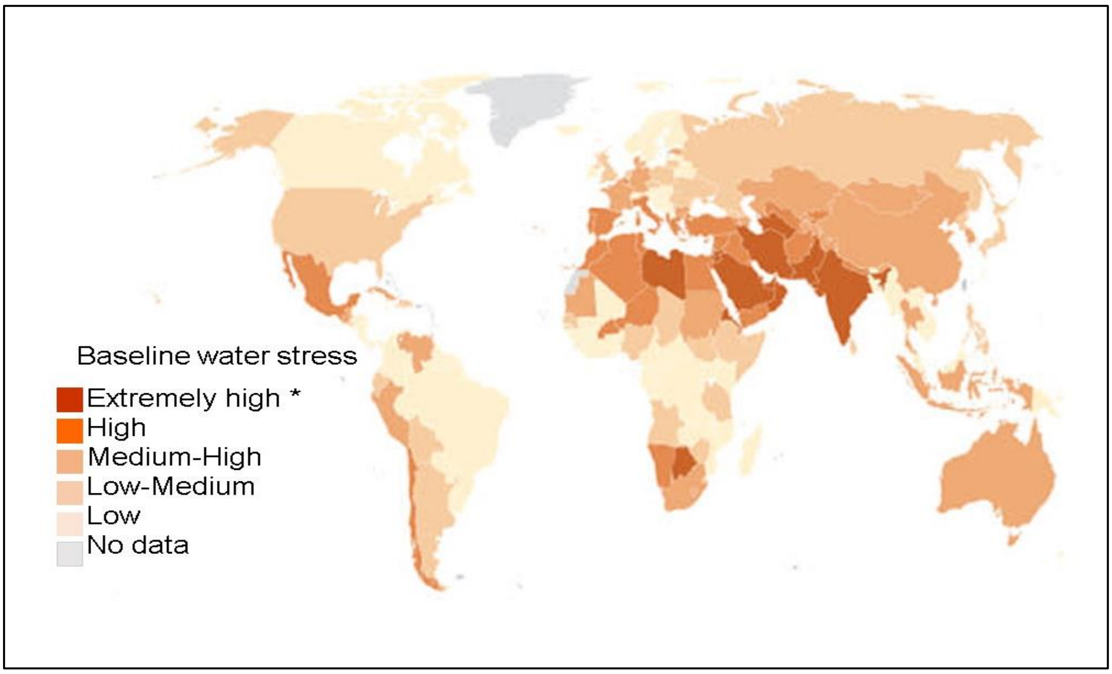
Activity 3.1 *Using the checklist below rate the areas of your business where you could become more water efficient, by ticking the relevant*

Water Awareness Checklist						
Area of the business where water is used	**Very poor**	**Poor**	**Fair**	**Good**	**Excellent**	
	We are not water efficient	**We have started to address water efficiency**	**We have a few water-saving methods in place**	**We are as water efficient as possible within**	**We have achieved complete efficiency**	**Not applicable**
Bathrooms						
Basins						
Taps						
Showers						
Kitchen						
Sinks						
Drinking fountain / water dispenser						
Dishwasher						
Dams						
Dam design						
Covering for dam						
Inlet and outlet from dam						
Gardens						
Plant types						
Watering system						
Lawns						
Water features						
Maintenance area with taps and drains						
Wash-bay area for vehicles						
Chemical room and mixing area						
Offices						
e.g., Air conditioner						
e.g., Water bottles						
Sheds and greenhouses						
Irrigation type						
Pipes						
Drainage channels						
Water storage and inputs						
Tanks						
Dams						
Boreholes						
Spring						
Taps						

The global water crisis

A world map showing water stress levels shows that 17 countries which are home to more than a quarter of the world's population face extremely high levels of water stress e.g., Botswana, due to irrigated agriculture, industries, and municipalities which withdraw more than 80% of their available supply on average each year.

Water stress by country according to World Research Institute Aqueduct Water Risk Atlas (2019)



The water crisis has been under investigation since 1998 and intensifies each decade as:

- Access to freshwater diminishes (Abu-Zeid, 1998; Rogers, 2008; Darwall *et al.*, 2018)
- Use and conservation of water continues to be a challenge.

The United Nations General Assembly (2016) realized that there was going to be a global water crisis by 2030, with a predicted shortfall of 40% freshwater resources. To try to avoid this they dedicated the decade 2018-2028 to 'Water Action'.

Some factors contributing to the water crisis include:

- Climate change causing temperature variations, melting glaciers, and increasing sea levels,
- Natural disasters like flooding and droughts which contaminate fresh water,
- Water wastage: 30%-40% of a city's water is lost due to wastage e.g., leaks, taps left running, burst pipes, poor maintenance of infrastructure,
- Wastewater and pollution of freshwater systems: industrial waste, plastics, rubbish, chemical spills, fertiliser leaching, and poor sanitation,
- Urbanisation and population growth worsening water abuse.

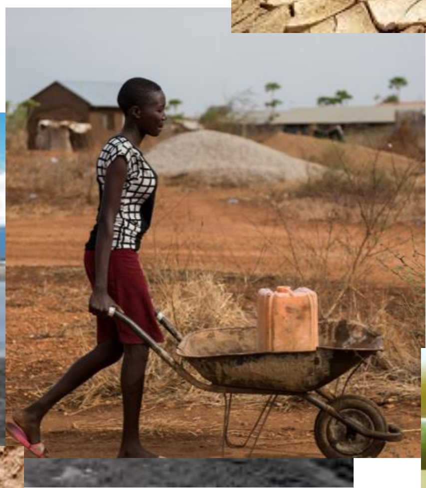
Water, like air, is a finite natural resource which has always been important. The *United Nations Committee on Economic Social and Cultural Rights* pointed out that 'the human right to water is indispensable for leading a life in human dignity' (UNESCO, 2002). Understanding its value is essential to achieving Sustainable Development Goal 6 – 'achieving universal, safely managed water and sanitation services by 2030' (Garrick *et al.*, 2017).

Not only is it a human right to have access to clean water, but the ongoing challenge is that water is vital for commercial development, maintaining viable eco-systems, agriculture, and the production of energy.

The water situation in South Africa

Do you think we have a water crisis in South Africa?

Yes ☐ No ☐ Unsure ☐



The Water Crisis in South Africa: A Looming Threat

INFORMATION BOX

Here are some water-related facts for South Africa

- Climate change is affecting rainfall (The Water Project, undated);
- Experts attribute the water shortage to **drought** (shortage of rain); a rapid **increase in demand** from residential and business sectors; and the **lack of investment** in infrastructure (Stoll, 2022, Earth.org)
- Almost 25%-30% of SA's water is being lost due to our failing infrastructure (about 70 million litres of treated drinking water a day) (Stoll, 2022, Earth.org)
- Theft and illegal connections are losing Durban about 35% of its water (The Water Project, undated);
- Vast amounts of water are being used to generate electricity - washing the coal and in the cooling towers (Greenpeace, undated)
- The shortage is made worse by water pollution by residents, factories illegally directing waste into rivers and dams, and toxic water produced after coal is washed for electricity generation.

Is anything being done about our water crisis?

South Africa, being a water scarce country, has its water protected by the *National Water Act (36)* of 1998, which was amended in 2014. This Act and Amendment regulate the source of water, its extraction and use and the quantity used for which purposes to ensure it is managed fairly and sustainably (South African Government, 1998, 2014). A *National Water Resource Strategy* (2004 and 2013) was developed to manage water *'efficiently and effectively for equitable and sustainable growth and development'* (Department of Water Affairs [(DWA, 2013). The challenge is that according to the World Wide Fund for Nature South Africa [WWF], 98% of all South Africa's water resources are already accounted for and being used, leaving a minimal stock for future use and the increasing demand due to population growth and food production, urbanisation, and development (Goldblatt, 2018).

It is important to find practical ways to conserve this resource and use it more carefully e.g., recycling and reusing it, and minimising its contamination to ensure sustainability (Valhondo & Carrera, 2019) and improved water conservation education (Hoy & Stelli, 2016; Turner et al., 2016). This resource is not only essential to humanity for safe drinking water and sanitation, but a lack of water poses a threat to agriculture (global food security), power generation, the natural environment and many businesses and industries (Bisbis, Gruda & Blanke, 2019; Knox et al., 2020).

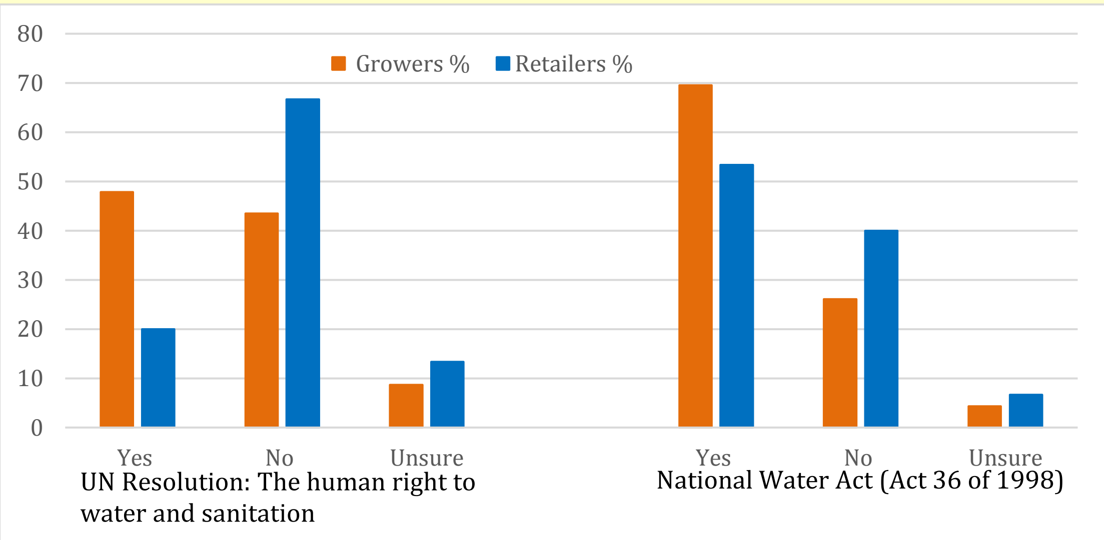
Activity 3.2 *How has the water crisis in South Africa affected your business?*

In South Africa numerous laws have been passed regarding water use. The agriculture, forestry, mining, industrial and power generation, local authorities, water service institutions e.g., *Umgeni Water* and *Rand Water,* and environmental and water resources sectors must comply with the water use stipulations of the following legislations:

- The *Water Services Act* (Act 108, 1997)
- *National Water Act* (Act 36 of 1998),
- *National Water Sector programme* (2008) and
- The *Municipal by-laws* (White Paper on a National Water Policy).

CASE STUDY RESULTS

The respondents in the 2021-2022 study of the ornamental horticultural industry were asked whether they were aware of the *United Nations resolution dealing with human rights to water and sanitation* (2010) and South Africa's *National Water Act* (1998). The following graph shows the percentage of the growers and retailers who were aware of the two acts.



As was the case with their knowledge of global and local legislation for ENERGY (see Module 2, page 26) the graph shows participants were more familiar with the local law than the international one. Only 48% of growers and 20% of retailers knew about the United Nations global resolution, but 70% of the growers and 53% of the retailers were aware of the national South African act, which highlights how important water is to the industry and their businesses.

World-wide, agriculture is one of the greatest water users, using about 70% of the fresh water extracted (World Bank, 2020) and this is true in South Africa as well, where 63% of extracted water is used for irrigation(Bonthuys, 2018). Similarly, the ornamental horticultural industry is dependent upon water for the production and care of plants.

How well does your business comply with recommendations?

The global sustainable development goal 6 (to ensure access to clean water and sanitation for all by 2030) is sub-divided by the United Nations into eight targets, six of which are very important in the ornamental horticultural industry.

Using the table below, assess how well your business complies with the United Nations sustainability development goal SDG 6, which is very much in line with South Africa's national *Development Plan and Water Policy.* You might not even have been aware of the targets, yet still be implementing some of them for health reasons, based on common sense.

Activity 3.3 *Complete the table by filling in information for your business in the last column of the table.*

Global targets for sustainable development goal 6	South African achievement of *UNICEF 2020* and *UNEP*	What is the situation in YOUR business
 **Target 6-1** Safe and affordable drinking water	94% of the population has access to safe drinking water	We have safe drinking water available to us at work Yes ☐ No ☐
 **Target 6-2** End open defecation and provide access to sanitation and hygiene	78% of the population is using safely managed sanitation services (at a basic level) 44% have handwashing facilities in their homes with soap and water	Number of toilets _____________ Number of basins ____________ Number of showers____________
 **Target 6-3** Improve water quality, waste-water treatment, and safe reuse	61% of domestic wastewater is treated 52% of water bodies have good water quality	Describe the quality of the water in your dams. ____________________________ ____________________________ ____________________________
 **Target 6-4** Increase water-use efficiency and ensure fresh water supplies	51.35 billion cubic metres/ year of water is renewable (2017) 41% of freshwater withdrawal as a proportion of available freshwater in 2000, 64% freshwater withdrawal as a proportion of available freshwater in 2018	How much of your water is recycled in the business? ____________________________ ____________________________ ____________________________ ____________________________
 **Target 6-5** Implement integrated water resources management	Integrated management including enabling environmental, institutions and participation and management instruments and financing grew from 65 (2017) to 71 (2020) as a score out of 100	Are you integrating natural resource use e.g., springs or groundwater with recycled water? Yes ☐ No ☐ Is your business using different methods to conserve water and get the best optimum use of each drop? Yes ☐ No ☐
 **Target 6-6** Protect and restore water-related eco-systems	3379 km^2 of water-related eco-systems in 2005 includes lakes, rivers, estuaries, and artificial water bodies 3415km^2 of water-related eco-systems in 2016	Do you have a wetland on-site? Yes ☐ No ☐ Unsure ☐ How do you protect your water resources? e.g., groundwater, dams, reservoirs Has the amount of water you store in dams or tanks increased in the last 5 years? Yes ☐ No ☐ Unsure ☐

By completing the above table, you have assessed the achievement of your business with regards to the SDG 6. There might have been areas which need work, and these will be investigated further, later in the manual.

Managing water efficiently is a key driver to sound environmental performance and the OHISA is committed to achieving improvements in water use efficiency across the whole of industry. This is highlighted by the attitude the participants had towards water usage, summarised below.

CASE STUDY RESULTS

	Knowledge of amount of water used	I see opportunity to save water in my business practices
Growers	100%	78.3%
Retailers	94.1%	70.6%

Do you know how much water you use daily?

Activity 3.4 *Complete the following table for a) your personal daily use and b) the amount of water you use in your business each day. Use the information provided in the middle column to see how much each listed activity uses, on average.*

Personal water usage		
Glasses of water, tea, or coffee	250ml / glass	
Bathing and brushing teeth	12l – 100l / activity	
Cooking	15l	
Toilet flushing	9l / flush	
Washing clothes	35l-55l / wash	
	Personal Total	
World average (173l/day)		
South African average (235l/day)		
Water usage at work		
Watering the plants in my section		
Mixing with fertilizer	40l in dosatron	
Washing the vehicles	30l/ small vehicle 100l/ truck	
Mixing pesticides	1l or 5l	
Leaking pipes, taps or toilets	30l / hour	
	Work total	
	FINAL TOTAL	

Note how much higher the average daily use of South Africans is than the global daily average. Are you water conservative (use less than 150l/day) or are you like most South Africans who use, on average, about 235l/day (there is a debate whether this includes leaks in municipal systems which actually isn't the user's water use)? As day zero approached (the day the city was predicted to run out of water) for Capetonians in 2018, they were only allowed to use 50l/day.

It is in times of water crisis that the nursery industry gets to showcase best practices when it comes to watering. This has been done not only in South Africa, particularly by the Capetonians, but also internationally. In Florida USA, where excessive water use can generate negative public and political pressures nursery operations show the public how best to conserve water (Florida Department of Water Quality / Quantity Best Management Practices for Florida Nurseries, 2014).

The importance of water in the ornamental horticultural industry

INFORMATION BOX

Horticultural businesses are dependent on their products, of which an average of 40–60% is plant material that is reliant on water. Plants require water for a number of vital functions:

- Plant tissue is 98% water, which is the medium for biochemical reactions in the cells of plants. It is therefore essential for various life processes in the plant e.g., **photosynthesis** (which uses sunlight to produce food for the plant) and **transpiration** (regulating the opening and closing of stomata for gaseous exchange).
- Water is an excellent solvent, assisting in the movement of nutrients from growing media into the plant and distributing the products produced during photosynthesis throughout the plant.
- Water is important for heat control in plants, e.g., heat capacity, heat fusion, and heat vapourisation. The process of vapo-transpiration cools the leaves.
- Water increases the turgidity of the plant and provides pressure which stimulates root movement in growth media.

Thus, high quality plant production and reduced plant loss is dependent on a reliable source of water during the germination, growth, and maintenance of the plant (Durner, 2013).

What happens if not enough water is available?

- Plant growth reduces
- Plants wilt
- Nutrient deficiencies prevalent
- Reduced cooling effect
- Reduced health of roots which leads to reduced plant health

What happens when a plant gets too much water?

- Root activity slows down or stops altogether and plants show drought symptoms
- Poor root growth slows plant growth processes
- Leaves may wilt because poor roots can't take up water properly
- The lower leaves may yellow

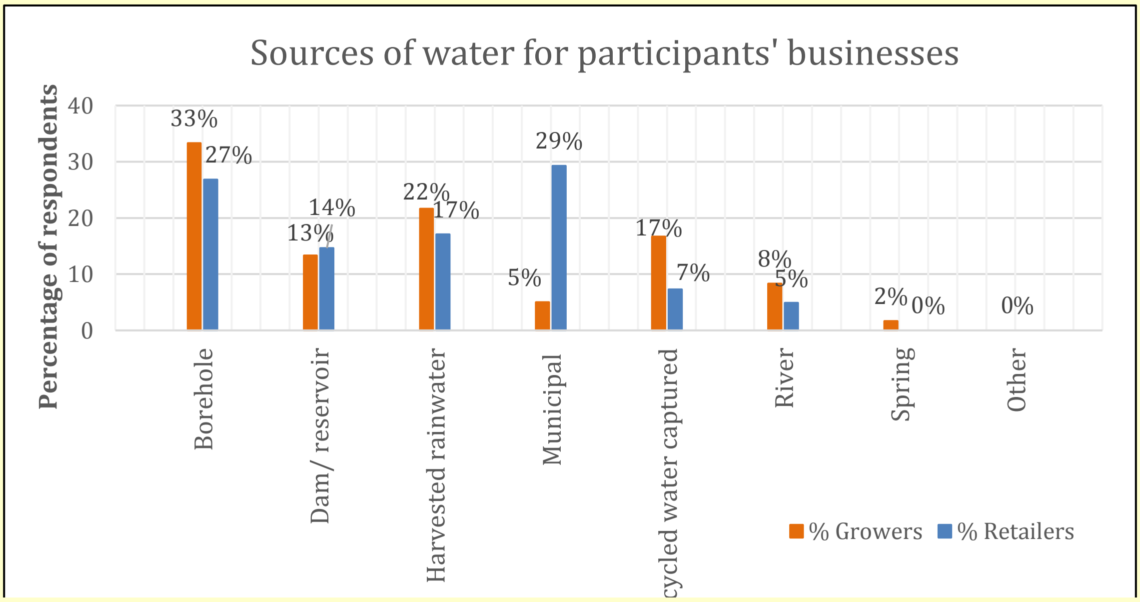
Now that you have the background to water sources and usage within the industry, let's have a look at your individual business and see where changes and savings can be made.

Activity 3.5 *What is the source of water for your business? (You can choose more than one)*

Borehole	
Dam/ reservoir	
Harvested rainwater	
Municipal	
Recycled water captured	
River	
Spring	
Other (please specify)	

ow typical are the sources you use, compared with others in the ornamental horticultural industry, as represented by the views of the participants in the 2021 - 2022 study? Note the difference between the growers and the retailers in terms of using municipal water and other (private) sources.

CASE STUDY RESULTS



The source of water is important because it influences the decisions you make regarding water accessibility, measurement, and licensing, for example, gravity-fed irrigation, whether you need a pump, and where are you might position your dam.

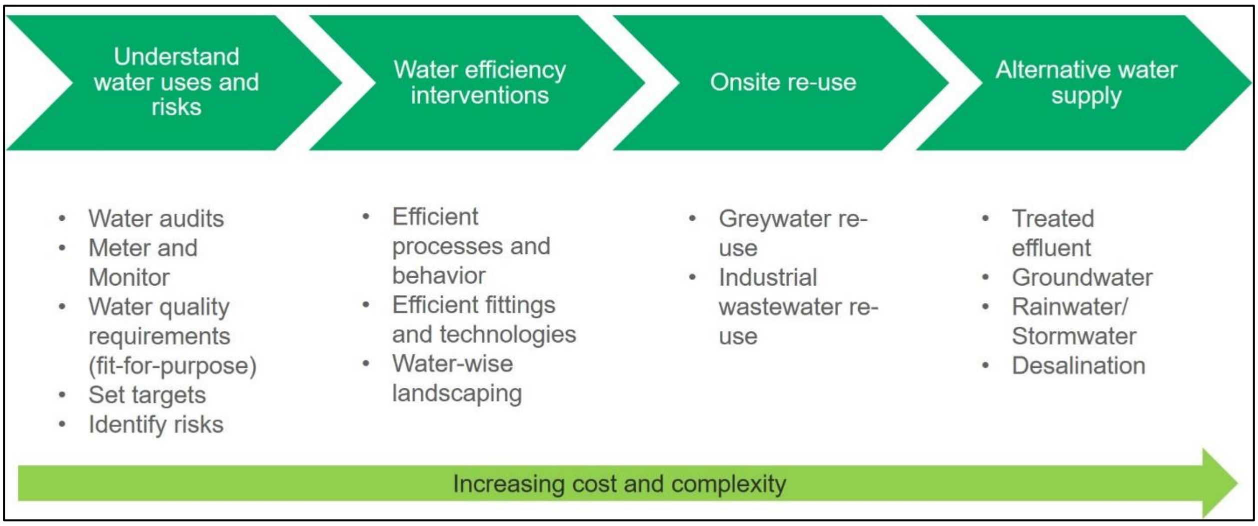
According to *Act 36 (*1998) each person is entitled to use water in or from a water resource for domestic purposes, such as household use and gardening, water for animals, firefighting, and recreational purposes (Schedule 1. NWA, 1998:10). Any commercial activity or activity not mentioned above that requires water must be registered with the responsible authority. This Water Use license can be obtained from and completed by the *Department of Water and Sanitation* (https://www.gov.za/services/mining-and-water/ registration-water-use).

Does your business have these licenses?

Yes ☐ No ☐ Unsure ☐

Sustainable water use by businesses in the ornamental horticultural industry is key in ensuring that your business survives the climatic changes South Africa is currently experiencing. The 'Green Cape' diagram below suggests ways in which this can best be achieved.

Sustainable Water Use Journey



(https://www.greencape.co.za/content/focusarea/drought-business-support [accessed 4 April 2017])

Water management plans help businesses set long- and short-term water conservation goals. The above strategy is re-iterated with the byline – 'Meter, Measure, Manage', which was initiated by the *United States Environmental Protection Agency* and has proven to reduce water usage by analyzing saving opportunities, ensuring that machinery is running correctly, and seeing that irrigation is being maintained properly to prevent leaks. The *Cape Resilience Forum* adopted a similar strategy during the droughts. It is user-friendly, and applicable aspects can easily be applied in ornamental horticultural businesses.

The first step in improving water management is to conduct a water-use audit within the business, like what you did for the activity when you accessed your awareness of water use and equipment within the business, and the activity where you did a brief personal audit of your own water usage.

In South Africa, the horticultural industry tends to use either their water bills or the amount of rainwater captured as a measurement to assess their water usage. They could also use the number of times they fill their dams or reservoirs on a daily, weekly, or monthly basis, providing water meters were available at the source.

Activity 3.6 Conduct *a water audit for your business. (Choose the appropriate table depending on your situation in your business)*

If one of your water sources is municipal, then you can complete the following table each year.

Water Costs													
Date:													
Source of Water: Municipal - Use water bill or rates account													
Municipal	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Costs
Year 1													
Year 2													

If your water sources are metered, you have reliable information at your fingertips e.g., if you have a borehole with a meter on it, you could complete a similar table for the different metered areas in your business to give an accurate water usage per month either in litres (l) or Rands (R).

Water usage or costs of metered sources													
Date:													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Costs
Borehole 1													
Borehole 2													
Outlet Dam 1													
Outlet dam 2													
Reservoir outlet 1													
Reservoir outlet 2													
Irrigation system access point 1													
Irrigation system access point 2													
Tank 1													
Tank 2													
Tap 1													
Tap 2													

It could be that you must use both (bills and meters) to get an accurate assessment of all the water used and the costs to use it within the business.

If you do not have meters and you use other sources of water besides municipal, then you must work on averages and estimates.

Water Costs									
Date:									
Water use for:	Number of times used:	Average litres used/ flush	Subtotal litres used per day	Jan	Feb	Mar	Apr	Etc.	Total
Bathroom									
Toilets									
Type of toilets									
Regular		*15l*							
Dual flush		*9-15l*							
Basins (washing hands)		*3l*							
Dripping taps		*6l/minute*							
Showers		*15l/minute*							
Kitchen									
How many sinks									
Frequency of dish washing		*15l/half-filled sink*							
Drinking fountain / water dispenser		*2l/person/day*							
Dishwasher used		*9-30l*							

(Activity continued on the next page)

Dams									
No. of dams / reservoirs									
Refilled rate per day		*20000l*							
Gardens									
Watering system		*15l/minute hosepipe*							
Lawns		*9-15 minute sprinkler*							
Water features		*1000l recycled*							
Maintenance, wash-bay and chemical room area		*10l bucket*							
Tap near tool room for washing tools		*10l/minute*							
Vehicle wash facilities		*50l*							
Measurement of water used for mixing chemicals		*1-5l*							
Production area									
Plant type									
Layout of containers in section and blocks									
Offices									
Air conditioner		*2l/day*							
Drinking water		*2l/person*							
Plants on desks			*50ml/day*						
Sheds and greenhouses									
Irrigation type									
Number of taps									
Water storage and inputs									
Tanks		*10000l water storage*							
Dams		*100000l water storage*							
Taps		*3-27l/day dripping leaking tap*							
Other									

You should now have an idea of the amount of water that you currently use each month and annually. Your next step is to develop a policy for your business to plan how to conserve water and use it wisely.

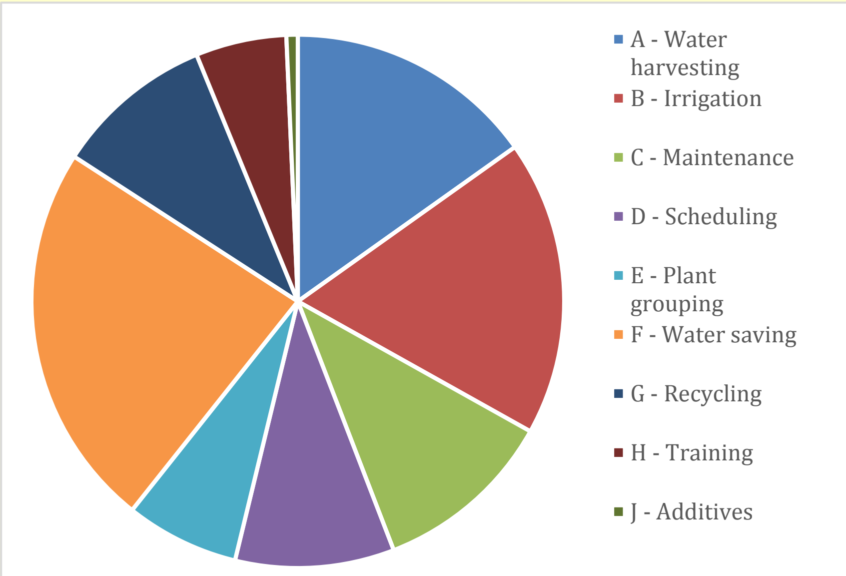
Activity 3.7 *List three ways in which your business already saves water*

Advice on "best practice" for conserving water

Using the above information, the next part of the manual goes into more detail about each aspect.

CASE STUDY RESULTS

1. Frequency of methods listed by the respondents in the 2021-2022 research into the ornamental horticultural industry when asked to *"List five practices that your business applies to optimise the use of water that could be included in a best practice's manual".*



Water harvesting, water saving, and irrigation are the top three ways that the participants of the OHISA save water. Interestingly, water saving varies from growers to garden centre with most growers saving water by recycling it and increasing the water-holding capacity of their growth media whereas the garden centres have retro-fitted their ablutions such as toilets and taps and do more staff training on waterwise water use.

A: Water harvesting

Rainwater harvesting and irrigation-water harvesting is the saving of water by capturing it captured in gutters, tanks, dams, reservoirs, and drains. This water is then channelled via drains or pipes into storage dams or tanks where it can be reused. Water is a finite resource and the recycling thereof within the horticultural industry will be essential to ensure long term sustainability. Growers, landscapers, and garden centre retailers can reuse water but the method with which you use is dependent on the plant varieties you grow, and pesticides or fertilisers added, as well as sediment and litter accumulation in the water.

What the experts say:
Water harvesting: e.g., *"all run-off was collected and used again"*.

- Business A had all plants on hard surfaces or concrete to allow for run-off to be funnelled into channels and into dams for recycling which is why they did not feel that as a business they contributed to soil or water pollution as all watering is within a closed loop.
- Business B: "has an underground drainage system which catches all excess water, and it can then be reused"
- Business C: mentioned that: "the slope of the nursery leads to a retention dam at the bottom to catch run-off"
- Business D: "catch all irrigation run-off water by ensuring all excess water can flow easily to catchment dams. Remembering to add plastic under weed matting, then flowing directly into furrows / gutters that lead into dams."
- Business E: "rainwater and aircon water harvesting and water saving toilets and taps, and nursery run-off channelled into gardens."

B: Irrigation

Irrigation design and methods are very scientific and are ways growers and retailers can make a difference to their water usage. Giving the **right amount** of **good quality water** at the **right time** to plants, whether in the landscape, gardens, or container plants, is important to achieve optimal plant growth. Using irrigation methods most suitable for the specific plant varieties and container size both in terms of amounts and timings is essential to conserving water. As well as grouping into "hydrozones" according to water requirements (low, medium, high).

Apart from considering design and equipment, wind is the next biggest contributor to irrigation efficiency. Irrigation methods also influence other horticultural operations such as employee hours, resource consumption and operational costs. Temperature and atmospheric conditions such as rain and relative humidity also influence the amount of water used and should be monitored. The growing media and landscape soils' physical properties, which are described in more detail later, also affect the amount of water used. Another way is making sure you're not wasting water by ensuring your irrigation is both efficient and uniform.

Irrigation efficiency measures the amount of water applied which is of benefit to the plant and not wasted (for example, by being sprayed onto pathways or leaking from taps or coming out the bottom of the container due to overwatering. Excess water that isn't being used by the plant becomes wastewater and needs to be captured and recycled to ensure watering efficiency is maintained.

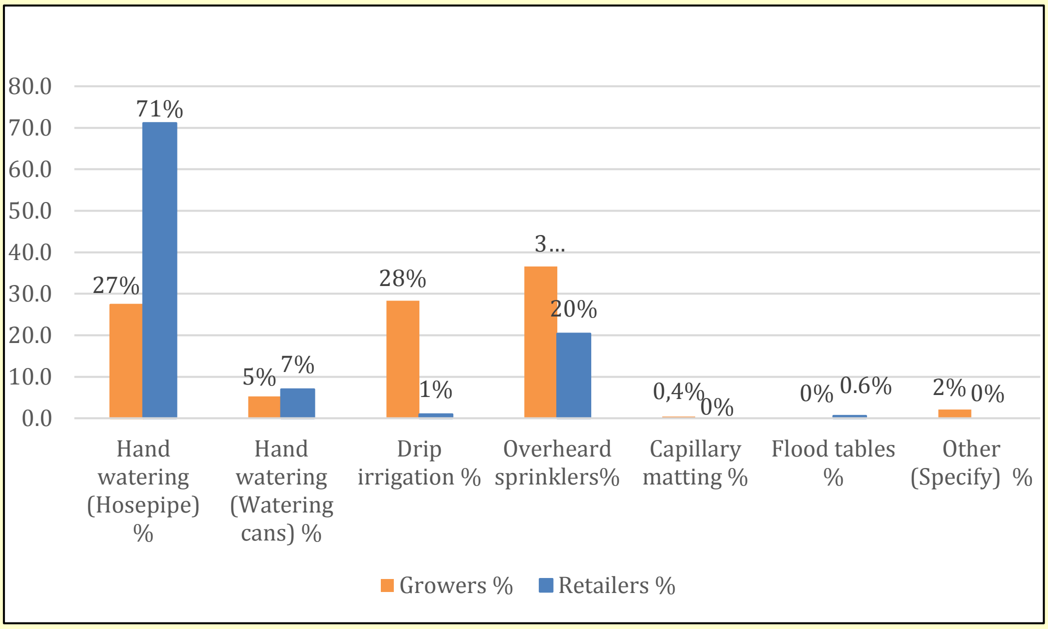
Plants can be watered by applying water to the growth medium or soil surface, for example, using drip irrigation; watering by hand with a hosepipe or watering cans, using overhead sprinklers or booms (these are not frequently used in the OHISA but rather in farming); by applying water through the bottom of the container (sub-irrigation such as capillary matting or flood tables); or by a combination of these methods. The different methods used depend on your business - whether you are a grower or garden centre retailer, but also on the species of plants you grow and sell, as well as the containers, trays, or bags that you grow or sell them in. From international observations and studies, overhead irrigation and hand watering are noted as wasting water and because the foliage of the plant gets wet when this method of watering takes place, there is an increased potential for disease and leaf damage.

Activity *3.8* Indicate which method of watering you use, and the percentage of plants that are watered this way

Watering method	% of plants watered by this method	e.g.,
Hand watering (hosepipe)		65%
Hand watering (watering cans)		2%
Drip irrigation		15%
Overheard sprinklers		18%
Overhead boom sprinklers		
Capillary matting		0
Flood tables		0
Other (Specify)		0

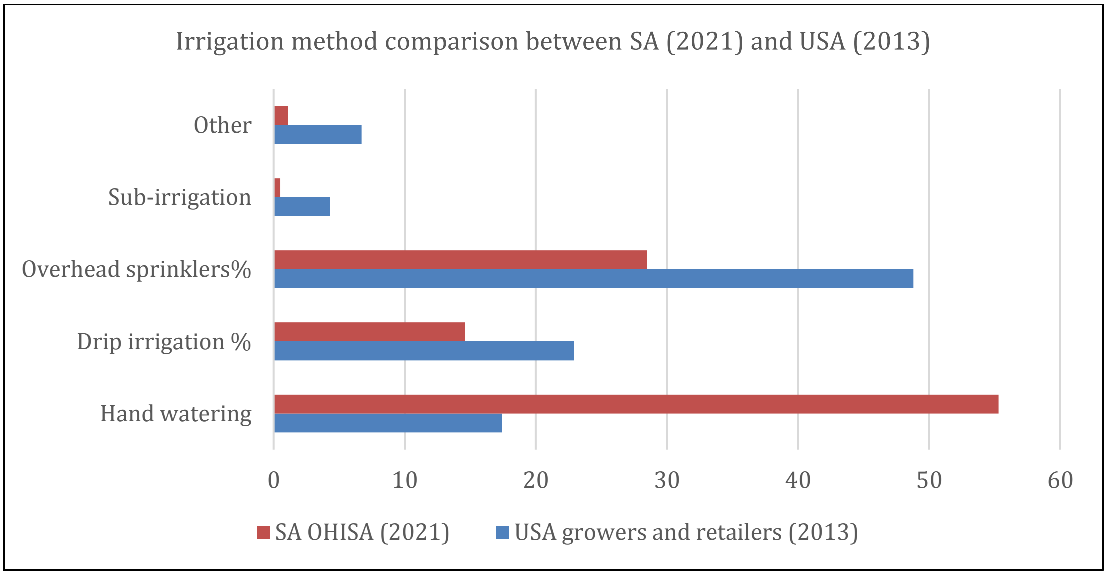
CASE STUDY RESULTS

During the 2021-2022 study the participants completed a similar question about the watering methods they used.



As can be seen, the growers use more irrigation whether it be drip or overhead compared to the retailers who prefer to water using hosepipes

Another interesting comparison, although from different years, is shown in the following graph. It can be seen that in the USA there was much more overhead watering and a lot less hand watering compared to South Africa – why do you think this might be?



Each of these methods has benefits and downfalls and it is up to the individual business to evaluate these and determine which is most suitable for them, both in terms of plant varieties, staffing, and costs.

When watering the amount of water each plant gets, must be consistent. This is known as **irrigation uniformi**ty - it measures the amount of water delivered to each plant by a watering system. It is important to monitor this to ensure plant vitality.

How do you do this?

When using overhead irrigation, catch cans can be set out in the different lines of the sections or plant area. These collect the water which the irrigation system is delivering to the plant and can be compared to other catch cans to ensure that the amount is similar in each. Then your irrigation is uniform. If you were using drip or micro irrigation, you would unplug some of the emitters and put a catch can where the plant would be and see how much water each plant container is getting. This could be tried for hand-watering but might not be successful due to human error or bias.

Types of irrigation systems

As mentioned above the correct configuration of an irrigation system at a nursery conserves water and energy which results in financial savings. The saving in energy is not only in terms of time and labour but also a reduction in greenhouse gas emissions released due to the optimum amount of fertilization applied in-line with the watering. The different equipment used, from the pump to the nozzles, drippers and hose-pipe sprayer attachments vary from nursery to nursery, but it is up to your team to ensure they know how to use the equipment efficiently.

1. Overhead sprinkler systems or booms

Research shows that both fixed overhead sprinklers and mobile booms are inefficient methods, with an estimated 300% variability in water application. This is especially true if they are poorly designed, as often pathways are watered and in some cases 70% of applied water runs off and does not reach the growing medium in the containers.

The advantages of overhead sprinkler irrigation are:

- Large areas can be watered simultaneously both in nurseries and landscapes
- Systems can be automated
- Suitable system layout, design and pressure are essential for an even water distribution

In South Africa it is the method most used by growers although many are converting what they can, to drip irrigation, as they have seen the benefits of drip, although this is a costly process.

Some important factors to considered when designing an overheard irrigation system:

- The most efficient methods with overheads are square, triangular, or rectangular patterns, where the sprinklers rotate 360^{O} for the body of the area or 180^{O} nozzles are used for the main areas and a 90^{O} is used in the corners of the sheds, tunnels, or greenhouses.
- Distance between risers is determined by the capacity of the pump, irrigation lines, and the volumes and pressures of the selected nozzles.
- The distance between sprinklers will be roughly 40% to 60% of the diameter of the wetting circle of each. The spacing is important to allow the low application rate of one sprinkler to match the area of high application rate of another.
- In windy situations and sandy, well-drained soils, sprinklers will be closer together.

The type of nozzle that you use is also important as it effects the droplet size -

- Big drops cause soil to crumble which leads to crust formation and compacting of the soil.
- Small droplets are more easily blown away from the area being watered and much can be lost by evaporation.
- Choose sprinklers that give droplets of a size that suits the situation:
    - The ideal droplet size is between 1 to 1.5mm
- Remember, the smallest droplets fall close to the sprinkler and the larger fly to the edge of the wetted area
- Average droplet sizes get smaller with smaller sprinkler nozzle sizes and higher water pressure.
    - Reduce the pressure or increase the nozzle size if too much misting occurs. Avoid excessive misting to minimise water loss through evaporation

To improve the effectiveness of overheads, check nozzles and spray patterns regularly and use the “*catch a can*” method to check uniformity of irrigation. Another method to determine water delivery rate is to use a water meter and take a meter reading, run the sprinkler(s) for an hour, take another reading. Determine the area covered by the sprinklers. This method is usually done for landscapes and gardens:

Average amount of water delivered = Amount of water used/area watered

Example: Water used: 500litres Area watered: 25sqm

Average amount of water delivered = 500/25 = 20mm

Remember: One litre of water spreads over one square meter (sqm) of surface to give a depth of 1mm.

Disadvantages of sprinkler systems:

- Water loss by evaporation
- When watering container plants with water containing fertilisers the loss of nutrients in run-off water is very high.

Overhead boom irrigation is a very accurate and flexible form of overhead irrigation. This method combines two elements: a spray bar with an even spray pattern and the movement of that spray bar over a crop at a uniform height and speed. Only one of the growers in the 2021-2022 investigation used this method to supplement watering when needed, which was using capillary matting.

2. Hand watering

Hand watering is one of the preferred methods of watering by garden centre retailers in South Africa, but it is expensive in terms of time, labour, and resources usage (e.g., water wastage). The training of waterers is essential as “a hose pipe in untrained hands can cause more damage than good”.

Factors to consider when hand watering:

- Hosepipe attachment or sprayer type suitable for container type you are watering e.g., Dramm sprayer, soft spray, lance sprayer
- Technique of holding hose and sprayer
- Consistent walking speed and even movement of hose to get a consistent even application of water.

Internationally many of the garden centres have a combination of flood tables and capillary matting for their seedlings, indoor plants and smaller containers plants, and use drip or overhead sprinklers outside. A hosepipe is only used for emergencies or spot watering. Nevertheless, in the 2021-2022 South African study, the research showed hand-watering was used by both growers and garden centre retailers.

3. Sub-irrigation systems

Sub-irrigation systems or bottom-watering systems (see diagram in Activity 3.8) supply water to the base of containers, from where it rises through the potting mix by capillarity. The physical properties of the growing media used in these systems are important e.g., an air-filled porosity of 12% - 14% is best for efficient capillarity.

Advantages of sub-irrigation systems:

- A very efficient method, up to 80% less water used than in sprinkler systems
- No nutrient losses from the system and no pollution of groundwater, dams, or streams with nitrogen and phosphorous.
- Exact amount of water needed can be applied without wetting the leaf surface
- This method is simple, can be automated and needs very little labour
- Variations in water pressure have no effect
- Work in the area can continue during irrigation

Disadvantages:

- The initial installation costs are high
- Root rot can be a problem. Allow the mats to dry out between floodings and ensure excellent hygiene. Disinfect sand beds and mats regularly.

Various types of sub-irrigation systems:

a. *Capillary matting or capillary beds*

Internationally capillary matting is an efficient watering method advised for growers and retailers. It is ideal for display stands and indoor plants. The matting is usually in a table to which a water source is connected. The mats are consistently damp which provides the growth media in the pots with water, and this also cools the plants. Similar in principle to capillary matting are capillary beds, where containers sit on sand instead of mats.

b. *Ebb and flow*

The area of concrete floor or moulded plastic bench top on which the containers sit is periodically flooded with water of nutrient solution. The excess water is allowed to drain back into a storage tank. This method is usually used in hydroponic systems.

4. Drip Irrigation

According to the World Health Organisation drip irrigation "*is an important innovation in agriculture, after the invention of the impact sprinkler in the 1930s. It replaced flood irrigation. Drip irrigation or subsurface drip is located at or below the plant roots. It is critical in areas where water supplies are limited*.'" (World Health Organisation, 2016).

With this irrigation method water is applied slowly and frequently to a limited part of a plant's root zone using drippers or emitters. This method is mainly used in container nurseries and production of vegetables such as tomatoes and cucumbers.

Advantages of drip irrigation:

- A very efficient watering method
- The right amount of water and fertiliser is applied directly where it is needed
- Work can continue in the area during irrigation
- Wind does not alter the distribution of water
- Prevents damage to flowers or foliage, as may be the case with overhead irrigation.

Disadvantages of drip irrigation:

- Capital cost - the payback on the investment can be anything from 2-10 years depending on the amount of retrofitting which has had to take place
- Clogging of drippers by nutrients, bacteria and elements e.g., iron or bicarbonates in the water are a big problem. Use a filter and always look out for blocked drippers.
- This system is not flexible and is best used if pots/containers remain in place for many months
- Water dripping onto potting mixes has very little ability to spread sideways. Most of the wetting of the mix is caused by capillary rise from the perched water table created at the bottom of the container.

The most efficient irrigation methods are drip and sub-irrigation systems due to the precision of the drip and the lack of water wastage of sub-irrigation. When using these methods, the foliage isn't wet and so there is less potential for disease and damage. Water and fertiliser usage can decrease at least 50% compared to conventional systems (Smith and Lopes, 2010). There is also less environmental damage using these systems e.g., soil erosion and excess leaching of fertilisers, especially if trickle or other low-volume irrigation or low-pressure heads which produce large droplets are used. Another advantage is that fewer staff members are required for watering.

Activity 3.9 *Evaluate the irrigation systems at your workplace and list 2 things you would like to change and 2 things that are working well.*

What the experts say:

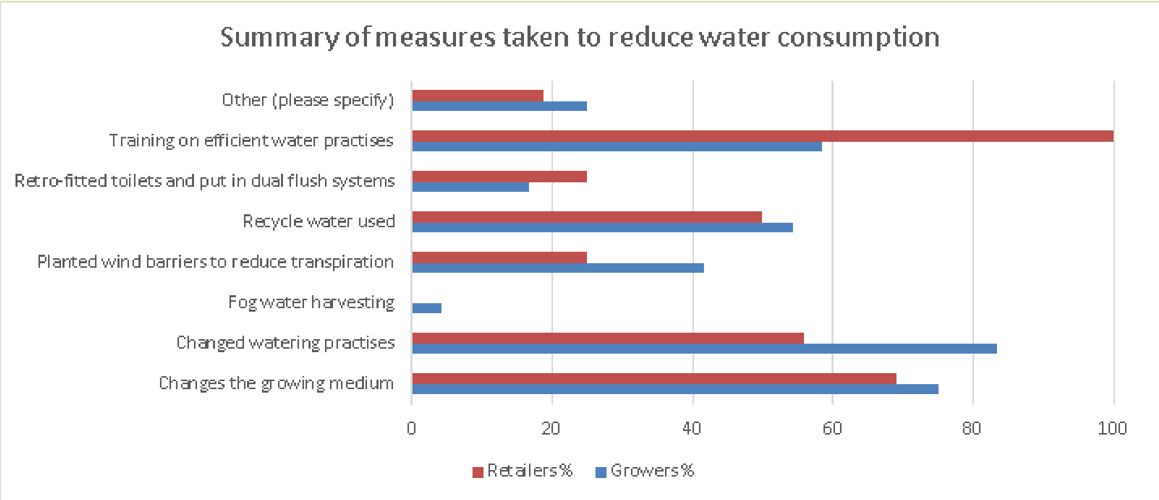
Irrigation: Drip irrigation (Business 1, 9, 20, 22, 24 and 32) and spot watering dry plants by hand

- Business 26 recorded that they had converted a section of plants in the nursery from overhead to drip irrigation and this *"reduced their water usage from 9000l/hr to 1200l/hr."*

- Business 28 suggested, *"replacing wasteful "old" irrigation systems with newer water saving options as well as drip irrigation"* because 97% of their watering is overhead.
- Business 28: "*actively monitor our irrigation system to prevent unnecessary and excessive water wastage*".

CASE STUDY RESULTS

The graph shows the percentage responses of growers and retailers surveyed during the 2021-2022 study of people in the ornamental horticulture business when asked what measure they have already taken to reduce water consumption.



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This graph shows that training, especially when using hand-watering, is essential as the retailers focus on it whereas the growers are changing their watering practices e.g., installing more drip irrigation and improving the water holding capacity of their growth media.

An interesting study was done in the Western cape during the drought, and it showed that a reduction of 50% in irrigation resulted in healthier plants and no loss of production (Bayer, 2018).

C: Maintenance

Good maintenance of all irrigation systems and checking for leaking pipes, taps, valves and fittings will help save water. A leaking tap or hole in the hosepipe wastes litres of water, while a nozzle or emitter not working can cause the dying of plants due to lack of water. Regularly clean filters and check irrigation nozzles. Check timer systems for accuracy especially during times of load shedding.

What the experts say:

Maintenance: ***"****good maintenance of all irrigation"* (Business 22) and checking for leaking pipes and taps.

- Business 26 stated that "making sure leaking taps and hoses are fixed as soon as possible" reduces water usage.

The maintenance was not only of the irrigation equipment and pumps and Business 17 mentioned using *"non-damaged pots"* saved water, and Business 30 said that *"Always have land cleared of any alien invasive species"* is also important to save water.

D: Scheduling

This is a no-cost or low-cost method of saving water that can reduce your water usage by 30%. Daily, the watering requirements of plants change according to weather, substrate, plant water use, whether they are in greenhouses, tunnels / shade-net sheds, precipitation rate and irrigation distribution, efficiency, and type.

How to use scheduling to conserve water:

- Use soil moisture sensors (e.g., tensiometers, neutron probes) and automatic irrigation systems
- Use rain gauges and local rainfall reports
- Determine daily evapotranspiration by using onsite weather stations, evaporative pans, or local sources. **Evapotranspiration** is the water loss from soils or medium which happens through evaporation from the soil surface and transpiration from the leaves. This process increases with sunshine, high temperatures, wind, and low relative humidity. High temperatures cause plants to 'shut down' to protect themselves from excessive water loss. The stomata close and prevent water loss.
- Visual and tactile inspection of soil for moisture content
- Always fine tune and confirm application schedule to production needs and water conservation goals.

Another type of scheduling is **cycled irrigation**, and this is done by some growers in South Africa, especially in the summer months. Cycled irrigation is when irrigation is used more frequently for short periods in a cyclic manner compared to the usual 30 minute per block intervals. When using cyclic irrigation, the wetting front of the water in the container moves a little deeper into the pot with each cycle eventually reaching the base of the container. Cyclic irrigation is preferred as the capillary action of the water moving through the growth media in a lateral manner gives better distribution of water throughout the pot, requiring 25% less water than overhead irrigation. The only downside of cyclic irrigation is ensuring that the water distribution from the nozzles is even.

What the experts say:

Scheduling: changing watering practices both frequency and times of day with the seasons, using timers for irrigation.

- Business 28 *"assesses rain patterns"*, while Business 9 documented *"using climatic conditions"* to determine watering schedule in the business.

This was further endorsed by other businesses which actually adhered to specific watering times for a limited amount of time e.g., Business 8: *"Only watering from 8 to 10 in summer and 8 to 11 in winter and all watering together so that pump is only on for a limited time".*

- Business 9: wrote about a “water demand management e.g., certain areas need less water and controller is set accordingly”.
- Business 31: “watering for 45 minutes via irrigation on a timer at 05:30 in the morning, run-off is channelled back into dam for reuse. Spot watering later if necessary”.
- Business 25 recommends *“computerising irrigation schedule”* to optimize water usage.
- Business 18 reduced watering by hand, reducing frequency of watering and having enclosed tanks rather than reservoirs or dams.
- Business 36 mentioned: “water plants early in the morning and irrigate plants not paths”.

E: Plant grouping

This involves the grouping of plants with similar water needs e.g., drought-tolerant plants into blocks or sections so they can be watered together. This is easier to do in garden-centre retailers compared to production nurseries. Hydro-zoning displays and labelling the water needs on plant labels should be done.

What the experts say:

Plant grouping: grouping plants with similar water needs e.g., drought tolerant plants. A few businesses do practice hydro-zoning in their display gardens (Business 13).

- Business 10, 28, 30, 33 “group plants of similar watering needs, so as not to be watering too much for one and too little for the other.

F: Water saving

1. Dams / reservoirs

The building of dams or reservoirs is usually essential to any horticultural business as there must be a reserve in case the borehole dries up and the taps run dry. These dams or reservoirs act as water storage areas, either collecting the water from the drainage channels, irrigation channels and flow of water due the gradient of the site, or it is pumped from boreholes, rivers and springs into the reservoirs.

Dam or reservoir covers are also important to prevent evaporation, contamination, and to save water.

2. Windbreaks

Many the growers have planted trees and hedges as windbreaks around their sheds and tunnels. Depending on the season, they also use plastic, frost cover, or shade-netting on the sides of the sheds and tunnels to prevent plant damage due to weather e.g., wind burn, frost, or sun damage.

3. ***GrowthKap, tree collars, dammetjies***

These are used more in landscaping than by growers and garden centres but are still water saving equipment which ensures that the water applied does not run away but is concentrated around the tree trunk.

4. ***Water saving bathroom equipment***

Dual-flush and sensor-based taps in the bathrooms and kitchen are also methods growers and garden centres are currently using to save water.

What the experts say:

Water saving: covering of reservoirs and dams to prevent evaporation and contamination, as done by Businesses 5, 6, 20, 23, 32, 36 and 38. Business 11 mentioned that their five dams were too big to cover (cost-wise) but they did have duckweed in them which did reduce the amount of evaporation from the water surface although it is an invasive species.

- Businesses 28, 36 and 37 use wind breaks e.g., hedging.
- Business 9 and 30 use water sensors to prevent overwatering.
- Business 34 has water saving toilets and taps (sensor-based).
- Business 14 *"introduced water wick system on plants"* to minimise watering of pots
- Business 40: *"installation of water tanks"* to reduce water usage.
- Business 30 wrote that they, "*measure water consumption continuously (we use apps such as "Hydrowise" from Hunter controllers – if water consumption goes outside of set parameters, immediate alerts are sent to our phones)"*

One example mentioned by Business 6 was "minimising bag size" to reduce watering. Business 28 also "changed their bag sizes, not only for watering reduction purposes but also for reduced growth media usage and easier and lighter for transportation e.g., they grow in an 8l instead of 10l and a 15l instead of 20l."

G: Recycling

The recycling and reuse of water within production nurseries and garden centre retailers is essential and this is done by having drainage channels wherever water might run and linking these together in a network to eventually flow into a dam where the water can be stored and reused.

The recirculation of nutrient water in closed-loop systems in production nurseries improves water use efficiency and reduces fertiliser usage. Like water harvesting, recycling of water also has the potential to be a great water saver but there is the risk that soluble salts, bits of organic matter, and diseases (for example, plant pathogens and bacteria) can be found in the reclaimed water. It is essential to test the quality, pH and EC before using it on your plants. It is for this reason that some growers and garden-centre retailers do recycle and harvest water, but they use it to water the garden beds and landscape rather than the plants they are growing and selling.

Within the OHISA, none of the members reported using grey water for irrigation purposes. Grey water is wastewater that is produced from baths, showers, and washing machines. It comes from household or office buildings and excludes sewage or water that contains oils. Water containing fats or fecal matter is known as black water and is generated from toilets, kitchen sinks and dishwashers. There are many products you can now add to grey water to make it safer to use to water your plants, but this is usually done in a home situation.

What the experts say:

Recycling: drainage channels and tunnels or sheds designed to catch run-off or excess water and feed back into system. Business 22 mentioned that this was one of best methods to save water. Business 6 recommended *"furrows to channel run-off water to catchment dam"* as was done by many businesses above to harvest rainwater.

- Business 5 suggested, "reusing wastewater (grey water) by installing a "BioBlue" sewerage plant which has filtration tanks above the ground".
- Business 40 also suggested *"using grey water – recycled sewerage water"* known as black water, as a water source, to reduce using potable water.

H: Training

In our industry watering is one of the most important jobs and the staff doing the watering, must be trained to water only when the plants need it. This knowledge should be shared with the consumers, too.

What the experts say:

Training: "*water only as needed"* stated Business 5.

The education of staff and customers is important and different businesses used various methods to do this:

- Business 34 *"via website and live screens in store".*
- Business 4 *"uses educational signage for customers and staff".*
- Business 27 said that *"as a new staff member enters the business water practices training takes place and it is re-enforced for all annually before summer."*
- Business 36*: "staff are trained to water efficiently"* and Business 20 also *"trained staff on good watering practises"*
- Business 17 documented that: *"staff know what water is needed through inhouse training and development."*
- Business 26 – *yes, we do training, 1 x per month with all watering employees".*

I: Additives

Depending on the quality of the water, some growers add acid or other additives to ensure the water is at the correct pH and quality to help the plants to grow.

What the experts say:

Additives: some businesses add products to their water or growth media to improve the absorption of water and minerals by the plants because a more favourable pH enables these processes to occur more easily

- Business 6 "adds ammonium sulphate to the growing media as the water used is too alkaline for the absorption of minerals by plants from the fertilizer" and for water saving.
- Business 17 and 36 adds "water retention granules to growing media".

- Business 26 stated that “adding air to water decreases phytophthora and fusarium and results in improved root growth of the plant and 25% better water usage of plant as a whole”.
- Business 11 documented that although they do not use additives to purify their water, they “planted aquatic plants to prevent silting and act as a filter to help purify water in their dams” which is working successfully.

Many businesses practice one or more of the water-saving ideas mentioned above, e.g., Business 3*: “water retention additives, drought resistant plants and covering dams to prevent evaporation.*”

Extensive information was provided over the last pages of the module about the different ways in which growers and garden-centre retailers are conserving water within their businesses. The information includes what should be done and why (the advantages and disadvantages of each method. This knowledge is very important for anyone wanting to change their practices to conserve water.

Planning changes in your business to conserve water

There are four important matters to consider as you start your planning, relating to WHY you are doing this.

- to minimize usage
- to reduce costs
- to create awareness
- to change behaviours towards water usage

Activity 3.10 ***Draw*** *up a WATER policy document for different parts of your nursery using the template on the next three pages to guide you.*

Changes to optimize water usage and savings								
Workplace strategies	Equipment needed	Methods to implement change	We could make a change	Our reason for changing				Cost
				To minimize usage	To reduce costs	To create awareness	To change our practices	
A - WATER HARVESTING								
Production / selling area	*Tanks*	Harvest rainwater						*Low*
	Concrete drains & channels	Capture runoff water						*Low*
	Gutters and downpipes	Collection of runoff water from green houses						*Medium*
	Drains	Harvesting rain and aircon water						*Low*
	Concrete drains and channels	Irrigation water harvesting						*Low*

	Channeling excess water into dams	Concrete growing areas & capture run-off						*Medium*
B – IRRIGATION								
Production / selling area		Drip irrigation						*High*
		Water by hand instead of overhead						*Low*
		Limit use of irrigation & use hosepipes instead						*None*
		Use of misting sprayers						*Medium*
		Only irrigate the plants and not the paths						*None*
		Hand water dry plants						*None*
C – MAINTENANCE								
Entire business		No leakage or breaks in pipes or taps tolerated						*Low*
Production / selling area		Good maintenance of all irrigation infrastructure						*Low*
		Actively monitor irrigation system to prevent wastage						*None*
		Check meter to find out if there are any leaks						*None*
Gardens		Use ponds that do not leak						*Low*
D – SCHEDULING								
Production / selling area		Water scheduling - time of day						*None*
		Water plants early in the morning						*Low*
		Daily checking of water - applied versus water drained from containers						*None*
		Irrigation on scheduled computer system						*Medium*
		Water at night in summer to prevent evaporation						*None*
		Frequency of watering						*None*
		Automation timers						*Medium*
		Everyone water at once						*None*
		Reduce watering times according to season						*None*
Water source		River, reservoir water pumped when needed						
E - PLANT GROUPING								
Producti on / selling		Group plants with similar needs						*None*
		Drought resistant plants						*Low*
		Aquatic plants do not require daily watering						*None*
Gardens		Practice hydro-zoning						*None*
F - WATER SAVING								
Offices, Kitchen and Bathrooms		Water saving toilets & taps (sensor-based)						*Medium*
Pr o d		Soil moisture probes used						*High*
		Use of shade netting to reduce transpiration						*Medium*

		Do not over water						*None*
		All hosepipes to be fitted with trigger nozzles						*Low*
		Wind breakers and trees						*Low*
		Sensors for over watering						*High*
		Exclude areas not under plants						*None*
		Plastic liners under plants						*Low*
		Flood tables						*High*
		Limit run-off						*None*
Production and selling areas	Growth media	Soil wetting agents						*Medium*
		Better quality substrate to reduce watering intervals						*Medium*
		Water retention additives						*Medium*
		Monitoring of soil types						*None*
		Add sand/topsoil						*Low*
		Minimize bag size						*Low*
		Coir growing medium						*Medium*
Water storage areas		Cover reservoirs and dams to prevent evaporation & contamination						*Medium*
		Aeration of water						*Medium*
Gardens		Limited display gardens & all water-wise						*Medium*
		Mulching after every landscaping						*Medium*
		Clear land of alien invasive plants which use ground water						*High*
Vehicles and delivery		Only use high pressure sprayers to wash machinery & equipment						*Low*
		Save water at all times						*None*
G – RECYCLING								
Gardens		Nursery water channeled into gardens						*Low*
		Do not water the lawns						*None*
Production or selling areas		Left over water flows back into river						*Low*
		Install tanks under gutters						*Medium*
		Re-using water from one area to another						*Medium*
Water storage areas		Recycle dam water						*Medium*
		Underground drainage system						*Medium*
		Furrows to dam						*Medium*
		Run-off water into dams not veld						*Medium*
H – TRAINING								
Production or selling areas		Supervision						*Medium*
		Education						*Medium*
		Merchandising to make watering efficient						*Low*
		Educational signage for staff & customers						*Medium*
		Water only as needed						*None*
I – ADDITITVES								
Water storage areas		Not to be forced to add chemicals to change pH						*Medium*

You are now ready to create your own water policy for your workplace to show how best you can conserve water and achieve SDG 6 (use the following table to help you as shown in Module 1 of the manual).

Activity 3.11 *You are now ready to create your own water policy for your workplace to show how best you can conserve water and achieve SDG 6 using this template to guide you*

	Production area of the Nursery	
Date	Business address	Contact details
Stakeholders and partners	*List those involved e.g., environmental officer:*	
Section on business	*List (e.g., admin, planting, selling, logistics, spraying etc.)*	

Purpose of document	
Relevant area in business	*List (e.g., Inside, outside, delivery bay, hothouse etc.)*
Document structure	Description of initial situation and problem
	Good practice being addressed
	Time schedule
	Risks to be addressed
Stakeholders and partners	*List those involved and benefitting from best practice implementation*
Methodological approach	*Describe business practices and process to be addressed and adapted*
Validation	Monitoring and recording changes both positive and negative
Impacts	Environment
	Economical
	Individual
Innovation	*List new technologies applied*
Success factors	
Constraints	
Lesson learned	
Targeted SD goals	
Repeatability and adaptability for other areas in business	
Conclusion	Impact and usefulness
Related websites	
Related resources	

Potential problems when trying to conserve water

When developing and applying a water-sustainability policy be aware they you may encounter obstacles along the way. Do not feel discouraged – others have also identified difficulties. Keep a positive attitude and try to find ways to overcome obstacles.

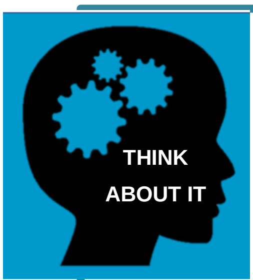
The case study showed some obstacles that were experienced by members of the OHISA in the 2021-2022 study.

CASE STUDY RESULTS

The three most frequently mentioned obstacles identified by the respondents in the 2021-2022 study of the ornamental horticultural industry when they tried to implement water sustainability practices in their businesses. They said these three factors reduced their business's ability to use water efficiently.

- costs,
- knowledge
- infrastructure.

Activity 3.12 ***Did*** *you have the same obstacles as others in the industry or were there new ones that are preventing you from using energy efficiently? List them.*



Why create a water-efficient business?

With South Africa's variable weather, there are periods of below-normal rainfall when drought conditions can occur. Droughts can be dangerous for commercial nursery operations particularly when they are combined with hot, dry, and/or windy weather that increases plant water needs. Furthermore, there is increased pressure on water sources during these periods when the water needs of non-agricultural uses increase as well.

Horticultural operations offer great potential for water conservation if the water demands of the plants being grown, sold, and planted are adhered to and not exceeded. Water is considered a finite resource, and one that the industry is dependent upon for the production, care, and sale of quality plants. Industry recognizes that managing water efficiently is a key driver to sound environmental performance and is committed to achieving improvements in water use efficiency across the whole country.

These best practice initiatives demonstrate that members of the horticultural industry are efficient and responsible water users and are willing to share their knowledge and improve their methods to become more efficient water users. The most efficient irrigation system would be ‘plant driven’ which supplies water at the correct time and at the right rate for the plant to use it.

Motivations for creating a water-efficient business include:

- Achieving a more resilient operation in terms of water shortages
- Conserving water which in turn saves other resources like fertilizer, energy, and manpower
- Promoting the horticultural industry as a good neighbour that conserves environmental resources
- Showing that the industry uses water as efficiently as possible during times when other users are being asked to conserve
- Promoting water sustainability within the business

All South Africans must participate in conserving and protecting this resource. The BMPs in this manual address the impact growers and garden centre retailers have on water quantity usage and will help the industry to use this resource more efficiently. This manual represents the industry’s commitment to do just that.

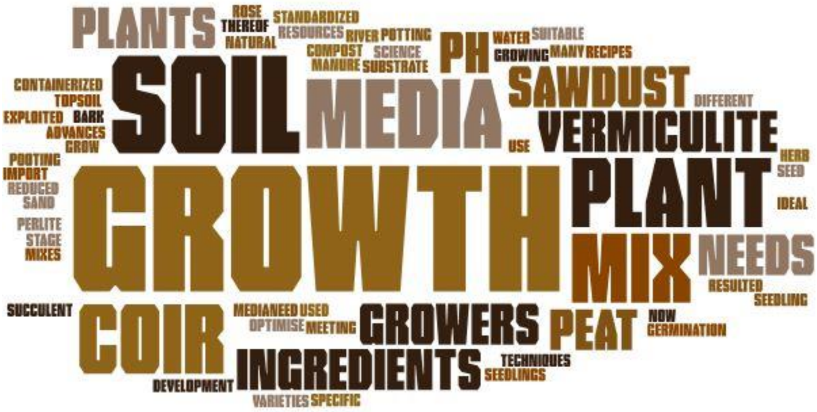
In conclusion, reducing the consumption of this natural resource has many benefits and the implementation of the various methods and technologies mentioned will not only improve the environmental footprint of the business but also its overall profitability.

WATER OUTCOMES checklist

	Become aware of the water use globally and the consequences of irresponsible water application and pollution	
	Gained knowledge about the water use within your workplace	
	Created a water use and conservation policy and a policy for preventing water pollution for the different parts of your workplace	
	Shared the policy with others for feedback	
	Implemented the policy and got more feedback	
	Created an opportunity for behaviour change within your workplace	
	Reduced the water-related input costs within your workplace	
	Improved your environmental footprint by responsible water use and conservation	
	Helped your fellow co-workers and peers become more environmentally friendly regarding water	
	Developed and applied a strategy to update policies annually to maintain environmental sustainability within your workplace	

Module 4:

Growth media sustainability



Save our soil!

INTERNATIONALLY (GLOBALLY)

Food security worldwide is being threatened. 95% of all food crops are grown in topsoil (The Guardian, 2019) and this is being lost through soil erosion or it becomes polluted and unsuitable to grow crops in. In 2008 it was already reported that globally we will have a fertile soil shortage (Penny Sleuth, 2008). Nine years later it was stated that in 60 years all topsoil could be gone globally (Semendo, 2017).

When plants decompose in wetlands or swampy areas, they form peat. It is a slow process (it takes about 10 years to form 1cm of peat) that happens more readily in moist, warm climates but peat bogs are also found in Ireland, Canada, Lithuania, and Scandinavia. Environmentally, peat bogs are essential to combat global warming as they absorb more carbon from the environment than they release (a carbon sink). However, they are being extracted (harvested) faster than they are forming because of their beneficial properties as a fuel source and a primary component of many different growth media formulations in the horticultural industry. In the United Kingdom there is a movement to ban peat sales by garden centre retailers by 2024, and for growers to stop using it as part of their growth media blend by 2028 (Barnes, 2022).

In agriculture, soil is essential for plant growth (Passioura, 2002), as it is for horticulture. But in horticulture there has been a transition from growing plants in soil to using more specialized growth media. This has resulted in the improved development and performance of the plant. Soil make-up for growers has become a science and, as the earliest people noted, certain plants grow better in certain types of soil. Improved mixes are now known as growth media or substrate development.

In Europe the growth media industry had a turnover of €1.3billion and provides 11000 people with jobs (2016)

The definition of soil aligns the relationship between soil, growth media and people and is highlighted in the *Revised World Soil Charter* (Food and Agriculture Organization of the United Nations, 2015), which promotes soil health productivity to ensure food security. This is illustrated in the diagram on the next page (Hatfield, Sauer and Cruse, 2017). Although soil isn't mentioned directly in the Sustainable Development Goals, its conservation and use as described by the *Soil Charter*, and the research and collaboration of soil scientists with other related disciplines is important to achieve some of the targets of the Sustainable Development Goals (Keesstra *et al.*, 2016):

- SDG 2 Improve the quality of land and soil to end hunger.
- Improve food nutrition and secure food availability by promoting sustainable agriculture (UN, 2019).

- SDG 11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage
- SDG 11.b Increase the number of cities and human settlements implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, and resilience to disasters
- SDG 12.2 By 2030, achieve the sustainable management and efficient use of natural resources e.g., soil and growth media components
- SDG 15.2 Promote sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally
- SDG 15.2.1 Progress towards sustainable forest management
- SDG 15.3. By 2030, combat desertification, restore degraded land and soil (including land affected by desertification, drought, and floods), and strive to achieve a land degradation-neutral world.

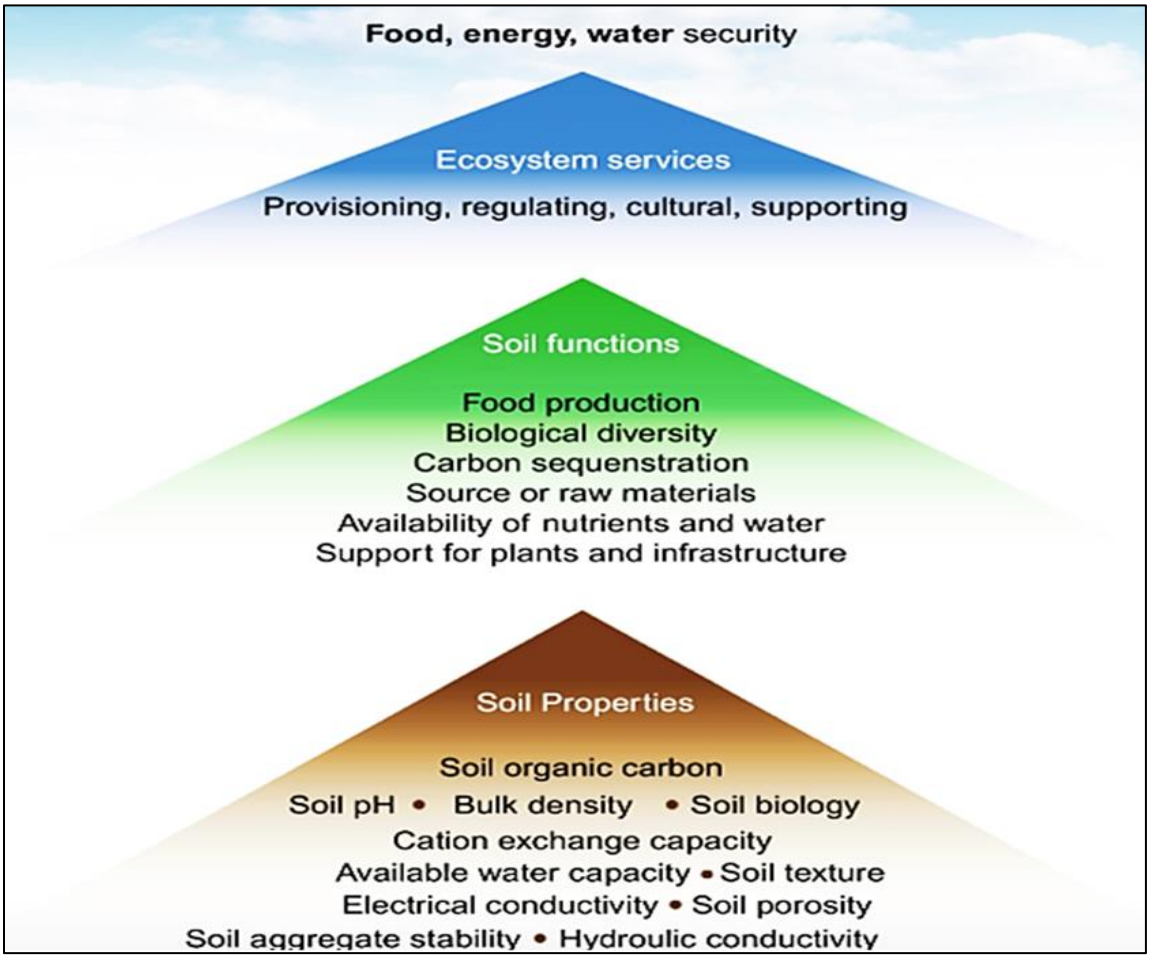


Figure 4.1: Interface of soil properties relative to soil functions and ecosystem services (Hatfield, Sauer and Cruse, 2017).

NATIONALLY: THE SOUTH AFRICA SITUATION

Is there a soil crisis in South Africa?

Yes ☐ No ☐ Unsure ☐

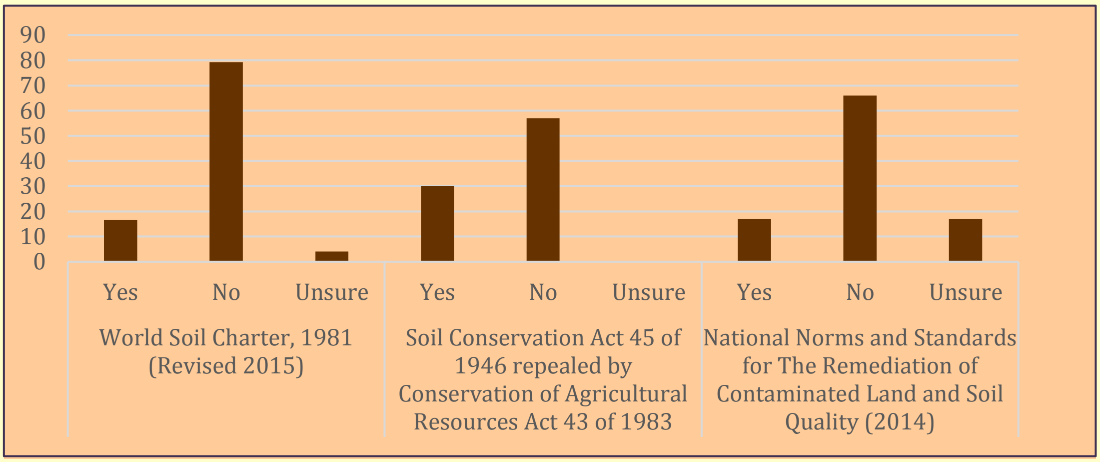
When it rains, how often do you see our rivers turn chocolate brown with soil being washed away into them. The soil is carried down the river and into dams and ultimately the sea where the blue water is changed to a muddy brown colour too. Have you seen the fields where there is now grass left and cows are still trying to graze or the damage the mines are causing to our grasslands? When we see the harvester turbines reaping crops, do you ever wonder if the farmer leaves a field fallow seasonally to allow it to recover from crop production or does he add more fertiliser and plant new crops to feed more people?

In South Africa, we have a serious problem of soil erosion due to flooding, destruction of wetlands and grasslands, urbanisation, unproductive agricultural practices, and poor veld management (overgrazing). Over 10% of the total land area was degraded in 2014 (Stats SA, 2019). The topsoil and soil sediments are ending up in the rivers and dams, which is contributing to our water crisis. The *Working for Land* project run by the *Department of Environmental Affairs* is addressing the land degradation problem by promoting sustainable land use and better conservation ethics.

INFORMATION BOX

CASE STUDY RESULTS

The 2021- 2022 research shows that more than 55% of the participating growers were not aware of the *Soil Charter, Soil Conservation Act 45 or the Norms and Standards* with regards to soil conservation and land rehabilitation, which is an opportunity for the industry to use these Acts and Standards to provide nature-based solutions and assist the Government in achieving sustainability.



The growers' knowledge of soil and growth media-related legislation and documentation

What is soil?

There are many definitions for soil and for the growing media used to produce ornamental horticultural plants. Growing media do not contain soil but as soil was the original substrate for growing it is necessary to understand it, to be able to understand growth media.

Definition 1: The soil layer is found between the atmosphere and the Earth's sub-surface. It is part of the lithosphere which provides a surface and substrate for human interactions and industries. It is also an essential component of the hydrological cycle. As described above, soil is formed from bedrock (parent material) through biological and other factors of weathering. If given enough time, soil layers (or horizons) form that have different physical and chemical properties. (Warrick, 2003).

Definition 2: '*Soil is comprised of a mixture of inorganic and organic matter, air, growth media and living organisms*' (Wallander, 2014).

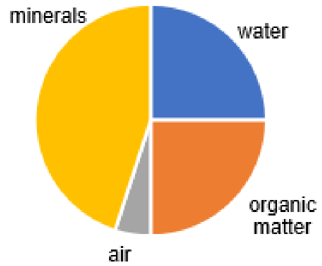
Definition 3: The nature of soil allows it to be a habitat for organisms including bacteria and fungi, a catcher for biological waste, a filter for poisonous substances and a storage place for nutrient-ions. As previously mentioned, soil is a product of its environment, but this definition highlights the importance of it as a component of it too (Binkley & Fisher, 2000).

The third definition highlights the beneficial properties of soil as can be found in Figure 4.1. This definition links the soil and human activity together. It highlights the importance of soil's ability to purify the surroundings by removing polluting residues and toxins and allowing for gaseous exchange (for example, by absorbing methane and nitrogen), which is also advantageous for humans (Smith et al., 2018). In this study, this definition will be used not only within the soil section of this the best practice manual but also in the organic waste management section, showing the beneficial properties the waste can have on soil properties and structure (Hossain, Fragstein and Niemsdorf, 2017) which can thus improve plant quality.

INFORMATION BOX

What is the difference between soil and growth medium?

	Soil	Growth medium / substrate (not soil)
Used where?	Large areas of crops usually edible or ex-open ground plants e.g., trees	Containerized, green house grown plants
Properties	Air pockets for root respiration, water transport and storage, nutrient provision and movement	Storage of air for roots water absorption and retention, supply nutrients to roots
Function	Anchor plants	Ideal rooting environment for plants to provide stability
Types	Sandy, loam, compost, and clay	Compost, potting soil, perlite, vermiculite, peat, bark, sawdust, horse manure, coir, sphagnum moss, rockwool, lecca clay balls etc.
Plants	General	Formulation (blend) often specific to plant varieties

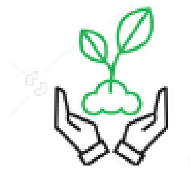


Like soil, a good growing medium consists of the following:

- Air spaces between the solid particles
- Mineral particles (the inorganic elements)
- Water (where nutrients are dissolved)
- Organic matter (decomposing living organisms and living organisms, bacteria, nematodes, and microbes)

Soil components https://content.ces.ncsu.edu/extension-gardener-handbook/1-soils-and-plant-nutrients

These components of growth media allow for the following functions:



- Gas exchange (oxygen and carbon dioxide)
- Creates a storage area for mineral nutrients
- Holds water which is then available to the plant
- Provides plant support

Activity 4.1 *Using the checklist below, rate the areas of your workplace where you could become more growth-media efficient (mark with a ✓).*

e.g. If your raw materials of growth media are exposed to elements & environment = **very poor**

If your growth media are kept in different areas on a concrete or plastic floor = **poor**

If your growth media are sealed in packaging until needed and then used as necessary = **fair**

If all growth media kept sealed until used and then kept on concrete flooring and kept damp to prevent loss and wastage = **good**

Growth media checklist					
	Not growth media efficient and needs	Have started to address growth media efficiency	Have a few growth media efficiency methods in	Growth media efficient within the constraints of	Yes, we have achieved sustainability
Areas of workplace which we have and are using growth media	**Very poor**	**Poor**	**Fair**	**Good**	**Excellent**
Growth media storage area					
Pot / bag filling area					
Seed sowing or planting area					
Plant dumping area					
Composting section					

Do you think we have a growth media crisis in South Africa?

Yes ☐ No ☐ Unsure ☐

Has your business ever experienced growth media shortages?

For example, if one of the ingredients for the growth medium-mix is missing; the peat got held up at the eThekwini Harbour; the truck broken down delivering the potting soil; the forestry mills were striking and so there was no bark; the farm producing the substates experienced a fire causing a lack of production. What effect does this have on your filling of pots and growing plants?

The South African growers mentioned that after water shortages, growth media was the second most important natural resource and if they could not get, it would be detrimental to their plant production.

In production nurseries the soil quality is becoming more and more important, as a good growing medium provides the plant's roots with water, air, and nutrients as they need it. In South Africa, the lack of standardized soil formulas which growers can depend on affects the production of plants, as growing media quality is one of the most important factors a grower must manage when growing ornamental plants in containers. It is for this reason some growers are now importing pre-formulated growing media from overseas to ensure uniformity in plant production. However, this increases the carbon footprint of the product. Similarly, for garden centre retailers, the importance of soil preparation before planting any plants in a garden must be stressed to each customer: the saying is: *"do not plant a R100-00 plant in R20-00 soil."*

INFORMATION BOX

Physical properties of a growing medium

- **AFP: Air filled porosity**
  - % of pores filled with air in a saturated substrate
  - Air filled porosity is the measure of the amount of air in a potting mix
  - Air filled porosity is influenced by the size and depth of a plant container
- **WHC: Water holding capacity**
  - A substrate's ability to hold water
  - It is the amount of pores of a substrate's total volume taken up with water
- **Bulk Density**
  - It is the weight of the medium per volume. The higher the bulk density, the heavier the medium will be, but fewer spaces will be available for air in the root area.
- **Shrinkage**
  - Media high in organic matter such as sawdust and bark can shrink dramatically due to the composting process that continues in the container during the cultivation period.
  - Shrinkage can be avoided by using stable media components like peat, coir, and perlite.
- **Wettability**
  - The ease with which mixes can be moistened varies and this can be a big problem in nurseries. Organic materials often used in potting mixes such as bark, sawdust and peat are hard to wet initially and very hard to rewet once they have dried out in pots.
  - Coir has an excellent wetting and rewetting ability. Adding coir to bark and peat mixes can help improve the wettability.

With regards to sustainability and growing media, certain soil components such as peat are no longer readily available. Some growers have evolved their growing media to include coir fibre for its excellent wetting and rewetting ability and its ability to increase the airflow porosity (information box below).

Environmental concerns related to growth media

The two main environmental challenges with regard to growth media are the impact of the products used in the growing mixes e.g., peat, perlite, topsoil and the transport of the growth media to site. The quality of the growth media is also important, and growers must determine the quality of the resources and environmental impact of the resources that they use as ingredients in their growth media recipes e.g., are they renewable like coconut pith (coir) and compost (Arpin and Maxime, 2010b; Peano *et al.*, 2012). It is recommended that growers carefully choose every ingredient of a growth mix based on its origin and how it was produced (Arpin and Maxime, 2010b). Garden centre retailers do not usually have to worry about growth media availability to produce plants but their organics sales e.g., compost, potting soil, mulch, bark, germination mix etc. makes up a large percentage of their overall sales and thus if there is a shortage, it affects their turnover. It should also be noted, (in the video with James Barnes (2022)), that peat sales to consumers should be discouraged.

INFORMATION BOX

Chemical properties of growing media

The chemical properties determine whether or not a plant's roots are exposed to the necessary nutrients in the correct concentration to promote growth.

These chemical properties include:

pH which **is important because it determines the solubility and availability of plant nutrients**

- pH is the measurement of acidity or of the hydrogen (H+ ion) concentration or activity.
- The pH scale ranges from 1 – 14 where a pH of 7 is neutral and a pH >7 is alkaline and a pH < 7 is acidic.
- The higher the H+ ion concentration is, the more acidic it is. The lower the H+ concentration the more alkaline it is.

EC: Electrical conductivity which is the measure of the amount of salts or nutrients in the mix which can be used by the plant.

- Does not tell you which nutrients are in the water/growing media

CEC: Cation exchange Capacity which is a substrate or medium's ability to hold and release positively charged plant nutrients such as Calcium, Magnesium, Potassium and Sodium.

- Soil organic matter or clay particles have negatively charged sites that attract and hold (adsorb) these positively charged plant nutrients. This helps prevent the nutrients being washed away when plants are watered.
- Cation Exchange Capacity is the measure of how many negatively charged sites are available in the substrate.
-

C:N Ratio: Carbon to nitrogen ratio - A high carbon to nitrogen ratio indicates that a medium tends to decompose quickly changing the physical properties e.g., decreasing the volume and aeration of the medium. It also takes nitrogen which should be used by the plant and instead the micro-organisms use it in the decomposition process. Sawdust and pine bark have a very high C:N ratio

The growth medium quality is affected by its chemical and physical properties which are detailed below:

Activity 4.2 *How have the growth media shortages in South Africa affected your workplace, if at all?*

____

____

____

____

Having already completed an awareness checklist with regards to growth media in your workplace, complete the table below to record which types of growth media are being used.

Activity 4.3 Please *indicate which type of growth media source you are using (You can mark more than one):*

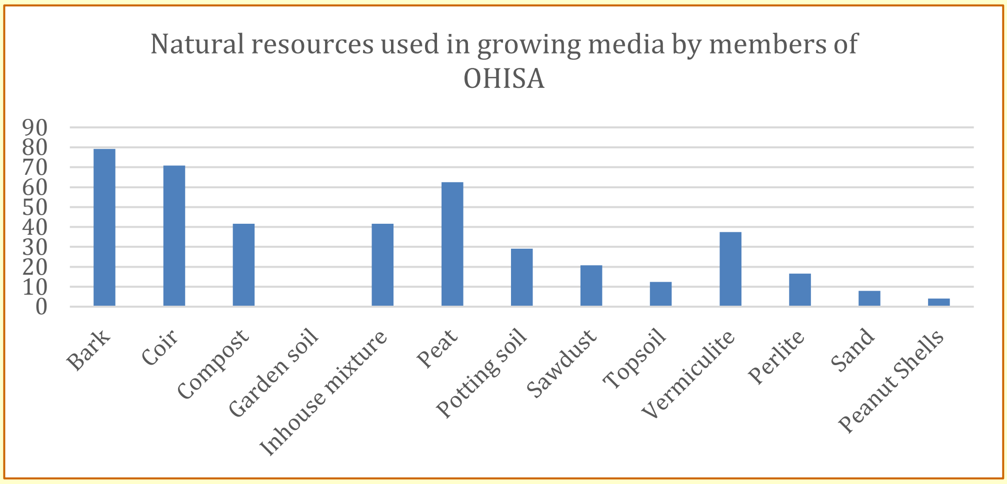
bark		inhouse mixture		sawdust,	
coir		peanut shells		topsoil	
compost		peat		vermiculite	
garden soil		perlite		other (specify)	
horse manure		potting soil		____________	

The components of various growth media

The physical, chemical, and biological properties of the primary components of some growth media ingredients are explained in this section. Horse manure, compost or potting soil are all aggregates of growth media and vary depending on their source.

CASE STUDY RESULTS

According to the research conducted in 2021-2022, the dominant growth media components used by growers in OHISA are bark, then coir, followed by peat.



INFORMATION BOX

Composted pine bark

This is a by-product of the timber industry. It is mainly made of *Pinus* species.

Chemical properties

- pH generally 5 – 6.5, it is acidic
- Low EC
- Fresh pine bark contains phenolic compounds, such as tannins, that are toxic to plants. The composting process removes these compounds.
- Bark aging in large, static heaps that may become anaerobic in the middle, produces organic acids in the heap, which are toxic to plants.
- Causes nitrogen fixation and pH downward drift, due to continuous decomposing process

Physical properties

- Unstable organic matter which keeps decomposing, which results in chemical and physical properties constantly changing.
- Very low water holding capacity
- Becomes water repellent when dry

Coir

This is the fibrous material of the coconut fruit. The short fibres and dust pith are suitable to be used as a growing media in horticulture. Coir is composed of millions of capillary micro-sponges that absorb and hold up to nine times its own weight in water.

Chemical properties

- Natural pH of 5.7 – 6.5
- Low alkalinity, low in bicarbonates
- Naturally high in sodium (N) and potassium (K) – must be leached out by washing with plain water or treat it with Calcium Nitrate (then it is called 'buffered coir')
- Naturally low in calcium (Ca)

Physical properties

- Homogenous material, it is just coir material with nothing else mixed into it.
- Consistent and uniform texture
- Holds moisture well
- Maintains air filled porosity AFP well (18 – 25%)
- No physical obstacles for root growth

Biological properties

- No weeds
- It is a stable organic material that does not decompose much further
- No pathogenic microbial life

Saw dust

The species of trees from which the sawdust is derived, largely determines its quality as a growing media. Saw dust is not a stable component. It decomposes rapidly, causing volume loss and loss of air-filled capacity. The microbes causing this decomposition have a high demand for soluble nitrogen. Very high applications of nitrogen fertilizer are necessary to ensure that plants receive their N requirement.

INFORMATION BOX

Peat

Peat is the partly decomposed remains of Sphagnum mosses, which grow in swampy areas. It is imported mainly from Europe, Lithuania, and Canada. Peats from different areas differ in physical and chemical properties. It is a highly porous material capable of holding large quantities of water and air.

The horticultural value of peat moss is due to the unique properties of the sphagnum cells. They are thin-walled cells with large cavities and their main aim is to absorb and transport water. An important characteristic of these cells is their lignified walls, built in the form of rings, spirals, which prevent them from collapsing when they become dry. This property continues long after the plant dies and forms peat. As water evaporates from the cells, air fills the pores, because the thickened walls do not collapse. Peat needs to be suitably moist to maintain optimum conditions of moisture and aeration for plant growth.

Chemical properties of peat

- Naturally low pH, 3.0 – 4.5
- No toxic properties
- Low EC
- Relatively high cation exchange capacity (CEC)

Physical properties of peat

- Stable structure
- No physical obstacles for root growth
- High pore volume, up to 96%, which gives it an excellent ability to hold water and air and nutrients
- Prevents leaching
- Poor rewetting ability once very dry

Biological properties of peat

- No weeds
- It is a stable organic material that does not decompose much further
- No pathogenic microbial life

Perlite

This is an extremely porous siliceous material which is produced by rapidly heating volcanic rock to temperatures around 1 200° C. It is a sterile medium. It is mainly used to aerate potting, rooting or germination mixes. It releases water quickly and allows air (oxygen) back into the root area.

Chemical properties

- pH 6 – 8.5

Physical properties

- It is very porous by nature and improves aeration
- It is very stable, it does not decompose or shrink

Vermiculite

Vermiculite is a flaky mineral which is crushed and graded to size before being rapidly heated to above 1 000° C. The particles expand to many times their original volume resulting in a light porous material. It usually is added to improve the water holding capacity of potting mixes. Vermiculite is also used to cover seed to help keep moisture levels around the seed constant during germination.

Chemical properties

- pH 6 - 9

Physical properties

- High water and nutrient holding capacity
- Tends to breakdown quickly, reducing the air-filled porosity.

Can you recycle growth media?

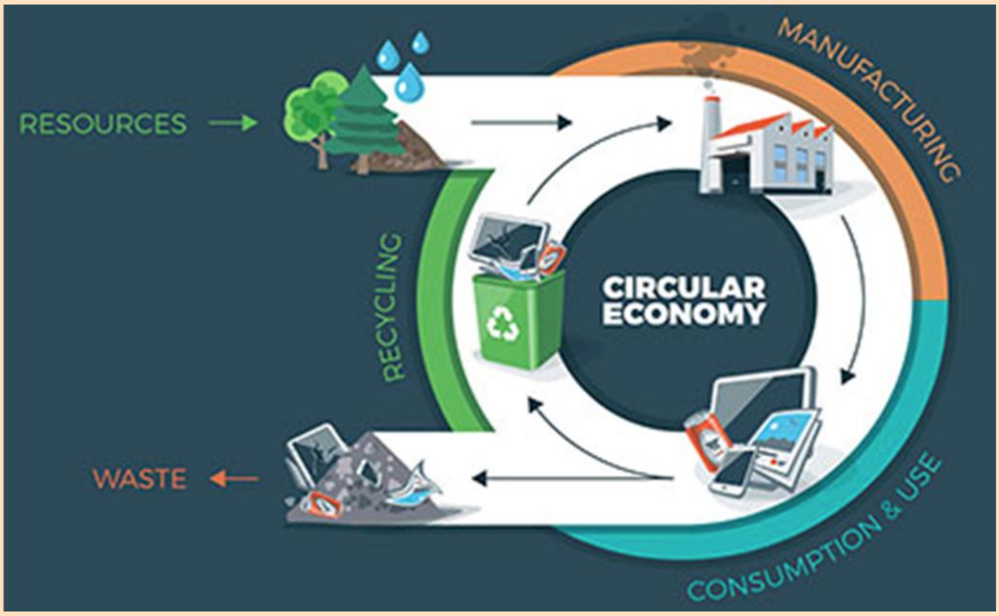
Activity 4.4 *Are any of the growth media components you use, by-products of other industries e.g., horse manure from stabling. LIST them.*

If you are, your workplace is contributing to part of a circular economy!

INFORMATION BOX

What is a circular economy you ask?

"An economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes." (Kirchherr, Reike and Hekkert, 2017). Each person can contribute towards it by eliminating waste, designing products for reuse, and reducing chemicals released into our environment allowing natural systems the opportunity to regenerate thus promoting sustainable development.



Diagrammatic representation of a circular economy (https://youmatter.world/en/definition/definitions-circular-economy-meaning-definition-benefits-barriers/) accessed 10 July 2022

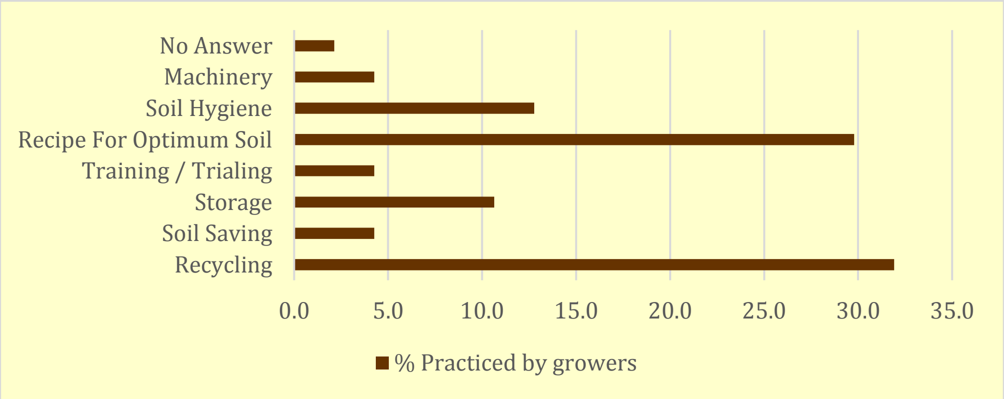
The recycling and reusing of growth media are recommended methods to reduce the environmental impact of harvesting or mining them as well as minimising the effects of transporting them, but it too has challenges. In the 2021-2022 study, the growers shared that growth media recipes for optimum growth media utilisation and recycling were the two predominant methods of utilising growth media efficiently (Figure 4). The recipes used for growth media formulations are often not only specific to a plant variety but also specific to a grower and hence why some of the policies would not want to be shared - it would be like sharing your family recipe for Chakalaka…not easily done!

Is your workplace recycling growth media?

Yes ☐ No ☐

CASE STUDY RESULTS

In research conducted in the ornamental horticultural industry, about 32% of growers say they do recycle their growth media.



Many growers stated how important growth medium is and say they have taken certain measures to ensure that it is used optimally (see graph above). To determine if these methods are being used successfully, it is important to measure and record expenses related to growth media and this too becomes part of the assessment of a policy.

The practices are applied to optimise growth media to either 1) wisely use that which they have and lessen the burden on the environment or 2) reduce the financial costs associated with growth media purchases.

Activity 4.5 *List 3 problems that your business faces with recycling growth media.*

____

____

____

Many of the growers, if they are recycling their growth media, do not use it again in containerized plants. Rather they recycle it into garden beds and landscapes. They also use it for the growing on of large shrubs and trees in bags where soil quality is not as important as in germination of seedlings, young plants, cuttings, or speciality plants.

CASE STUDY RESULTS

The respondents in the 2021- 2022 study of the ornamental horticultural industry identified the following difficulties when they tried to implement efficient growth media sourcing, use and conservation:

There were a few obstacles that some of the growers experienced with regards to growth media optimization. The examples of some are:

- Soil borne disease transfer e.g., *Phytophthora* – which is why soil hygiene is so important
- Soil sterilisation – no cost-effective methods in South Africa
- Supply and consistency of local growth media is inconsistent
- Weed control
- A lack of training on the different properties and benefits of the different substates to use
- The lack of facilities to cleanse recycled growth media *e.g., storage, soil mixing machine, steaming facility*
- Fluctuating exchange rate
- Wind – blowing the components away and causing air pollution
- Air and Water Pollution – the dust and loss in the water due to storms and erosion

These are some of the problems world experts have with recycling and reusing growth media:

- Sterilization of growth media - if you are going to reuse it for containerized plants you do not want diseases due to soil bacteria and pathogens to be transferred
- Weeds or seeds in the growth media being transferred to the new containers or into the gardens
- Organic material (plant material) not composted sufficiently taking extra nitrogen from the media which needs to be used by the new plants in the containers or gardens
- Some beneficial properties of the growth media are altered in the original plant growing process, making the recycled media less efficient e.g., particle size and absorption properties
- Solid waste materials found in recycled growth media e.g., labels, plastics

To complete the following exercise, you would have to access information from documents such as invoices and purchase orders etc.

Activity 4.6 *Determine the MONTHLY and ANNUAL costs of using growth media in your business, in rands:*

Worksheet Growth Media Costs													
Source of cost:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Cost (Rands)
Costs for growth media													
Bark													
Coir													
Compost													
Perlite													
Potting Soil													
Pre-Mixes													
Soil													
Vermiculite													
Other													
Invoices for transport													
Freight costs													
Import duties													
Local transport													
Other													

Now that you have a baseline to work from, you can list the changes that you can make to optimize growth media utilisation in your workplace using Activity 4.6 as a guide and then calculate your costs a year later and see if there is any difference. Do not forget to take into consideration the number of plants that your workplace produces using that growth media, as the more plants you produce, the more growth media you could need. This is why 26% of the growers mentioned they could not reduce their growth media quantity. Ideally you would work out a cost of growth media used per plant container e.g., 14cm pot or 20cm pot and see if you can reduce this cost – then you would really be using growth media efficiently!

Activity 4.7 *Indicate whether you could implement the following changes:*

Make changes to achieve the following

Minimize usage

Reduce costs

Create awareness and / or

Change behaviour towards growth media usage

Remember that you do not have to do all of this at once!

Worksheet Growth Media Implement change								
Areas of business	**Equipment**	**Methods to implement change**	**Can implement change**	**Objective of change**				**Type of change and cost**
				minimize usage	reduce costs	create awareness	change behaviour	
Storage area packaged or imported of growth media								
	Flooring	Concrete to prevent loss	✓			✓		Soil saving -low
	Flooring	Plastic sheeting						Soil saving - low
	Shed/building	Keep covered for protection						Soil saving - medium
	Packaging of growth media	Keep sealed and out of weather to prevent damage						Soil Hygiene - none
		Once opened use all						Soil saving - none
Other growth media storage	Allow space for easy access for delivery							Storage - none
	Wind proof by covering or putting in a protected area to prevent loss from wind and air pollution							Soil Hygiene - low
	Do not store near water sources in case leaching occurs polluting groundwater, river of borehole							Soil Hygiene - none

Worksheet Growth Media Implement change								
Areas of business	**Equipment**	**Methods to implement change**	**Can implement change**	**Objective of change**				**Type of change and cost**
				minimize usage	reduce costs	create awareness	change behaviour	

Soil mixing area								
	Flooring	Concrete to prevent loss						Soil saving -low
	Mixing machine and tools	Keep clean and sterilize after use						Soil Hygiene - low
	Service machine regularly to ensure in good working order							Training - low
	If using coir - fluff it out correctly and use according to recipe							Recipe for optimum growth media usage - medium
	Mix only the quantities you can need to fill the containers you can complete in that day							Soil saving -low
	Mix according to recipes both growth media components and quantities							Recipe for optimum growth media usage - medium
	Mix media according to the plant varieties you are sowing or planting							Recipe for optimum growth media usage - medium
Potting or container filling area								
	Clean machinery regularly							Machinery training - none
	Do not use wet growth media							
Propagation								
Seed sowing	Use the correct media							Training and trials
Cuttings area	Use the relevant growth media recipe for mix							Recipe for optimum growth media usage - low
Planting area	Keep growing media in piles on wheelbarrow or in containers							Soil saving and soil hygiene - low
Composting or recycling section								
	Separate growth media from vegetative plant material when dumping							Recycling - low
	Ensure that area has plastic or concrete flooring to prevent leaching in soil							Training - low
	Have facilities to sterilize growth media nearby to soil recycling area							Recycling - low
	Do not keep fresh or new growth media near growth media recycling area							Training - low

You are now ready to create your growth media policy document for your workplace and see how best you can conserve growth media and work toward achieving SDG 11 more specifically but the others too (use the following table to help you as shown in previous modules of the manual).

Activity 4.8 *Fill in the table below for the different parts of your workplace that use growth media*

Title	*Best Management Practice for GROWTH MEDIA USE in the production area of the nursery*	
Date	Business address	Contact details
Stakeholders and partners	*List those involved e.g., environmental officer:*	
Section on business	*List (e.g., admin, planting, selling, logistics, spraying etc.)*	
Type of document *(Tick the most relevant choice)*	☐ Worksheet ☐ Standard operating procedures ☐ Policies guidelines ☐ How to … (training guides)	☐ Review document (monitoring report) ☐ Information sheet ☐ Educational poster
Target Audience *(tick relevant boxes)*	☐ Worker ☐ Team leader ☐ Supervisor ☐ Manager	☐ Manager ☐ Workplace owner ☐ Other
Purpose of document		
Relevant area in business	*List (e.g., Inside, outside, delivery bay, hothouse etc.)*	
Document structure	Description of initial situation and problem	
	Good practice being addressed	
	Time schedule	
	Risks to be addressed	
Stakeholders and partners	*List those involved and benefitting from best practice implementation*	
Methodological approach	*Describe business practices and process to be addressed and adapted*	
Validation	Monitoring and recording changes both positive and negative	
Impacts	Environment	
	Economical	
	Individual	
Innovation	*List new technologies applied*	
Success factors		
Constraints		
Lesson learned		

Targeted SD goals	
Repeatability and adaptability for other areas in business	
Conclusion	*Impact and usefulness*
Contact details	
Related websites	
Related resources	

Activity 4.8 *List 3 obstacles your business might face when trying to use growth media efficiently.*

____

____

____

By applying methods to try and achieve the targets mentioned above, and by complying with the law, you will reduce your workplace's environmental risks with regards to growth media consumption, thus improving the conservation thereof and the environment.

Using the checklist, tick the boxes you feel that you have achieved for growth media after completing this module

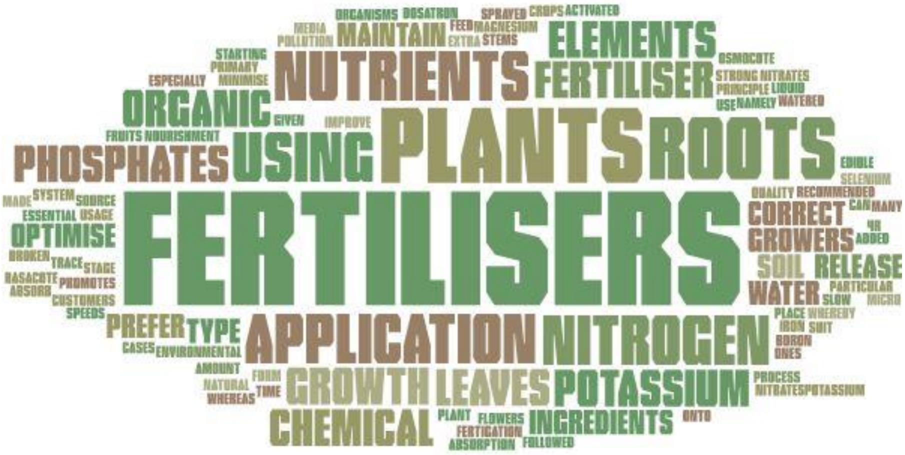
GROWTH MEDIA OUTCOMES checklist

	Became aware of the growth media crisis globally and the consequences of irresponsible growth media consumption and use of non-renewable growth media	
	Gained knowledge about the use of growth media within your workplace	
	Created a policy for the use of growth media for the different parts of your workplace	
	Shared the policy with others for feedback on if they can implement the practices required to fulfill the policy	

	Implemented the policy and got more feedback from the team of what works best it works within their areas	
	Created an opportunity for behaviour change within your workplace in terms of looking after the natural resource soil and not pollution it	
	Reduced the growth-media related input costs within your workplace	
	Improved your environmental footprint	
	Reduced your carbon footprint	
	Helped your fellow co-workers and peers become more environmentally friendly	
	Developed and applied a strategy to update growth media policies annually to maintain environmental sustainability within your workplace	

Module 5:

Nutrients and fertilizers



The use of fertilizers is essential in the growing of healthy plants as they contain vital nutrients and trace elements to stimulate growth of the plant and help maintain quality. As you learnt previously, our soils are not as fertile as they used to be, and many growers use specialised growth media for growing their specific plant varieties, adding nutrients to ensure a quality plant can be grown in the shortest time.

The fertilizer predicament

The predicament with fertilizers is the vast benefits they bring to agriculture and plant growers, but the serious consequences to the environment when they leach into soils and water supplies, especially when over-used.

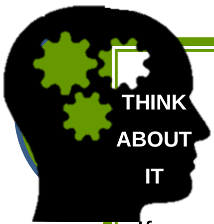
One the of greatest scientific advances was the formation of nitrogen-based fertilizers using the Haber-Bosch process, at the start of the 20th century. It resulted in record growth in the agricultural industry which helped feed a growing population and still assists farmers and growers throughout the world. But nitrogen, although essential to many facets on earth, in excess becomes a toxic pollutant affecting most aspects of the environment – life below the water (SDG 14), life on land (SDG 15), climate action (SDG13), responsible consumption and production (SDG 12), good health and well-being (SDG 3) and clean water and sanitation (SDG 6).

Nitrous oxide is one of the greenhouse gases released into the atmosphere from a variety of activities, such as agriculture, manufacturing, and industrialisation when fossil fuels are burnt, and during wastewater management. This contributes to climate change. The over-fertilisation of crops results in the leaching of fertilizer and this excess runoff ends up in rivers and dams, groundwater and soil which is extremely hazardous, especially to the freshwater and marine ecosystems, for example, causing algal blooms from eutrophication. The minuscule particles of ammonia elements (from fertilizers and those from exhaust fumes), cause serious air pollution that affects the respiratory systems of humans and animals causing an increase in sickness and disease.

Nitrogen isn't the only element which has the potential to cause problems due to excess fertilisation and use – potassium, sulphur, calcium, magnesium, and phosphate, although assisting plants become more productive, if over utilised will have detrimental environmental consequences.

Nutrient management of fertilisation of plant varieties requires skills to find a **balance** of the correct nutrients to ensure quality crop production but avoid using surplus which will then either be detrimental to the plant (for example, excess nitrogen in some crops can cause overly succulent plant tissues that may be more susceptible to disease, physical breakage and pest attacks) or leach out into the soil so that the fertilizers becoming environmental pollutants (Johnson, Magnifico and Obropta, 2013).

The solution is the correct use of fertilizer at the correct dosage to minimise environmental pollution and save costs. There are numerous ways to promote sustainable use of nutrients and increase soil fertility in agriculture without over fertilising. The use of organic fertilizers, minimal tillage of land, nature-based solutions (planting nitrogen-fixing plants such as legumes) and regenerative agricultural practices, can usually be applied to the ornamental horticultural industry too.



Are we over fertilizing our land?

Yes ☐ No ☐ Unsure ☐

If you are unsure, look at the dams and water bodies in the environment - do they have high levels of algae? This is a sure sign that there is an excess of nitrogen in the environment. It doesn't only come from fertilizers but also from people washing their clothes and sewerage in the water.

The fertilizer situation in South Africa

The important problems facing us in this country are summarised in the information box, and then discussed in more detail below that.

INFORMATION BOX

A number of fertilizer-related problems face anyone involved in agriculture or horticultural businesses.

- There is currently a fertilizer shortage, mainly because of the war between Russia and the Ukraine.
- The price has increased at least 78% since 2021 which makes it unavailable and unattainable to many farmers (Bourne, 2022) both in horticulture and agriculture.
- Many of the fertilizer suppliers had to dramatically increase their prices in 2022 and there were shortages of certain products.
- The expenses are reflected in rising costs in the ornamental horticultural industry.

Although the cost of fertilizer in Africa and South African has always been a limiting factor (which reduces usage) there are still the signs of nitrogen, phosphate and other elements in our water and soils. (Farmers Weekly, 11 April 2022 – Staff reporter). Synthetic fertilizers are often cheaper, making them more readily used in agriculture and by plant growers. In rural communities, where access to fertilizer is limited, nutrients for farming are obtained from organic sources such as manure and sewerage that, when used in excess, can still cause soil and water pollution.

Fertilizer-related legislation in South Africa

Fertilizers are expensive and can be dangerous to humans and animals. The storage, manufacturing, transport, and sale of fertilizers is highly regulated in terms of both Environmental legislation and policy as well as the *Occupational Health and Safety Act* and procedures. **These regulations are in place to protect humans and the environment.** For example, ammonium nitrate, which provides nitrogen and ammonia for plants, is produced using anhydrous ammonia gas that can explode when exposed to air.

It is important to be aware of the global recommendations but note that they are mirrored in the national legislations which regulates fertilizer importation, sale and use within South Africa. The wording of such acts shows the extent to which the attempt to regulate the situation:

> ***"Fertilizers, farm feeds, Agricultural Remedies and Stock Remedies Act 36 of 14****7: to provide for the appointment of a Registrar of Fertilizers, Farm Feeds and Agricultural Remedies; for the registration of fertilizers, farm feeds, agricultural remedies, stock remedies, sterilizing plants and pest control operators; to regulate or prohibit the importation, sale, acquisition, disposal or use of fertilizers, farm feeds, agricultural remedies and stock remedies; to provide for the designation of technical advisers and analysists; and to provide for matters incidental thereto."*

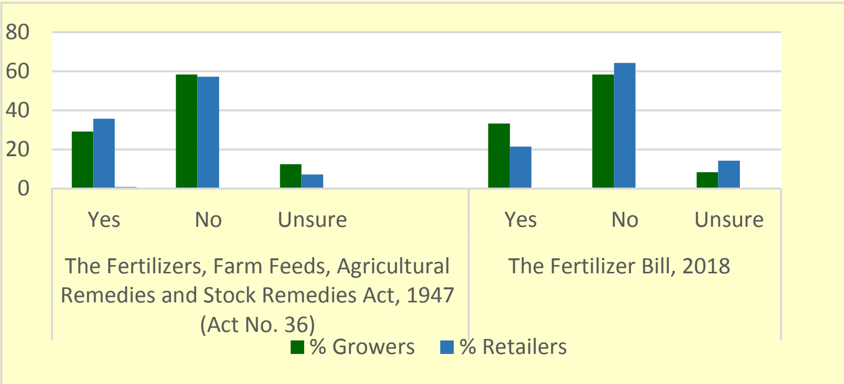
Following on from this, within the Act (Act 24 of 1977) which is relevant to the ornamental horticultural industry are the following regulatory statements:

> *"No person shall for reward or in the course of any substituted industry, trade or business - by section 8 of (i) use, or recommend the use of, any agricultural remedy or stock remedy for a purpose or in a manner other than that specified on the label, on a container thereof or described on such container; (ii) use any agricultural remedy unless he is a control operator registered in terms of this Act or otherwise than in the presence and under the supervision of a pest control operator so registered."*

The **Fertilizer Bill of 2018** is there to ensure the manufacturing of safe, good-quality fertilizers suitable for plant production and monitor the manufacturing of fertilizers to ensure that they play a critical role in food safety, human and environmental health, nutrition, and food security.'

CASE STUDY RESULTS

The 2021- 2022 research shows that the awareness of the *Fertilizer, Farm Feeds, Agricultural Remedies and Stock Remedies Act* is not well known by the growers and garden-centre retailers (more than 50% from both sectors said they did not know it) and they are even less aware of the *Fertilizer Bill.* But remember that a lack of awareness did not mean that they weren't practicing it in reality – as was noted during the on-site visits.



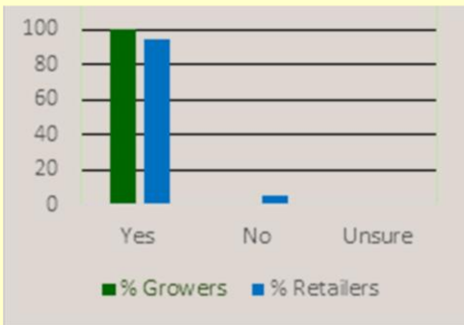
Use of fertilizers, and their advantages and disadvantages

Does your workplace use fertilizers?

Yes ☐ No ☐ Unsure ☐

CASE STUDY RESULTS

The 2021- 2022 research shows that show that 100% of the growers fertilise their plants so that they can ensure quality plants with a shelf-life on the retail floor. One of the garden centre retailers replied that they do not fertilise their plants as no plant should stay in their garden centre long enough for it to need feeding which is a sign of good retailing and that they stock plants which have a fast turn-around time.



If you do not use fertilizers in your workplace, you might still have to sell them and so the information in this best management practice is still relevant to you as you could share it with your customers to ensure that they follow good nutrient management practices.

Before we get started on the fertilizers, conduct an audit of your workplace, using the checklist in Activity 5.1. Take a walk through your workplace, and note where your fertilizer is being stored and used. This is information that you will need to complete the questions and tables in Activity 5.1

Activity 5.1 *Using the checklist below, rate the areas of your workplace where you could become more fertilizer efficient. Tick the relevant boxes.*

Fertilizers not in a shed, exposed to elements	=not efficient
Fertilizers in a storage room with a concrete floor	=slightly efficient
Fertilizers in a storage room with a concentrate floor on wooden pallets	=fair
Fertilizers in a storage room with concrete floors and metal or plastic shelving	=good
Following all the recommended methods	= excellent

Fertilizer Checklist					
	Not efficient (needs attention)	Slightly efficient	Improved efficiency but current average	Efficient within the constraints of the workplace	Using best practice
Areas of workplace which we have and are using fertilizer	**Very poor**	**Poor**	**Fair**	**Good**	**Excellent**
Storage area					
Mixing area or application area					
Equipment used for fertilizer application: Dosatron, irrigation etc.					
PPE Availability and Storage					
Excess fertilizer captured and maintained in a closed loop system					

Activity 5.2 *Correct each of the sentences by CROSSING OUT the incorrect option when a choice is provided (e.g.* ~~**increases**~~ **/ decreases***)*

Advantages (benefits)	Disadvantages (risks)
Produces a quality plant in a **faster / slower period**	**Increases / decreases** pollution - to air (nitrous oxide), soil (ammonia) and water (nitrogen causing algae bloom)
Decreases / increases crop yields reducing poverty	**Decreases / increases** soil fertility overtime if synthetic
Decreases / increases resistance to climate change	Contributes to / decreases greenhouse gases
Decreases / increases use of crop turn-around time therefore improving use of fields and time	Excess chemical fertilizers can be **beneficial / harmful** to human, animals, and eco-systems
Difficult / easy to transport and store	Plants can grow **too fast / too slowly**
Consistent quality and predictable / unpredictable yields	**Long term / short-term** rewards for long term damage if using synthetic fertilizer
Provide jobs / causes job losses	Organic fertilizer improves / degrades soil structure

Knowing what fertilizers to use when

You need to apply the 4R principles of nutrients, for best practice in this regard. These are explained in the information box.

INFORMATION BOX

The development of the best management practices for fertilizer was written in line with the sustainable development goals and 4R principles of nutrient stewardship recommended by the International Fertilizer Association.

These principles are:

- **Right source** – fertilizer meets the needs of the plants
- **Right rate** – the amount applied is the correct dosage for the plant
- **Right time** – the nutrients are made available to the plant when it needs them
- **Right place** – the nutrients are available from a place where the plant can utilize them (Reetz Jr., Heffer and Bruulsema, 2015). This is shown in Figure 5.1.

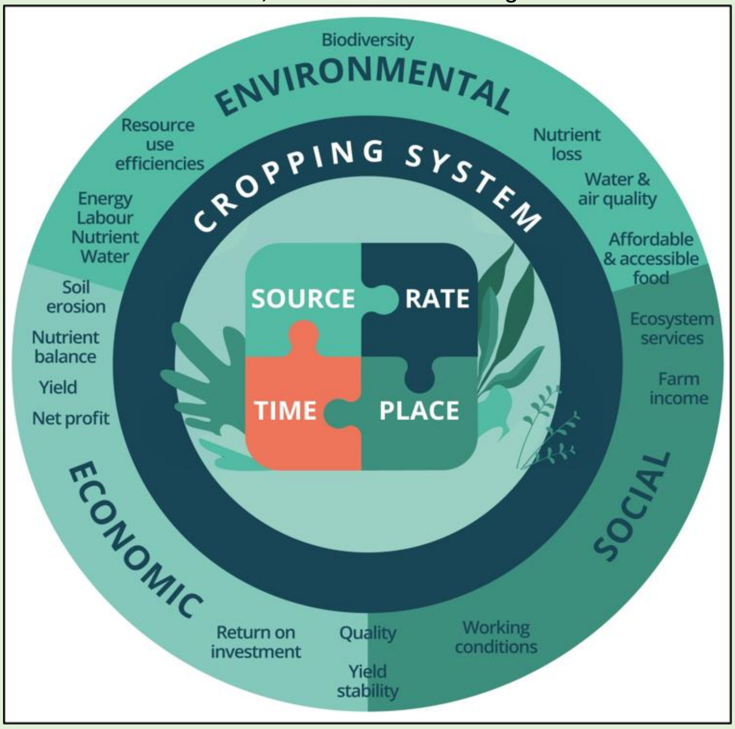


Figure 5.1: Adapted by author from: Performance indicators reflecting the social, economic, and environmental aspects of the performance of the cropping system. (IFA, 2009; IPNI, 2012. Adopted from Reetz Jr., Heffer and Bruulsema, (2015)

It is important that you know what to use and when, and that you have an understanding of what ingredients are in the fertilizers. The two information boxes of the next page give you useful information in this regard.

INFORMATION BOX

Beneficial properties of some of the chemical elements necessary for plant growth and signs of deficiency (the list below contains examples of functions and deficiencies.

Element	Function	Deficiency
Calcium (Ca)	Essential for cell wall formation and strength	Curled and distorted leaves
	Regulates transport of other nutrients into plant	Short roots
Magnesium (Mg)	Part of chlorophyll molecules	Interveinal chlorosis on older leaves
	Is a carrier involved in enzyme reactions and plant structures	Mature plants lose leaves
Nitrogen (N)	Crucial for plant growth	Bottom leaves turn pale green to yellow as new growth takes N away from older leaves
	Necessary for plant cell division	Weak stems
	Needed for photosynthesis	
Phosphorus (P)	Vital for energy transfer resulting in root, flower, seed, and fruit development	Stunts plant growth
	Stimulates quick growth	Reduces growth speed
Potassium (K)	Important for the functioning of stomata, thus water movement in plant	Slow growth
	Essential for photosynthesis as an enzyme activator	Chlorosis on leaf margin resulting in brown, burnt looking leaf edges
Sulphur (S)	Structural component of some amino acids	Slow growth
	Needed for Nitrogen fixation in legumes	Loss of green colour
	Contributes to taste and scent of plants	
Boron (B)	Necessary for cellular activities such as cell division, differentiation, maturation, respiration, and growth	Weak roots unable to provide a good anchor for the plant
	Pollen production	Discolouration
		Stunted growth
		Lack of buds and fruit
Cobalt (Co)	Needed for nitrogen fixation	Stunted growth seed germination
		Poor seed germination
Copper (Cu)	Essential for photosynthesis	Growth retarded
	Part of lignin (cell walls) development	Deformed younger leaves
		Necrosis of apical meristem
Iron (Fe)	Needed for synthesis of chlorophyll	Interveinal chlorosis on older leaves on young leaves, some even turning complete yellow
	Needed as an enzyme co-factor in plants	
Manganese (Mn)	Part of photosynthesis essential in building chloroplasts	Stunted growth
		Chlorosis on younger leaves
Molybdenum (Mo)	Cofactor to enzymes vital for building amino acids	Plants stunted
	Involved in Nitrogen metabolism	Pale leaves because of nitrogen deficiency
Silicon (Si)	Strengthens cell walls and improves plant health	Weak leaves, stems and roots
Zinc (Zn)	Component and activator of plant enzymes	New leaves curl
		Chlorosis between leaf veins
		Both leaves and flowers drop off before maturity

INFORMATION BOX

Fertilizers are vital for providing plants with readily available nutrients to improve their growth and resilience to climate changes thus increasing productivity of agricultural and horticultural products which contribute to human health especially as food sources.

There are 16 elements that are essential for healthy plant growth. These elements are also called plant nutrients, and they must be in diluted (in solution) around the root area of the plant to be able to be absorbed by the root hairs. The pH of the growing media is most important in determining if these elements can be taken up by the plant. There are two main groups:

	Macro Nutrients	**Micro Nutrients**
	Needed in large amounts	Needed in small amounts
Mineral nutrients	Nitrogen - N	Zinc -Zn
	Phosphorus - P	Iron – Fe
	Potassium - K	Manganese – Mn
	Calcium - Ca	Boron – B
	Magnesium - Mg	Molybdenum – Mo
	S, Sulphur	Copper – Cu
		Chlorine - Cl
Non-mineral nutrients Derived from air and water rather than soil nutrients	Carbon - C Oxygen - O Hydrogen – H	

Incorrect application use and application methods of these nutrients through fertilization is responsible for 2.5% of global greenhouse gas emissions and the leaching of excess nutrients from over fertilization can result in environmental problems such as a water pollution and soil contamination (International Fertilizer Association (IFA), 2021).

Activity 5.3: *Answer the following questions related to fertilizers within your workplace*

	Yes	No	Unsure
Do you have a fertilization programme?			
Are the fertilizers that you use all registered?			
Do your staff working with the fertilizers have any type of training?			
Formal			
Seta accredited			
Certificate			
Informal training			
Experience on the job for more than 3 years			
Do the suppliers of the fertilizers that you use offer training?			
Have you ever been on this training?			
Are your fertilizers stored safely:			
Away from sun and rain			
In a secure building, off the ground			
Out of reach of children and animals			
Do you wear PPE when working with and applying fertilizers			

Do you keep a record of all fertilizers stored and used?

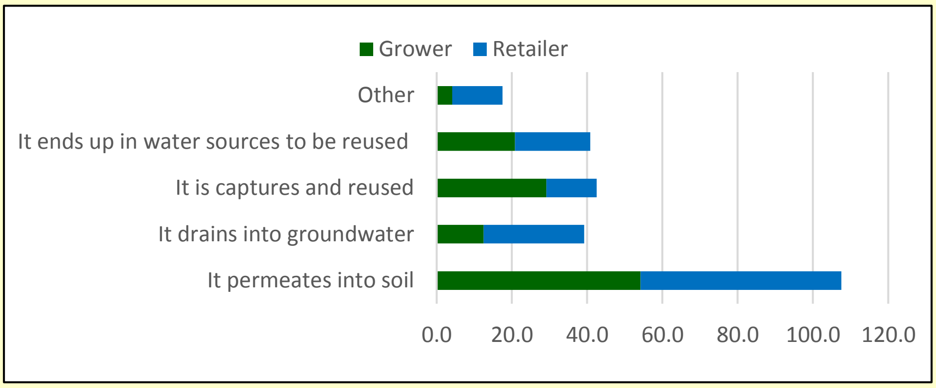
Are your fertilizer recipes plant variety specific?

As new technology enhances fertilizer application and specification, do you change your programmes accordingly?

Due the regulations associated with fertilizer and the importance that it plays in each of our workplaces, it is necessary to have a policy for it. The 2021-2022 research in OHISA showed that only 54% of growers and 27,5% of retailers in the sample have a policy (see case study results below).

CASE STUDY RESULTS

Apart from having a policy to adhere to regulations and ensure that fertilizers are used safely, the negative environmental impacts of poorly applied fertilizer and the resultant leaching should also be minimized. The results from the research (2021 – 2022) show what that the participants believe happens to their excess fertilizer.



This background illustrates the necessity for developing your own fertilizer policy that focuses on supplying the correct nutrients to the plants at the correct growth stages, and with little wastage. When you apply the policy, you will be helping to protect humans and the environment by working towards the following sustainable development goals:

The results shown in the cases study at the top of the page are concerning and as highlighted above under “the fertilizer predicament“ at the start of this module, **phosphorus** and **nitrogen** have the following effects on the environment if leached

- Phosphorus binds to elements in the soil e.g., iron and/or oxygen and then moves with the soil when erosion occurs into dams and rivers.
- It collects and causes eutrophication (an excess of nutrients), causing increased algal growth because of the rich supply of nutrients available.
- This reduces the amount of oxygen available to fish and other aquatic organisms, often resulting in their death.
- Phosphorus is a slow mover because it binds with elements in the soil, and if this happens in pots or where soil doesn’t move, it can build up, which can have a negative effect on the plant e.g., stunted growth.

Nitrogen moves easily through soils.

- Nitrogen, if not absorbed and used by plants as it moves through the soil, can end up in groundwater and can contaminate it.
- This in turn affects the drinking water (Johnson, Mangiafico and Obropta, 2011a).

- The excess use of nitrogen-based synthetic fertilizers can also release gases such as ammonia and nitrous oxide into the environment, which contribute to greenhouse gas emissions
- Affect biodiversity and cause eutrophication of in water systems resulting in algae blooms.
- This can negatively affect biodiversity.

This highlights the negative effects of fertilizers and the plant nutrients therein, if used incorrectly. So why do we use them? This is because of their benefits to the ornamental horticultural industry. Let us investigate some of the beneficial properties of the elements in fertilizers.

Let's have a look at your individual workplace and see where changes and savings can be made.

Having already completed the checklist of which areas in your workplace store and use fertilizer and whether you feel it was done efficiently, let's investigate which fertilizers you use and why?

Activity 5.4 Which *types of fertilizers do you use? Tick the relevant box.*

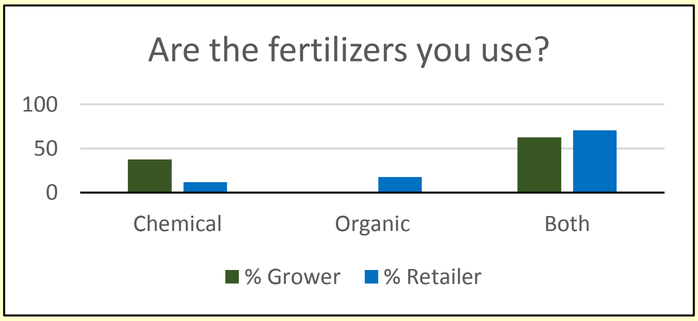
Chemical / synthetic	Organic	Both	Unsure

Chemical or inorganic fertilizers are industrially synthesized e.g., the following blended, water soluble ones which are easily absorbed by the plant and include two or more fertilizer salts and macronutrients: potassium nitrate (KNO3), calcium nitrate ($Ca(NO_3)_2$), mono-ammonium phosphate (MAP), ammonium nitrate, urea $CO(NH_2)_2$, ammonium sulphate (NH_3SO_4), magnesium sulphate ($MgSO_4$) and magnesium nitrate ($MgNo_4$).

Organic fertilizers are made from organic plant material and animal matter e.g., agricultural plant waste, manures, animal wastes and products such as bonemeal. The nutrient content, solubility and nutrient release rates are typically lower than inorganic fertilizers which results in variable nutrient content available to plants e.g., nitrogen and phosphorus, but mitigate the environmental problems caused by over-chemical fertilization on soil fertility. They also support and encourage beneficial soil micro-organisms.

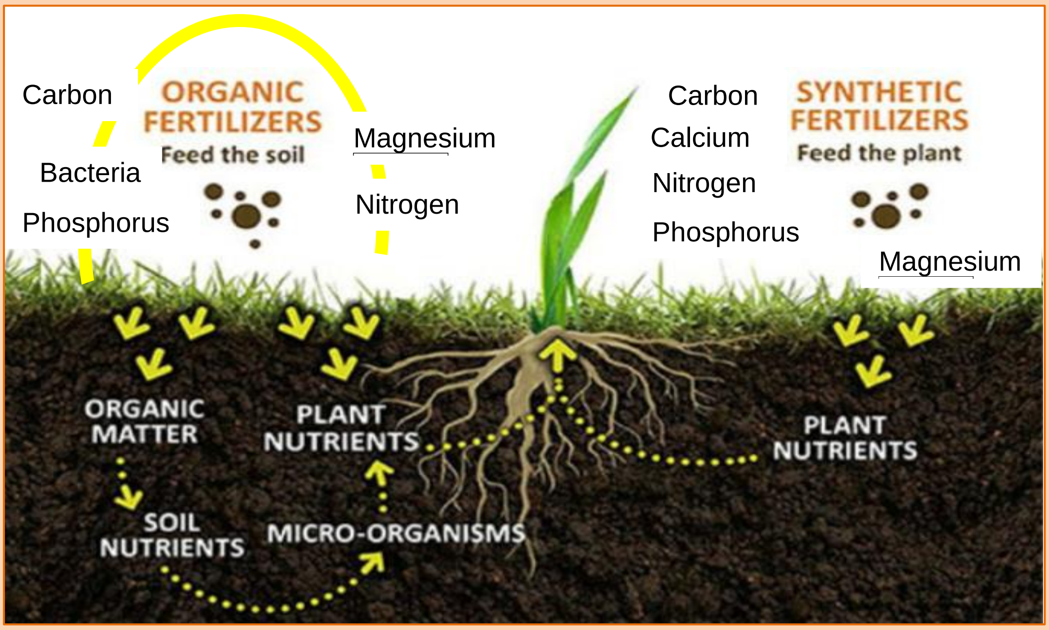
CASE STUDY RESULTS

From the research in 2021-2022, most of growers and garden centre retailers use a combination of organic based fertilizers with the chemical ones (Figure below). There are no growers in the sample who use only organic. There are a few retailers who use only organic.



The information box on the following page summarises the routes taken by the elements in organic and synthetic fertilizers as they pass through the soil and are taken up by plants,

INFORMATION BOX



Diagrammatic representation of how chemical (synthetic) and organic fertilisers work (https://www.fertilizer-machine.net/solution and market/fertilizer-affects-plants-grow.html) adapted by the author.

Organic fertilizers are part of the cyclic nature of the environment and that the bacteria break down the fertilizer into the elements and releases them into the soil for the plant to use – feeding the soil.

Chemical or synthetic fertilizers have the same elements but they are in a form that the plants can easily absorb them and so they work faster – feeding the plant.

These are just a few of the elements shown,

.

When developing a policy with regards to fertilizers, one starts with knowing the needs of the plants as well as the nutrients in the soil. The plant's needs are often supplied as cultural notes with the seeds or plugs of the plant and they have been determined by many trials under various growing conditions. They usually include the **ideal pH** (level of acidity), **EC** (electrical conductivity - a measure of the amount of nutrients available to the plant) and other **micronutrient specifications** which should be given to the growing plant.

A soil test is needed to determine the pH, EC, air-filled porosity and measures the various other nutrients within your growth media or soil sample. Soil tests should be done regularly.

All the information provided so far in the module is necessary before you can determine which fertilizer is best for your plants.

Activity 5.5 *Conducting a soil test.*

Have you ever done a soil test? (Circle your answer)

Yes No

1. **Take a soil sample** by collecting at least one liter of soil (you can use a clean, sterile yoghurt tub or ice-cream container).
2. **Use a calibrated pH/EC meter to test the soil. P**lace the clean probe into the soil and leave for a minute or two. The machine will then give some readings.
3. **Write down the results** in the table below.

	pH	**EC**	**Air-filled porosity**
Soil Sample 1 (from a garden bed)			
Growth media 1 (from a containerized plant)			

The following principles form the basis of a good fertilisation strategy to ensure healthy plant growth in container plant production:

- **Analyse the growing media:** know what the chemical and physical properties are. What is the pH, nitrogen draw-down, water holding capacity, EC?
- **Analyse the water quality:** know what the chemical properties are. Water contains plant nutrient elements, and the alkalinity influences the pH in the growing media.
- **Consider the crop specific nutritional needs**
- **Calculate a balanced fertilizer recipe:** considering the growing medium and water analysis results and crop nutritional needs (include all elements needed for healthy plant growth).
- **Never apply water without nutrients:** while plants are actively growing (at production nurseries)
- **Measure pH and EC regularly and keep records:** track the pH and EC levels on a graph.

The next important aspect of fertilizer usage is how to apply it to the plants. The application method affects the absorption of the nutrients by the plants but also the effect it could have on the plants e.g., if too much chemical fertilizer is applied too close to the stem it could potentially burn the plants as well as have a negative environmental impact.

Activity 5.6 *How do you apply the fertilizers you use to your plants? Tick the relevant boxes. You may tick more than one option. Please give an example of*

Method	✓	Example
By hand		
Liquid - (Dosatron or inline fertigation)		
Add to growing medium		
Foliar feed		
Other (specify		

CASE STUDY RESULTS

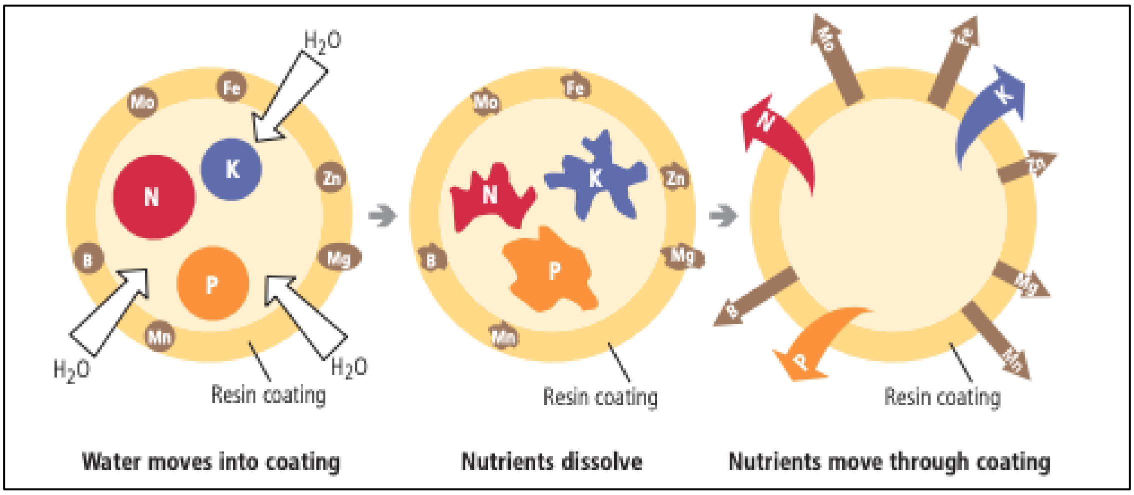
The participants of the research were asked how they applied their fertilizers, and the different methods they used. The preferences of the growers compared to the garden centre retailers were also determined.

As can be seen the results reflect the nature of the businesses:

83.3% of the growers add fertilizer into their growing media and from the interviews this is **usually a controlled release fertilizer** which will feed the containerised plants for four months.

75% of growers and 67% of the garden-centre retailers dilute their fertilizers and apply them via a fertigation method (for example, as a solution in the drip-irrigation or via a Dosatron) when watering their plants. A Dosatron works without electricity, using water pressure as the power source. The amount of concentrate is directly proportional to the volume of water entering the injector. Many organic fertilizers are ideal for this purpose as they come in a liquid form and easy to mix and apply.

- **The advantage of using a slow-release fertilizer in the growing mix:** The fertilizer is immediately in the root zone area. This method is usually used in conjunction with a balanced fertigation schedule. Controlled release fertilizers can also be applied by hand. Controlled release fertilizer is a coated NPK fertilizer that releases nitrogen, phosphate, and potassium and trace elements over a pre-chosen period of time. The nutrients encapsulated in the organic resin coating are protected from leaching and release only a little every day, shown in the following figure.



Mode of action of a coated/encapsulated controlled-release fertilizer (adapted from Trenkel, 2010 (Reetz Jr., Heffer and Bruulsema, 2015))

- The advantage of using a fertigation application: This is a very efficient way to use fertilizer and environmentally safer as small amounts of fertilizer are applied at a time, and as long as run-off, if any happens, is captured, then leaching using this method is minimised (Maxime *et al.*, 2014).
- A slow-release fertilizer is different, they are NPK formulations where only the nitrogen is in a slow-release form.
- Applying fertilizers by hand is done predominantly by garden centre retailers (87%) either by broadcasting the fertilizer on the soil surface of the container or side-dressing it closer to the root zone. It is labour intensive.
- **Foliar feeding:** is feeding when water soluble fertilizers are applied directly onto the leaves or fruits of horticultural crops.

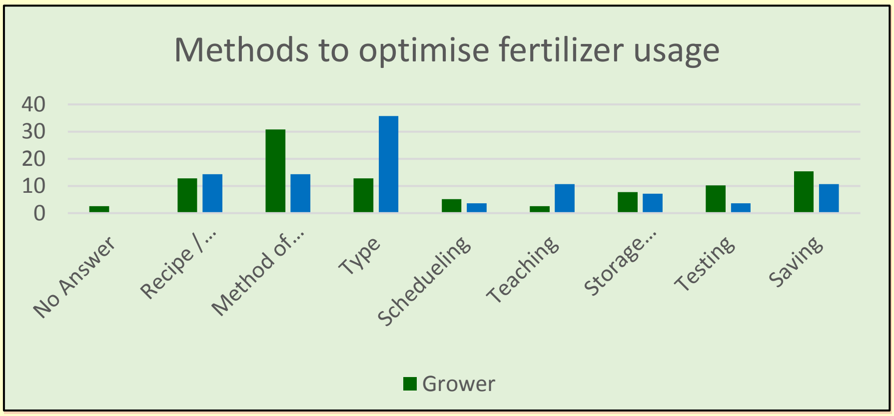
Before changes are made and you start writing a policy for fertilizer usage and determining where saving can be made, complete you need to have a record of costs. The spreadsheet in the following activity can be copied into a programme like Excel and completed every month. It can then be updated annually to determine if positive or negative changes have been made to the financial costs of this resource.

Activity 5.7 Determine *the ANNUAL cost of your fertilizer usage either in financial ways (cost in rands) or by usage (in kilograms). Complete the records each month.*

Worksheet 2 - Fertilizer Costs													
Date:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Cost (Rands)
Source of cost:													
Supplier invoices													
Equipment purchases for fertigation													
Maintenance invoices for equipment													
Training invoices for fertilizer use													
Other													

CASE STUDY RESULTS

These results from the 2021-2022 study show that there are numerous ways that growers and garden-centre retailers are conserving costs and protecting the environment by using fertilizer optimally.



One of the first responses was how the **choice of fertilizer is changing** and this is reflected in graph above. We saw earlier that more and more growers and garden centres are starting to use organic-based fertilizers in combination with the chemical ones. There were no growers in the sample who use only organic. There are a few retailers who use only organic, and this is usually manually done using a pelletised product making it easy to apply by hand.

There are many low-cost options to promote fertilizer saving and a move towards a sustainable fertilizer usage. The worksheet in the next activity (Activity 5.8) includes a list of fertilizer-saving ideas and methods being utilized by the members of OHISA in the sample.

Activity 5.8 Indicate *whether you could implement the following changes (yes / no) and then ticking the relevant boxes to show the 4R benefits*

The “4R’s of Nutrient Stewardship” will explain how their use will benefit you. You could complete this smaller table after you have completed the larger one starting on the next page.

Type of cost reduction		yes	no	By doing what?
	Minimize usage			
	Reduce costs			
	Create awareness			
	Change behaviour			

To complete this exercise, fill out the table starting on the next page.

Fertilizer changes to optimise usage and savings						
Method to implement change	Can we implement this change?	Objective of change				Cost
		Minimise usage	Reduce costs	Create awareness	Change behaviour	
Recipe and dosage						
Using the correct fertilizer, in the correct quantities or dilution rate depending on the application	Yes	✓			Training	*Low*
Using different nutrient recipes for different plant varieties						*Medium*
Using specific fertilizers for specific needs						*Medium*
Using a pre-mixed fertilizer						*Medium*
Method of application						
Mix correct amount of a controlled fertilizer into potting mix prior to planting to optimise absorption of nutrient						*Low*
Fertigation using drip irrigation, hand watering and/or a Dosatron						*Medium*
Manual application to prevent burning of plants						*Low*
Purchase pre-mixed growing media most suitable to plant varieties you are growing						*Medium*
Use efficiently and if cost allows look for models that do multiple containers using less manpower						*High*
Control dosage, quantity specific to plant variety						
Measuring pH and EC regularly to ensure dilution of inline and Dosatron correct						
Type						

High preference for organic and those that aren't currently using organic are starting to include it more and more, especially the garden centre retailers and at the correct dosage					*Training*	*Low*
Alternate monthly between chemical and organic						*Low*
Use only slow-release or controlled-release fertilizer						*Medium*
Use only organic on edibles and surrounding gardens						*Low*
Using pellet-based fertilizers to prevent spillage						*Low*
Using a seaweed conditioning throughout the year.						*Low*
Scheduling						
Have a spray programme in place						*Low*
Monitor use of fertilizers						*Medium*
Fertilise with knowledge of weather						*None*
Teaching						
Only supervisor decides which plants to be fertilised						*Low*
Training offered to staff on fertilizer application, dosage, and use						*Medium*
No harmful fertilizer used						*None*
Storage and Hygiene						
Use Personal Protective Equipment (PPE) when applying fertilizer						*Low*
Store in a dry space						*Low*
Clean tanks every second month						*Low*
Extra temporary staff employed to assist with weeding						*Low*
Do not spill and if you do clean it						*Medium*
Testing and Trials						
Use EC meter to see if more fertilizer is needed						*Medium*
Calibrate meters						*Low / None*
Measure pH and EC in the bag or pot						*None*
Savings						
Err on side of less						*None*
Determine needs of plants and only use as much as they need						*None*
By hand minimises use						*None*
Using better quality substrates (growth media) means less fertilizer is used						*Medium*
Reducing watering intervals conserves fertilizer in containers						*None*
Mulching to cover soil to reduce losses						*Low*

Activity 5.9 *List three obstacles that you have when using fertilizers in your workplace.*

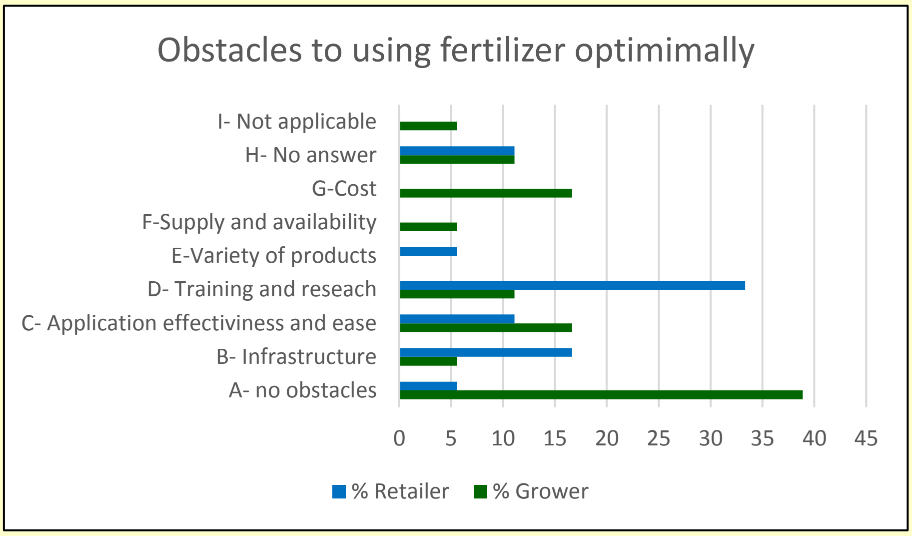
____

____

____

Are these like the obstacles listed below by the participants of the 2021-2022 case study?

CASE STUDY RESULTS



The obstacles that are preventing the sample from using fertilizer effectively are mentioned in the graph above. Most growers have no obstacles, but those that do, experience cost, application effectiveness and ease. It is interesting that the common obstacles are infrastructure, supply and availability of products, training and research, no obstacles and not answering the questions. For the garden centre retailers, the lack of training is an obstacle and similar to growers, the infrastructure and application of fertilizers.

You are now ready to create your fertilizer policy document for your workplace and see how best you can conserve fertilizer and work towards achieving a few of the sustainable development goals namely 3, 6, 7, 9, 12, 13, 17 listed on page 97. Use the next activity to help you, as shown in introductory module of the manual).

Activity 5.10: To develop a "best management practice" for your business. Fill in the following for the different parts of your workplace that use fertilizer (it is the same format as the one you have used for each module).

1.1.1.15

Title	*Best Management Practice policy for fertilizers and nutrient use within the production area of the nursery*	
Date	Business address	Contact details
Stakeholders and partners	*List those involved e.g., Environmental officer:*	
Section on business	*List (e.g., admin, planting, selling, logistics, spraying etc.)*	
Type of document *(Tick the most relevant choice)*	☐ Worksheet ☐ Standard operating procedures ☐ Policies guidelines ☐ How to … (training guides)	☐ Review document (monitoring report) ☐ Information sheet ☐ Educational poster
Target Audience *(tick relevant boxes)*	☐ Worker ☐ Team leader ☐ Supervisor ☐ Manager	☐ Manager ☐ Workplace owner ☐ Other
Purpose of document		
Relevant area in business	*List (e.g., Inside, outside, delivery bay, hothouse etc.)*	
Document structure	Description of initial situation and problem	
	Good practice being addressed	
	Time schedule	
	Risks to be addressed	
Stakeholders and partners	*List those involved and benefitting from best practice implementation*	
Methodological approach	*Describe business practices and process to be addressed and adapted*	
Validation	Monitoring and recording changes both positive and negative	
Impacts	Environment	
	Economical	
	Individual	
Innovation	*List new technologies applied*	
Success factors		
Constraints		
Lesson learned		
Targeted SD goals		
Repeatability and adaptability for other areas in business		
Conclusion	Impact and usefulness	

This is an opportunity for the relationship between the allied trade suppliers and garden centre retailers to offer more training in store to teach staff about the different fertilizers and the application thereof. Similarly, it is an opportunity for SANA to get involved with the tertiary institutions to do research into the use and application of fertilizers.

FERTILIZER OUTCOMES checklist

	Became aware of the fertilizer crisis globally and the consequences of irresponsible application of nutrients	
	Gained knowledge about the fertilizer use within your workplace	
	Created a policy concerning fertilizer use for the different parts of your workplace	
	Shared the policy with others for feedback	
	Implemented the policy and got more feedback	
	Created an opportunity for behaviour change within your workplace	
	Reduced the fertilizer-related input costs within your workplace	
	Improved your environmental footprint with regards to fertilizer use	
	Reduced your carbon footprint (decreasing nitrogen fertilizer usage and transport of fertilizers	
	Helped your fellow co-workers and peers become more environmentally friendly with regards to using and applying fertilizers	
	Developed and applied a strategy to update policies annually to maintain environmental sustainability within your workplace	

Module 6:

Pesticides: best management practices and

Royalty-free photographs in this module

The pesticide dilemma

A pest is considered to be "*Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products"* (FAO, 1990; revised FAO, 1995; IPPC, 1997). Pests can be viruses, bacteria, fungi, plants (for example, those we consider to be weeds), animals of many types, such as nematodes, insects, birds, reptiles, mammals (Dent, 1995). Sometimes these pests do not themselves cause the problem, but are *vectors* that carry the disease and transmit it from host to host. A range of different methods and mechanisms can be used to control or eliminate pests. Substances used to repel or destroy pests are known as *pesticides*.

Pesticides were increasingly relied on in the 1900s to protect animals and plants from destruction and disease. By the 1960s humans started to become aware of the associated risks they cause, and the resulting issue became known as "the pesticide dilemma". The benefits to humans of using pesticides are enormous, as without them there are immense crop losses due to disease and consumption by pests. However, side effects of the use of pesticides started to become obvious: 1) The pesticides themselves are toxic to humans and animals; 2) many pesticides are non-specific, killing other plants and animals that are beneficial to humans – e.g. wiping out bees and other pollinators that are essential for pollination and the development of all plant crops; and 3) the subsequent biodiversity and habitat loss because of pesticides being spread by air, and by leaching into the soil and water tables and into the rivers and dams. Furthermore, pests started developing a resistance to chemical pesticides, and are in danger of becoming "super-pests" immune to many pesticides.

International (global)

There is *"no such thing as a safe pesticide*" (Gerber, 2006), but the risks to humans and the environment are minimised by the use of an *integrated pest management* strategy (Johnson, Mangiafico and Obropta, 2011b). The benefits and disadvantages of pesticides are known globally, but undeveloped countries have suffered more from the disadvantages of uncontrolled use.

The quest of the ornamental horticultural industry to produce healthy, well-developed, quality plants to increase plant sales often results in the use of pesticides, particularly on the production side.

INFORMATION BOX

- Globally there are > 30,000 types of weeds,.3000 types of worms, and > 10000 types of insect pests (PesticideFacts.org)
- > 4 500 000 tons of pesticides are used worldwide each year (Alavanja, 2009)
- Pesticides have helped to triple crop production in the last 60 years.
- > 385 000 000 cases of unintentional pesticide poisoning globally a year, with about 11,000 fatalities (Boedecker et al, 2020)
- About 50% of insecticides were banned [2008-2018] due to tighter environmental controls (DEFRA, cited by Driskoll, 2020)

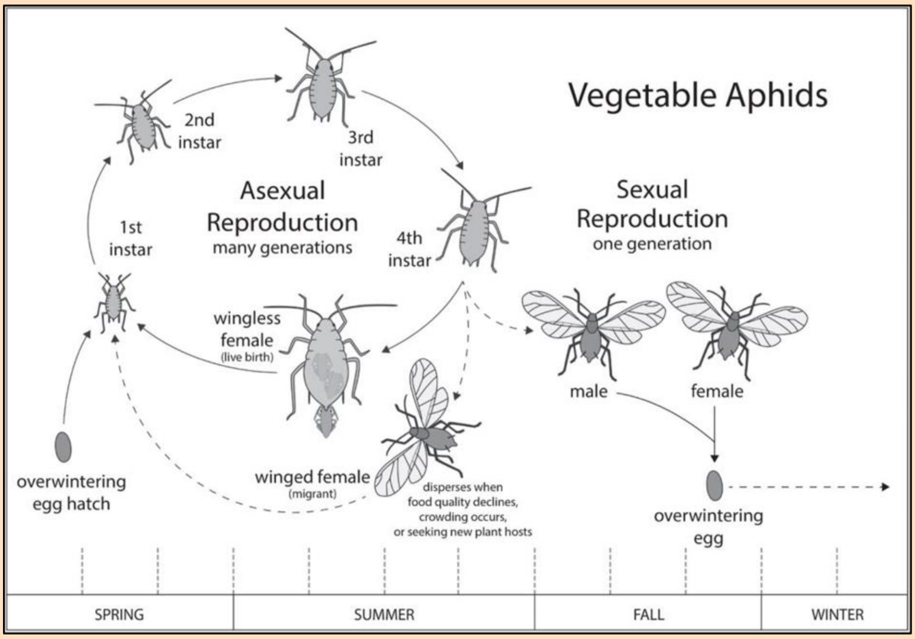
Nationally (OHISA)

The most common pests associated with ornamental plants in South Africa are: aphids, beetles, caterpillars, fungus gnats, grasshoppers, leaf-miners, slugs, scales, spider mites, thrips, and whitefly etc. These pests cause damage to ornamental plants, decreasing the plant health and value. They therefore need to be minimised within the greenhouses, tunnels, sheds, and sales areas. The best method to reduce pest destruction and grow healthy plants is to maintain hygienic sanitation processes and have good housekeeping practices within the vicinity of the plants. In addition, judicious (careful) use of pesticides is important.

Because of the potential risks associated with using pesticides, an awareness and knowledge of what they are and the "best practice" for using them is essential to anyone working in the ornamental horticultural industry. The following section gives a description of the most common pests encountered in ornamental horticulture in South Africa, the damage they cause and some information on how to control them. The diagrams of the life cycle of each are included to help with the *integrated pest management* which is discussed later in this module.

APHIDS

Aphids are very small, soft-bodied, pear shaped insects with piercing-sucking mouthparts. Aphids are usually green but can also be black, brown, pink, red or white. They may be winged or wingless.



Life cycle of aphid (***https://extension.usu.edu/pests/research/high-tunnel-pests-aphids***)

How they damage the plants

- Aphids feed on most plant parts and decrease the plants vigour and value. Aphids produce honeydew, which can cover leaves and flowers with a sticky layer. Either a sooty, black fungus (sooty mould) grows on the honeydew, or it attracts ants or both mould and ants occur on plant
- Aphids are important vectors (carriers) of numerous plant viruses.

Scouting methods

- Visual inspection or the use yellow sticky traps are used monitor aphid activity. Many aphids do not have wings, looking for colonies, white flakes of their shredded skin or plant damage is important.
- Look for sticky substance - honeydew
- Keep an eye open for ants.

Control methods

- Biological - introduce predatory pests or natural enemies e.g., specific lady beetles, specific lacewings, the aphid parasitic wasp and some praying mantis
- Mechanical - keep nursery areas weed free
- Nutrient control - manage nitrogen levels of fertilizing as high levels of N encourage aphid reproduction.
- Organic insecticides e.g., oils (neem, canola etc.) suffocate aphids but also beneficial insects too.
- Chemical - use a systemic pesticide and alternate with non -systemic pesticides

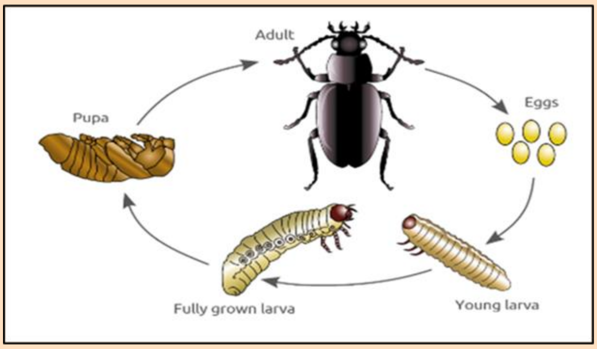
Aphids come in a variety of shapes and colours, and often exist in a symbiotic relationship with ants that care for them and “milk” them for their honeydew. They can be biologically controlled by ladybirds, which feed on them.






BEETLES

Adults have the front pair of wings hardened, forming a “shell”. The beetle feeds during its larval and adult stage.



Life cycle of a beetle *(**https://ahdb.org.uk/knowledge-library/identification-and-management-of-beetles-in-field-crops**)*

How they damage the plants

- Many adults cause severe flower and foliage damage through feeding. Beetles are important vectors (vectors) of numerous plant viruses.
- Some beetle species' larval stages feed on plant roots.

Scouting methods

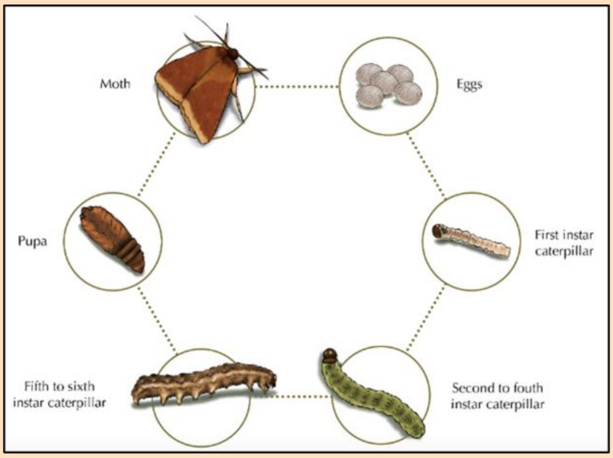
- Observation for beetles and damage caused

Control methods

- Adults can be killed by foliar sprays Mechanical - keep nursery areas weed free
- Most effective control is directed at the larvae on the soil by pesticide drenches Organic insecticides e.g., oils (neem, canola etc.) suffocate aphids but also beneficial insects too.
- biological control

CATERPILLARS

This group includes armyworms, leaf worms, cutworms, loopers and borers. The adults are dull-coloured moths that are generally active at night.



Life cycle of a caterpillar ***(https://www.syngentaornamentals.co.uk/caterpillar-life cycle)***

How they damage the plants

- Larvae (caterpillars) are destructive as the feed on leaves, buds, flowers, and growing points of plants. They usually bore circular holes through plant parts and apart from this damage, these holes are place for infection to take place. Some beetle species' larval stages feed on plant roots.

Scouting methods

- Look out for plant injury, feeding larvae, excrement (faeces) on leaves and 'windows' on foliage

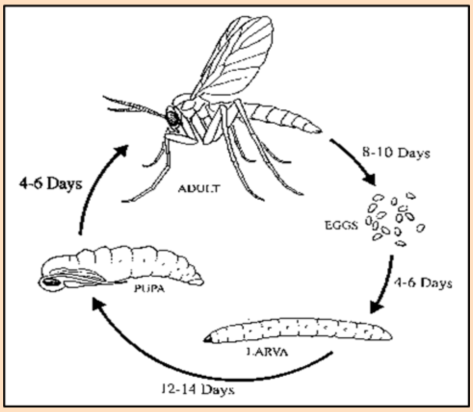
Control methods

- Biological control using Bacillus thuringiensis which is a bacterial disease sprayed onto plants into the evening and affects only caterpillars
- Mechanical - keeping moths away from plants using an insect barrier fabric Biological control.
- Chemical (deltamethrin) and organic pesticides. Spinosad and Pyrethrin work.

Caterpillars are usually the larval form of butterflies and moths, which later under-go metamorphosis.

FUNGUS GNATS

Adults are small, dusky, grey flies with long antennae which look similar to mosquitoes. They can fly considerable distances. Fungus gnats produce higher populations in growing media, which contain bark or manure.



Life cycle of Fungus gnat ***(**https://ag.umass.edu/greenhouse-floriculture/fact-sheets/fungus-gnats-shore-flies**)***

How they damage the plants

- Larvae feed on organic matter and fungi in soil but can also chew on plant roots

Scouting methods

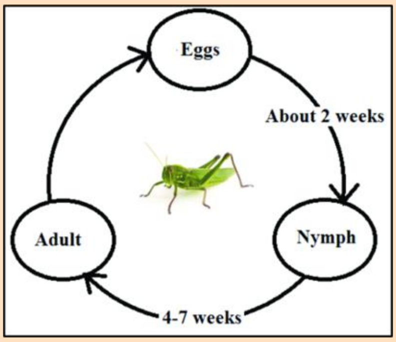
- Fungus gnats can be seen flying or walking near growing medium surface. They are attracted to yellow sticky traps. Larvae can only be seen around the root area.

Control methods

- Mechanical - remove excess moisture from growing media. Avoid overwatering or excess organic matter near production area
- Most pesticides, both chemical applications (Pyrethrin or Pyrethroids) and biological control (e.g., *Bacillus thuringiensis* sub-species Israelensis [Bti]), applications are aimed

GRASSHOPPERS

Grasshoppers have chewing mouthparts and can eat a whole plant or specific parts of a plant.



Life cycle of grasshopper *(Ullah and Hussain, 2019)*

How they damage the plants

- Feed on foliage causing defoliation

Scouting methods

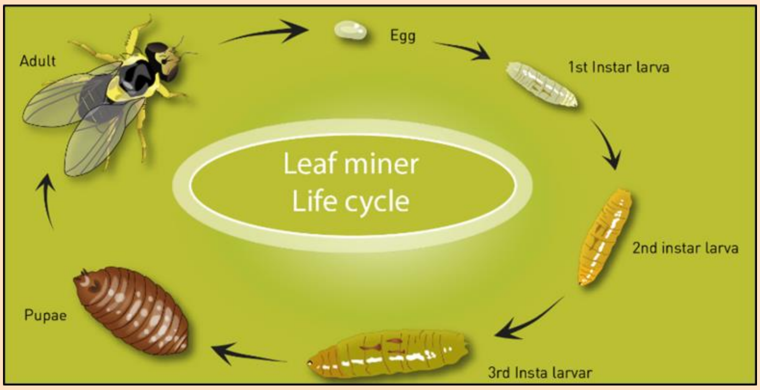
- Visual inspection and looking for damage

Control methods

- Keep these large insects out of greenhouses using screens on vents or intake fans

LEAF MINERS

Leaf miner adults are small, grey-black flies with yellow marking. The female pierces the leaves to suck out the plant sap and lays her eggs in the leaf tissue. Females lay hundreds of eggs, which hatch into larvae within 4 – 5 days.



Life cycle of a leaf miner *((https://biobee.co.za/pests/leafminer/leaf-miner-life cycle/)*

How they damage the plants

- Leaves are damaged by puncture (small whitish dots) made by female and the larvae feed within the leaves, forming narrow trails or mines.
- These mines decrease the plant's ability to photosynthesise.

Scouting methods

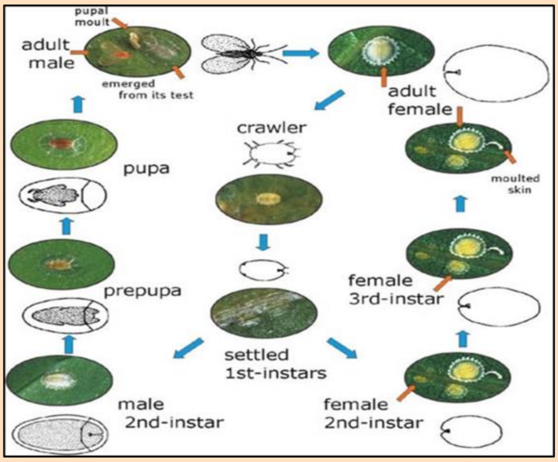
- Inspect plants regularly for punctures or mines in foliage. Use yellow sticky traps to monitor the population.

Control methods

- Use screens to reduce leaf miner invasions or movement between crops
- Chemical control - Mercaptothion (Organophosphate)
- Organic control - Spinosad or pyrethrin
- Biological control - *Diglyphus is* an ectoparasitic wasp used

SCALE INSECTS

Scale female insects are circular, wingless, sucking insects which lack separate body parts. Males are tiny and rarely seen. There are three main groups of scale: armoured scale, soft scale, and mealybugs. Armoured scales: adults have hard, waxy cover over their bodies, the covering can be separated from the body. Adult males can fly. Soft scales: form an armoured scale which can't be separated from the body, when mature. Mealybugs: are soft-bodied insects with a waxy powder over their bodies.



Life cycle of a scale insect *(*https://www.landcareresearch.co.nz/discover-our-research/biodiversity/plants-invertebrates-fungi-and-bacteria/invertebrate-systematics/scale-insects/life cycle/*)*

How they damage the plants

- High populations of scale insects weaken and kill plants.
- Chlorosis and leaf drop can occur.
- Scale insects excrete honeydew, which covers leaves with a sticky coating. A black sooty fungus can grow on the honeydew.

Scouting methods

- Visually check plants for little round bumps especially on stems of woody shrubs
- Sticky traps can be used to attract crawlers
- Look for sticky honeydew and ants
- Mealybugs look like small pieces of cotton on the plant

Control methods

- Biological control - predatory parasitic wasps e.g., *Aphytis, Coccophagus, Encarsia*, and *Metaphycus* or ladybugs e.g., *Chilocorus, Hyperaspis*
- Contact pesticides e.g., oil-based pesticides work well when sprayed at regular intervals
- Systemic insecticides are usually not effective because infestations occur on older woody plants
- Chemical pesticides: such as Cypermethrin (Pyrethroid) which is also a contact pesticide



SLUGS AND SNAILS

Slugs are snails without shells. They are generally active at night and found in moist areas, beneath plants, shrubs, trays, and pots.

How they damage the plants

- They eat irregular holes on foliage and can strip plants of their leaves.

Scouting methods

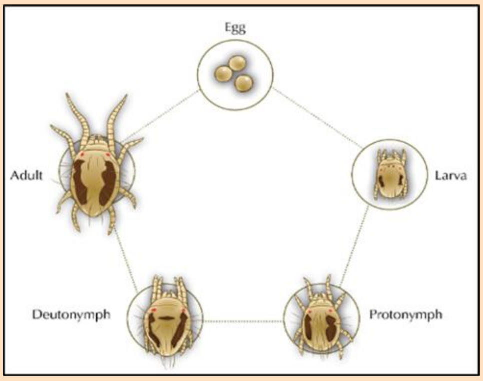
- Observation of actual pests or the slime trails that they leave

Control methods

- Ensure you have good sanitation practices near production and plant sales areas

SPIDER MITES

Spider mites are very small, about 0.5mm long. They can be reddish, yellow, green, or straw brown and black. High populations occur on dry, moisture stressed plants.



Life cycle of a Spider mite (*https://www.syngentaornamentals.co.uk/spider-mite-life cycle/*)

How they damage the plants

- Spider mites occur on the underside of leaves and suck the cell sap of the plants, removing the chlorophyll, resulting in yellow leaves and stunted growth.
- They can result in flowers losing their intense colour

Scouting methods

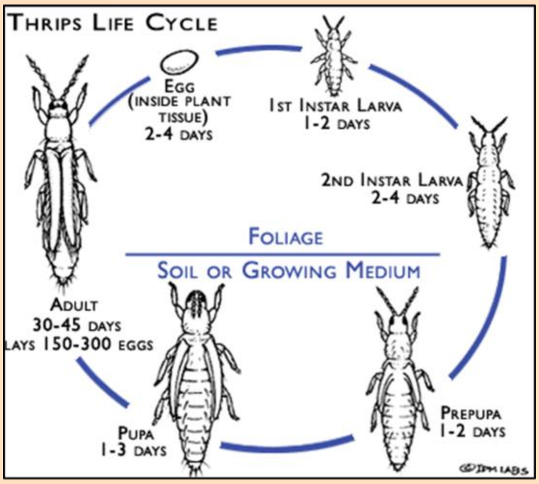
- Look for minute red dots on the underside of leaves and webbing
- Shake the plant with a piece of white paper beneath and mites begin to move, and some might fall onto paper

Control methods

- Biological control - *Galendromus occidentalis*, and *Phytoseiulus* predatory mites. Other predators include spider mite destroyer lady beetle (*Stethorus picipes*), the larvae of specific flies including the *cecidomyid Feltiella acarivora* and various bugs e.g., minute pirate bugs, bigeyed bugs, and lacewing larvae.
- Good sanitation e.g., areas weed free and clothing clean as mites can spread on clothing
- Keep leaves moist and tunnels and selling areas dust free
- Chemical - use insecticidal soaps and oils e.g., neem oil. Sulphur is also effective

THRIPS

Thrips are tiny, narrow, about 1mm wide, few millimetres long and vary in colour. Adults have fringed wings, but they are weak flyers and instead are transported via wind currents, growth media, plant material and equipment.



Life cycle of a thrip *(https://www.ipmlabs.com/thrips-damage/)*

How they damage the plants

- Thrips larvae feed on developing leaves and flowers, this causes the leaves to be distorted and flowers not to open.

Scouting methods

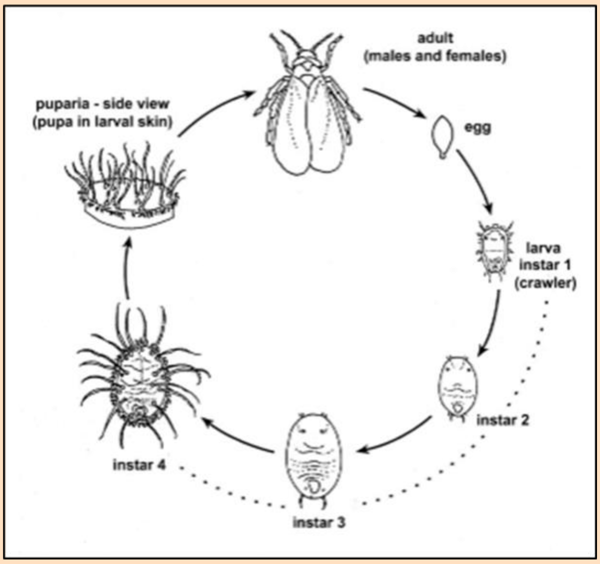
- It is very difficult to see thrips on plants. When the damage on leaves and flowers can be seen, the thrips are usually not there anymore.

Control methods

- Sanitation is one of the best pest prevention solutions e.g., remove all weeds and avoid growing flowering plants near the production area and sales areas.
- Mechanical control: use mesh screens to prevent movement of insects.
- Biological: predatory mites e.g., *Neoseiulus* and netamtodes e.g., *Steinernema feltiae* in soil eat thrips larvae, Beauveria bassiana is a fungal pathogen which can be sprayed onto the plant.
- Chemical control. It is very difficult to reach thrips inside developing flowers and the larval stages are only present for a few days.

WHITEFLY

Young adults (flies) are pale green to yellowish and soon become covered by a powdery, white wax. That is why they are called ‘white flies. The larvae are oval in shape and found on the underside of leaves.



Life cycle of a whitefly

(https://nzacfactsheets.landcareresearch.co.nz/factsheet/InterestingInsects/Cabbage-whitefly---Aleyrodes-proletella.html)

How they damage the plants

- Whiteflies do best in moderate to warm climates. They consume large quantities of plant sap and excrete honeydew resulting in weak plants, with reduced plant vigour.
- Sooty moulds are attracted to sticky honeydew and cover leaf surface reducing photosynthesis and transpiration and on fruit, mould can cause rot.

Scouting methods

- Use sticky strips and visual observation. Look for honeydew secretions on plants.

Control methods

- Good sanitation - keep production and surrounding areas weed free around plants near the production area and sales areas.
- Chemical control can be a systemic imidacloprid as a soil drench.
- Organic control - Neem oils on nymph stage and pyrethrin as a contact spray for the adults

BACTERIA

We also get pests that aren't insects, for example, bacteria. They are 'single celled' organisms which can quickly reach very high numbers in or near plants. Bacteria can live in roots, leaves, stems and flowers, on leaf surfaces and become pathogenic under the right environmental factors.

To scout them you need to check for symptoms of the disease, for example:

- Bacterial wilt
- Soft rot of cuttings, corms, and bulbs
- Bacterial leaf spots on foliage plants
- Crown gall

Bacterial disease control is based on prevention and cultural control measures which include:

- Always start with clean and healthy plant material
- Proper fertilization
- Promote airflow with correct spacing of plants
- Have a high level of hygiene in production areas
- Do not splash water during watering which will spread bacteria
- Destroy sick and diseased plants

VIRUSES

Plants are also susceptible to viruses which are infectious parasites that live and multiply only within the host plant's living cells. Viruses cause diseases in the host plant.

How they damage the plant

- Plants infected with a virus may have smaller leaves, reduced internode length and smaller flowers. In general, the growth looks stunted.
- Symptoms such as ring spotting, vein banding, and mosaic show up on leaves.

To scout the disease

- Look for the symptoms of the disease

Control methods

- To treat viruses is extremely difficult and prevention is *'better than cure'* so to ensure this:
- Grow plants from virus free stock
- Maintain high levels of hygiene in the production area
- Discard infected plants immediately
- Prevent insects that spread viruses from entering the greenhouse

FUNGAL DISEASES

The next group of pests that cause problems are fungi which are described in the table below:

	Description	Damage plants how	Control methods
Powdery mildew	Powdery mildew is a white growth, caused by fungi, appearing on leaves and stems. These mildews are host specific	Part of the fungi grows inside the cells of the host plant and injures it.	• Cultural practices such as reducing high humidity • Use fans to circulate the air • Fungicides
Rusts	Rusts are also host specific and sporulate on leaf tissue.	Rusts are cool weather diseases. Rust spores spread in air currents and splashing water. Rusts must have water to germinate	• Keep temperatures high • Water early in the day to allow leaves to dry out before the night • Fungicides
Water mould root and crown rots	Pythium and Phytophthora are two examples of water mould rots. They have a spore stage that spreads by swimming in water.	These organisms cause root rots, stem rots and cutting rots.	• Prevent these water mould root rots with good sanitation • Improve growing media drainage, these fungi do not survive in well drained media • Use a soil drench fungicide
Root and stem rotting fungi	Many other different fungi than water moulds can cause stem and root rots	Fungus such as Rhizoctonia, Fusarium and Thielaviopsis live in and on the soil and attack many different plants.	• Good soil sanitation • Do not plant cuttings or plants too deep • Drench soil with fungicides
Plant wilts	These fungi invade the roots, grow into the stem, and plug the plants vascular system, which causes the plants to wilt, although they are wet.	Two examples: *Fusarium* and *Verticillium*	• Chemicals can't control these fungi once they are in plants • Prevention through good growing media sanitation is vital • Use only healthy stock material
Leaf and flower spots	Causes spots on leaves and flowers. These fungi need water on the leaf surface for infection to occur. Spores spread from leaf to leaf by splashing water.	*Botrytis* and *Alternanthera* are two common examples	• Avoid water on leaves • Fungicides
Cutting rot and damping off	Cutting rots: are often caused by water moulds, bacteria, *Rhizoctonia* and *Botrytis.*	Damping off: is often caused by *Rhizoctonia* and water moulds	• Prevention is the most important control method • Good growing media sanitation • Use only healthy stock material • High levels of hygiene in the propagation area • Keep rooting area warm • Manage moisture levels of rooting/germination media • Allow enough air into the medium for healthy root development • Manage moisture levels of rooting/germination media

Activity 6.1 Try *to list three other pests that occur in your workplace that have not been mentioned:*

Maybe you did mention this above, but certain **plants** can also be pests. These are known as 'weeds'. They compete with other plants for water, nutrients, and light. Weeds in and around the production area host insects and other organisms, bacteria and fungi which spread diseases and move to plants in production and selling areas. Examples are:

- Algae
- Annual blue grass
- Oxalis
- Sow thistle
- Nutsedge
- Bitter cress
- Common chickweed
- Common dandelion
- Horseweed or Fleabane

With all these pests around our workplace, how do you control them?

Activity 6.2 ***Do*** *you use pesticides in your business?*

Yes ☐ No ☐ Unsure ☐ If not, why not?

CASE STUDY RESULTS

The use of pesticides by the participants in the 2021-2022 study is 91.7% of the growers and 94.1% of the garden centre retailers do use pesticides. In the sample 4.2% of the growers are unsure as to whether they use pesticides and those not using pesticides at all are 4.2% of the growers and 5.9% garden centre retailers with the reasons that they are harmful to the environment and the plants do not stay in the business long enough for pests to be a problem.

During the discussions with the growers and garden centre retailers, it became apparent that there is a move away from harmful pesticides. For example, certain garden centre retailers do not sell 'Round up' any longer and the growers are trying to use more and more biological controls in greenhouse production. However, many biologicals are not registered for certain pests in South Africa, which is a challenge for the businesses trying to achieve more environmentally friendly practices.

Activity 6.3 *Use this checklist to become more aware of the pests in your business. Do a thorough inspection, tick the relevant boxes to*

For example, *pesticides not stored in a shed, exposed to elements* = very poor; I*n a storage room with a concrete floor* = poor; *In a storage room with concrete floors and lock and key* = fair; *In a pesticide suitable store room with strict record keeping procedures and spill kit on hand* = good; *We do not stock or sell any pesticides* = excellent

Pesticide Awareness Checklist					
Measure of safety	**Very poor**	**Poor**	**Fair**	**Good**	**Excellent**
Storage area for pesticides					
Mixing area or application area					
Equipment used for pesticides, spray bottles, misters, mixing instrument					
PPE availability and storage					
The use of pesticides:					
in tunnels or greenhouses					
In sheds					
In open areas for field crops					
Have an integrated pest management plan which is strictly followed					

Activity 6.4 Are *you aware of the following legislations with regards to pesticide usage within ornamental horticulture?*

The Occupational Health and Safety Act (OHSA). 1993 (Act No. 85 of 1993) regulates health and safety at the workplace for all workers. This Act places the onus on employers to maintain a safe workplace. The regulation makes provision for various mandatory safety measures to protect the health of workers handling hazardous chemicals, such as risk assessment, safety training, safe practices, and medical, biological, and environmental monitoring of all workplaces.

Yes ☐ No ☐ Unsure ☐

The Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947). For detailed information regarding the use, the labels of these products must be consulted. Each chemical product is supplied with a Material Safety Data Sheet (MSDS which includes all the information about the chemical a user should know about. To obtain the best results and ensure that the remedy is used correctly, it is imperative that the label be read carefully, and label instructions strictly adhered to. It is illegal to use an agricultural remedy for a purpose or in a manner other than that specified on the label. The knowledge of this legislation is important because, as discussed in the fertilizer/nutrient management section, the part relevant here for both growers and garden centre retailers is that "No person shall for reward or in the course of any as substituted industry, trade, or business - by section 8 of

- use, or recommend the use of, any agricultural remedy or stock remedy for a purpose or in a manner other than that specified on the label on a container thereof or described on such container;
- use any agricultural remedy unless s/he is a pest control operator registered in terms of this Act or otherwise in the presence and under the supervision of a pest control operator" (South African Government, 1947).

Yes ☐ No ☐ Unsure ☐

Agricultural Pests Act, 1983 (Act No. 36 of 1983) To provide for measures by which *agricultural pests* may be prevented and combated; and for matters connected therewith

Yes ☐ No ☐ Unsure ☐

Adoption of pesticide management policy for South Africa (Notice 1120 of 2010) to ensure that pesticides are used in ways that lead to the minimisation of significant adverse effects on human health and the environment Yes ☐ No ☐ Unsure ☐

South Africa has committed to the following international conventions relating to hazardous waste and other chemicals:

- **Basel Convention on the Transboundary Movements of Hazardous Wastes and their Disposal** Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
- **Stockholm Convention on Persistent Organic Pollutants** (POPs)
- **Montreal Protocol of the Vienna Convention**
- **Minamata Convention on Mercury (**signed the text, but yet to ratify the Convention)

In accordance with these commitments and the health and environmental risks mentioned above, South Africa has strict regulations with regards pesticide registration, use, storage, transportation, and disposal, similar to those of fertilizers and overlapping in some cases.

Global studies on life cycle assessment of pesticides

Globally, case studies have been done of the life cycle assessment (LCA) of pesticides which revealed that pesticides are contributing to ±70% toxicity in humans and 50% toxicity of freshwater ecosystems (Foong et al., 2022) which is why these regulations are in place and it is important to adhere to them and then work towards the following sustainable development goals which are related to their use, as shown on the next page.

Sustainable development goals	South African achievement (Statistics South Africa, 2019b)	OHISA (2021)
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally	National Development Plan - Environmental sustainability and resilience (5)	As mentioned under water resources the industry takes all measures to limit or ensure that no chemicals or pesticides end up in the water courses.
Ensuring the chemicals and waste doesn't pollute air, water and soil thus affecting human health and the environment.	The main limitation faced by South Africa in reporting progress on SDG 12 is a general lack of indicator-specific reliable and verifiable data at national level.	Not allow chemicals and fertilizers to leach into soil or water sources thus polluting them.

… / module continued on the next

Activity 6.5 Tick *the relevant box* Yes, No *or* Unsure *to show your workplaces' safety practices with regards to hazardous*

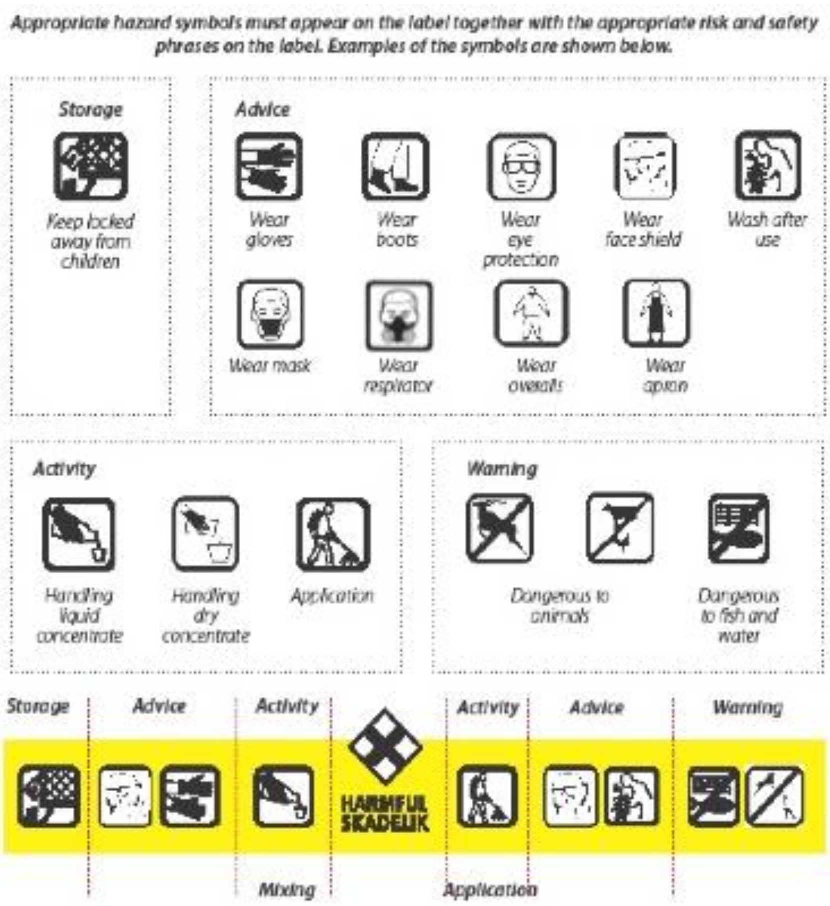
Hazard substances (Pesticide) safety practices				
	Description of pesticide storage area	Yes	No	Unsure
Is your storage area for pesticides?	Secure and locked			
	Has secure racking / shelving / plastic pallets.			
	Has a work surface or table			
	Well ventilated with windows or extractor fan			
	Good lighting			
	Insulated from extreme temperatures			
	Wash basin & soap etc.			
	Well demarcated by signs			
	Isolated from dwellings, animals and public			
	Has a "Bund wall" at entrance to contain spills or water in case of fire.			
Recording keeping	Pesticide Application Record (Spray Book)			
	Inventory (List of stock)			
	File for Material Safety Data Sheets (MSDS)			
	Separate area for spray masks & protective clothing.			
	Year planner.			
	Signage (posters and information on walls / poison emergency Tel. number)			
	Notice board or black board.			
Protective clothing	Boots			
	Alternative overall or spray suit or plastic apron			
	Gloves			
	Approved spray mask and filters			
	Safety glasses or googles			
	Spray cap or hat.			
Equipment	Calculator			
	Scales			
	Syringes			
	Measuring cylinders			
	A source of good quality water for spray mixtures.			
	Spare nozzles/ filters/ pump diaphragms/ fittings/ hose/ hose joiners etc.			
	Tools for changing nozzles / opening drums etc.			
	Spray nozzle cleaning brush (soft toothbrush)			
Health, safety, and first-aid	Fire extinguisher.			
	Safety eye-wash bottle.			
	Skin barrier cream.			
	Emergency shower & soap.			
	A spill kit			
Safety disposal tools and procedures	Plank or broomstick with nail - for puncturing empty "triple rinsed containers"			
	Large drum to contain leaking containers.			
	Drum to contain absorbent material – for mopping spills. (Cat litter or sawdust)			
	Area for storage, and list of redundant chemical stock.			
Exterior area to storage room	Drainage to "French drain" (Hard well drained area for filling spray rig.)			
	Bio-bed (Bed for biological "break down" of pesticides)			

Following on from above, where do you think you will find all the important information regarding the pesticides –

Answer: *On the Material Safety Data Sheet (MSDS).*

When you have training sessions on pesticides, ensure that you understand the information on these MSDS sheets and make sure that when you are teaching someone about pesticide usage or explaining it to a customer that you set an example and actually open the box and read from the packaging (the MSDS) as to how the pesticide should be applied and what pest it targets, even if you know about the product and how to use it.

Example of MSDS pictograms *(Efekto Introduction Course Retail Training Programme (Section 2 Pest control)*



Activity 6.6 Pesticide *labelling and packaging awareness. Fill in answers as directed below*

a) Have you noticed the colour bands on the chemicals that you purchase? It could be the "Doom" for your home or the "Malasol" in the retail garden centre or the in the production nursery.

Yes ☐ No ☐ Unsure ☐

b) What do the different colour bands on the pesticide bottles mean? *Complete the table by filling in your answers for the hazardous column.*

	Class	Hazardous	Toxicity	Precautions
 Red Band	Ia (1a)		Most toxic pesticides in South Africa	Take all precautions
 Red Band	Ib (1b)		Toxic	
 Yellow Band	II (2)		Harmful	Use PPE and protective clothing
Blue Band	III (3)		Caution	Use PPE
Green Band	IV (4) or U			Keep away from children, pets, and food

(adapted from Rother and Jacobs (no date) and https://farmbizafrica.com/farmbizopinions/3288-hazard-colour-bands)

c) D[...] th[...]rams on the labels, and do you know what they mean? Choose [...]t they mean.

e.g., Store under lock and key
1.
2.
3.

[...]cating pesticide hazards and safety instructions *(Riyaz et al., 2020)*

In accordance with the Occupational Health and Safety Act, when pesticides and other chemicals are prepared and applied, persons working with them must be extremely careful. They must always wear the appropriate personnel protective clothing and equipment (PPE). The person must check the label and MSDS (material safety data sheet) and determine the toxicity class of the chemical and its potency. This information implies what protective gear and emergency measures are appropriate.

Levels of Pesticide Toxicity and Safety Equipment Needed			
Pesticide Signal Word	**Level of Toxicity**	**Label Symbol**	**PPE required**
Danger-Poison	High	Skull & crossbones	Rubber boots, rubber pants, hat, raincoat, face shield & respirator/gas mask
Warning	Moderate	None	Same as for high toxicity
Caution	Low	None	Rubber boots & gloves, respirator recommended when used indoors

Precautions to take when mixing pesticides

- Always read the label first and follow the instructions carefully. Do not increase the recommended rate and/or intervals of application.
- Follow the safety precautions on the label.
- Wear the appropriate protective clothing and equipment and wash hands after use.
- Do not smoke, eat, or drink while working with chemicals
- Avoid spilling on skin and clothing
- Check the pesticide formulation and type of application equipment needed

- Record the date, time, location, and amount of pesticide used.
- ALWAYS ADD WATER FIRST TO THE MIXING CONTAINER & THEN THE CHEMICAL. Never add water to the chemical, it will not mix properly and when using acids, it is extremely dangerous. Allow enough time for the mix to go into solution before application.
- Always use different sprayers for pesticides and herbicides therefore label the applicators accordingly
- Rinse spray tanks with water thoroughly after use
- Make sure chemicals are handled with the necessary precautions on-site and during transport.

Ensure that you use the correct use of pest control equipment

Always ensure that the pest control equipment is working properly and is well maintained. Effective pest control depends on applying the proper amount of pesticide where it is needed.
Pesticide application equipment basically consists of three main parts:

- The spray tank which holds the spray mix
- A pump that provides pressure
- Nozzles attached to a wand or boom to deliver the pesticide in the desired spray pattern

During spraying a constant pressure must be maintained to achieve consistent application rates.

Tips when using pesticides

Wear appropriate PPE
Dilute according to recommended rate, using less could result in pest resistance
Mix only what you need and use it all
Calibrate sprayers and spreaders
Switch pesticides used within the same class to reduce potential resistance build up
Do not spray when windy, in the heat of the day or when about to rain

As mentioned above, good record-keeping is imperative, and the following is an example of a pesticide application record that should be used every time a pesticide is sprayed or applied within your workplace.

Pesticide application record	
Date:	Time:
Area / Crop / Variety:	
Weather conditions before & after:	
Reason for application (Target pests):	
Pesticide used & formulation:	
Dosage used:	
(Amount of chemical / Mixture used / area)	
Methods of application:	

(Spray / drench / fog / dust etc)	
Stage & condition of crop:	
Person responsible & spray team:	
Effectiveness of treatment (Observations post-application)	
Notes & Comments: (Condition of equipment / change of filters / nozzles etc.)	

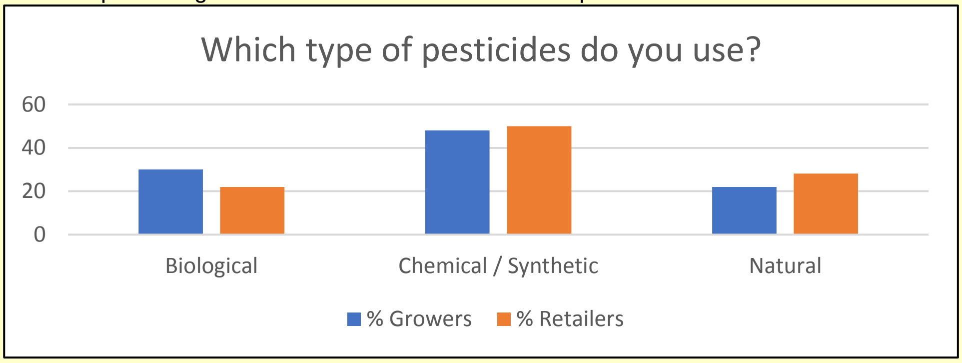
The knowledge and application of pesticide information is important in the achievement of sustainable pesticide usage within your workplace.

Pesticide practices within the workplace

There are various pesticide types but for the purpose of this manual we used, **biological, chemical,** and **natural (organic)**. The type of pesticides used, whether it be chemical or natural (organic) still has the intended purpose of killing the pest and if they are used incorrectly can do harm to humans and the environment, even the natural ones such as canola oil is often part of a natural remedy and used to block the breathing organs of the pests but if this is sprayed near water, the oil droplets will negatively affect the aquatic life in the pond or river.

CASE STUDY RESULTS

The participants in the 2021-2022 were asked which types of pesticides they used in their business. The graph shows the percentage of the answers for each TYPE of pesticide.



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Activity 6.7 ***Which*** *type of pesticides do you use, and give the name of an example from your workplace (you can answer for*

Biological ☐	Chemical / Synthetic ☐	Natural / Organic ☐

Activity 6.8 ***Do*** *you use pesticides preventively and/* or *curatively*. *If you use for both, then, tick both boxes.*

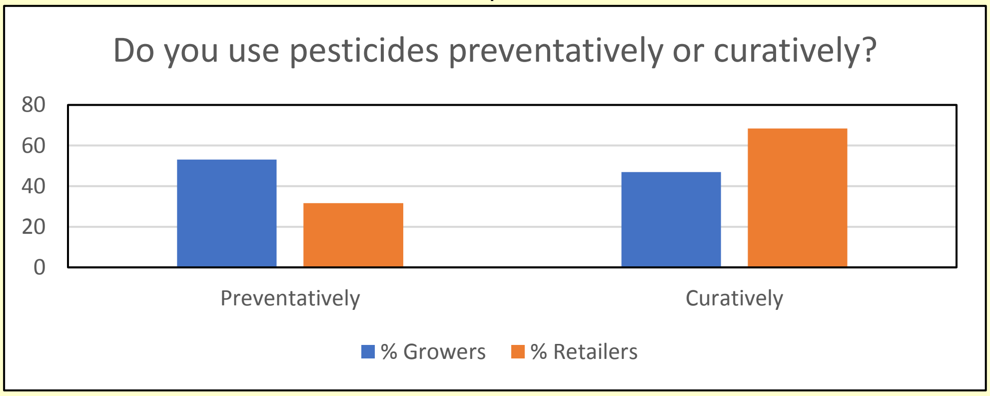
Preventatively ☐ Curatively ☐

Biological control of pests and diseases in horticulture is a method of controlling pests and diseases using natural predators rather than chemicals. The use of chemicals to minimize the risk of pests and diseases should only be used to compliment sound cultivation practices.
Some chemical precautions:

- Use chemicals only as prescribed and on crops for which they are registered
- Do not increase the prescribed application interval
- Increased dosage and application intervals may be harmful to plants and the environment.
- **Use the right application methods and equipment**
    - Do not spray if you need to drench
    - Use the right pressure
    - Use the right nozzles to get the correct droplet size

CASE STUDY RESULTS

The participants in the 2021-2022 were asked whether they used pesticides to prevent pests occurring (preventatively), or to get rid of them (curatively). The following graph shows the percentage or growers and retailers for each answer.



More growers (53.1%) than retailers (31.6%) use pesticides preventatively (Figure 53). It is vice versa with regards to curative treatment as when plants arrive at the garden centre retailers, they should always be pest and disease free, or the garden centre receiver would return them and so it is only when the plants show signs of pest damage that they are usually treated for that specific pest thus 68.4% of the garden centre retailers treat pests curatively compared to 46.9% of growers.

Whether you use pesticides preventatively or curatively, you must know how to look for them and this is known as *scouting*. It involves inspecting crops and areas in a nursery on a regular, systematic basis to determine if you have problems from pests, diseases, weeds, and cultural problems. It is important to inspect the following:

- Foliage, flowers, root systems
- Soil pH and EC
- Use monitoring tools such as insect traps
- Production practices and greenhouse conditions that contribute to pest problems are poor air movement, areas of standing water and dripping taps

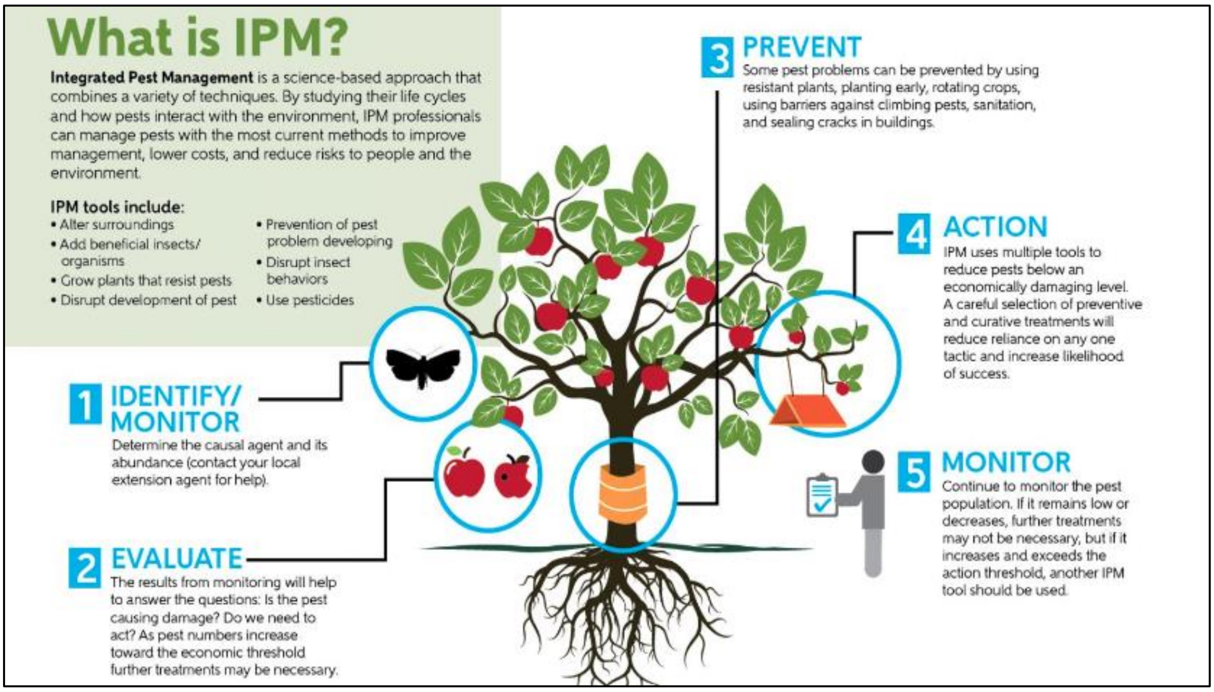
Use this information to decide whether action is needed and which technique to use.

The way you treat pests and use pesticides can also influence the cost to company. Now is a good time to work out what it costs to treat the pests in your workplace. The table on the next page indicates in the first column the places where you could look for evidence of how much it has cost you each month. You would need to do this for a whole year to get an accurate record.

Pesticide Costs													
Source of cost:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Cost (Rands)
Supplier invoices for actual pesticides													
Equipment purchases for spraying													
Maintenance invoices for equipment													
Training invoices for pesticides use													
Skill kit invoice													
Disposal of pesticide containers and products safely													
Other													

One of the ways to reduce these costs is by having an integrated pest management (IPM) system. It is the way forward both environmentally and economically.

Integrated pest management (IPM) (illustrated in the figure below) combines the monitoring of the pest, its lifecycle and environmental conditions with the careful use of cultural, biological, physical, and chemical controls and technology to manage pest problems (Johnson, Mangiafico and Obropta, 2011).



IPM Strategy *https://www.ipmcenters.org/about/what-is-ipm/* accessed 21/05/2021

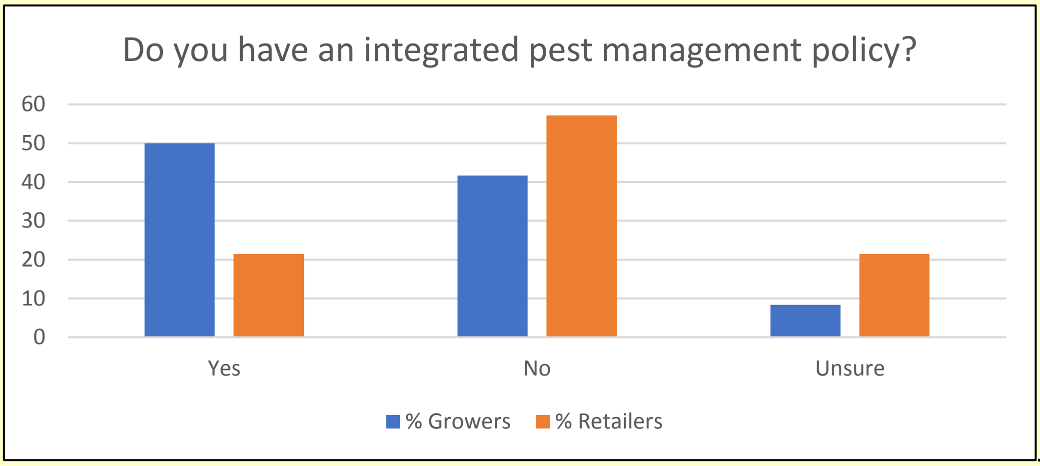
IPM has various sustainable strategies based on scientifically made decisions which minimise damage to plants, people, and the planet.

Activity 6.9 ***Do you have an integrated pest management policy (IPM) at your business?***

Yes ☐ No ☐ Unsure ☐

CASE STUDY RESULTS

The participants in the 2021-2022 were asked whether their businesses had an integrated pest management policy.



The results show that 50% of the growers have an integrated pest management plan and 21.4% of the garden centre retailers.

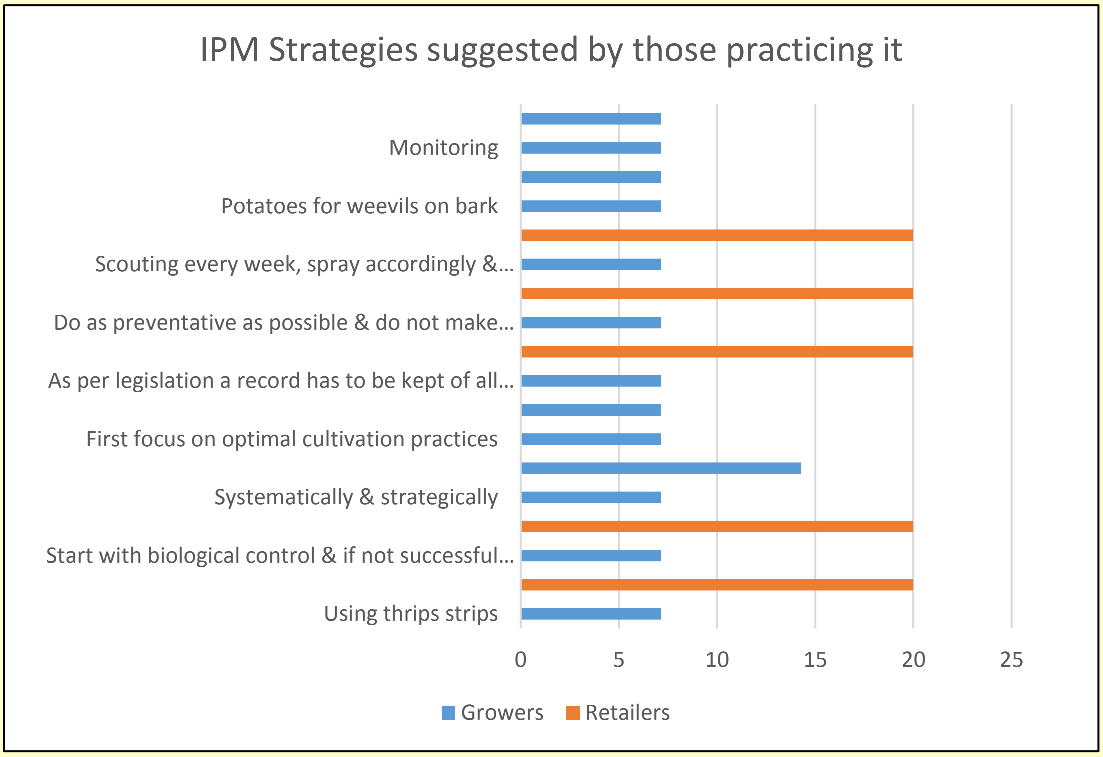
The recommended principles of IPM from the European Commission (Barzman, Bàrberi, Nicholas, *et al.*, 2015) are:

1. **Prevention and suppression** – optimising cultivation practices and preventing attack from pests
2. **Monitoring** – scouting and using thrips strips (observation), forecasting problems, and predicted methods of treatment
3. **Decision making** – based on plant varieties using multiple measurement methods and threshold allowances
4. **Intervention** – biological, organic, then chemical with reduced amount of pesticide used thus causing as little damage to environment as possible. Also changing the active ingredients used to combat pests to reduce resistance build-up. This is done systematically and strategically.
5. **Evaluation** – record the process and products used and the effectiveness of them to accurately assess strategies and make necessary changes for improvement.

The results from the interviews in the 2021-2022 investigation in the ornamental horticultural industry it appears that **garden-centre retailers** mostly believed that they do not have to have an integrated pest management strategy because they receive healthy plants from the grower and hopefully sell them before any pests can attack. If this isn't the case, they treat curatively and usually with an organic pesticide as reflected in the result above. The **growers** on the other hand are more likely to have an IPM and the different strategies that both them and the garden centres retailers use are listed below.

Those of the respondents who said they did have an IPM were asked what strategies they would recommend be used. The responses are shown on the next page, for growers and retailers.

CASE STUDY RESULTS



Activity 6.10 *Complete the table below to assist you in developing an IPM for your workplace.*

Pesticides changes to optimise usage and savings

Workplace strategies	Methods to implement change	We can implement change	Objective of change: Minimise usage	Objective of change: Reduce costs	Objective of change: Create awareness	Objective of change: Change behaviour	Cost
Prevention and suppression							
Optimising cultivation practices	Good nutrient management practices					✓	*Medium*
	Correct watering practices						*Low*
	Introduce beneficial insects						*Medium*
	Timeous prevention tactics						*Low*
	Preventing pest attacks						*Low*
Good sanitation	Clean equipment thoroughly						*Low*
	Inspect and quarantine new plants						*None*
Monitoring							
Scouting (identify pest)	Observations - record pest activity						Low
	Using sticky cards, thrips strips, pheromone traps						Low
Training	Pest identification scouts						Medium
Investigate pest's life cycle	Observation and research						Low
Determine which part of lifecycle will be targeted	e.g., insect adult, egg, larva/nymph, or pupa						None
Forecasting							Medium
Decision making							
Plant variety susceptibility	Grow more disease resistant varieties					Training	Medium
Setting thresholds of minimum requirements	e.g., day degree model						Low
	Prior experience of attacks and damage caused						None
Determine best method for intervention	Experience or consultants						Low
Pesticide resistance	Be aware when determining strategy						

Table continued on the next page

Intervention							
Training	Read label and follow instructions carefully						Low
Biological	Introduce beneficial insects						Medium
Organic							Medium
Chemical							Low
Mechanical	Reduce pest habitat						Medium
Evaluation							
	Record treatment and processes						Low
Compare notes with other growers /garden centre retailers	Access strategies						Medium
	Make recommendations for change if necessary						None

Apart from creating an IPM, the other important policies and procedures that have a place when working with pesticides are that when using pesticides:

- Wear appropriate PPE: Glasses (goggles), mask, gloves, waterproof coat, gum boots (closed shoes) which is governed by the Occupational Health and Safety Act
- Dilute according to recommended rate, using less could result in pest resistance
- Switch pesticides used within the same class to reduce potential resistance build up,
- Mix only what you need and use it all
- Calibrate equipment correctly and before each use e.g., sprayers and spreaders
- Do not spray when windy, in the heat of the day or when about to rain and
- Dispose of containers and pesticides that are not used or expired.

Activity 6.11 *How do you dispose of the pesticides and their containers that have expired or that you no longer use?*

Dilute and pour into environment ☐

Return empty bottles/containers to supplier ☐

Add to general refuse collection ☐

Call a chemical waste disposal company ☐

Bury them ☐

Other (specify)

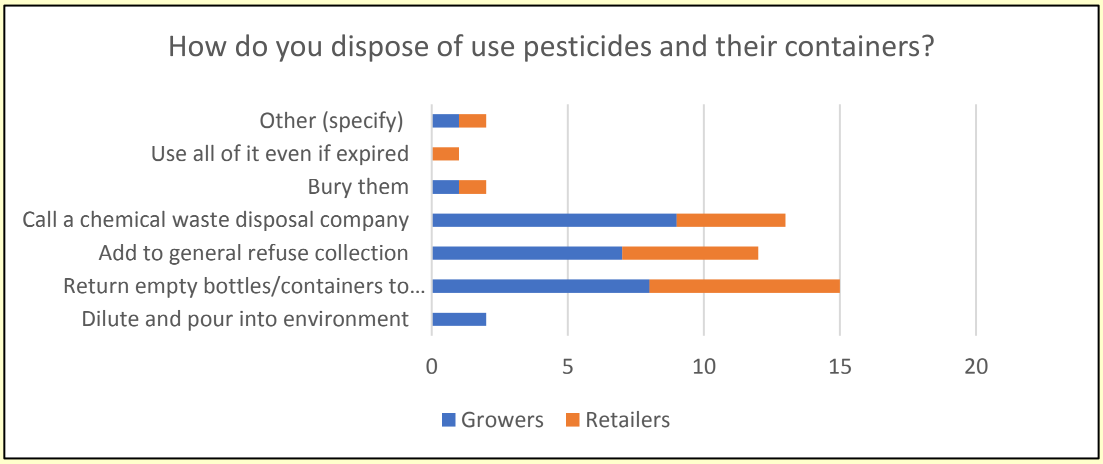
____

____

Obstacles when using pesticides

The primary obstacles when working with pesticides was the disposal of the empty containers, one grower mentioned that disposal was a “big problem” for the industry. The second is enforcing the legislation and correct PPE is worn and safety measures adhered to by the team. However other participants in the study said that they disposed of the pesticides and their containers using the following methods

CASE STUDY RESULTS



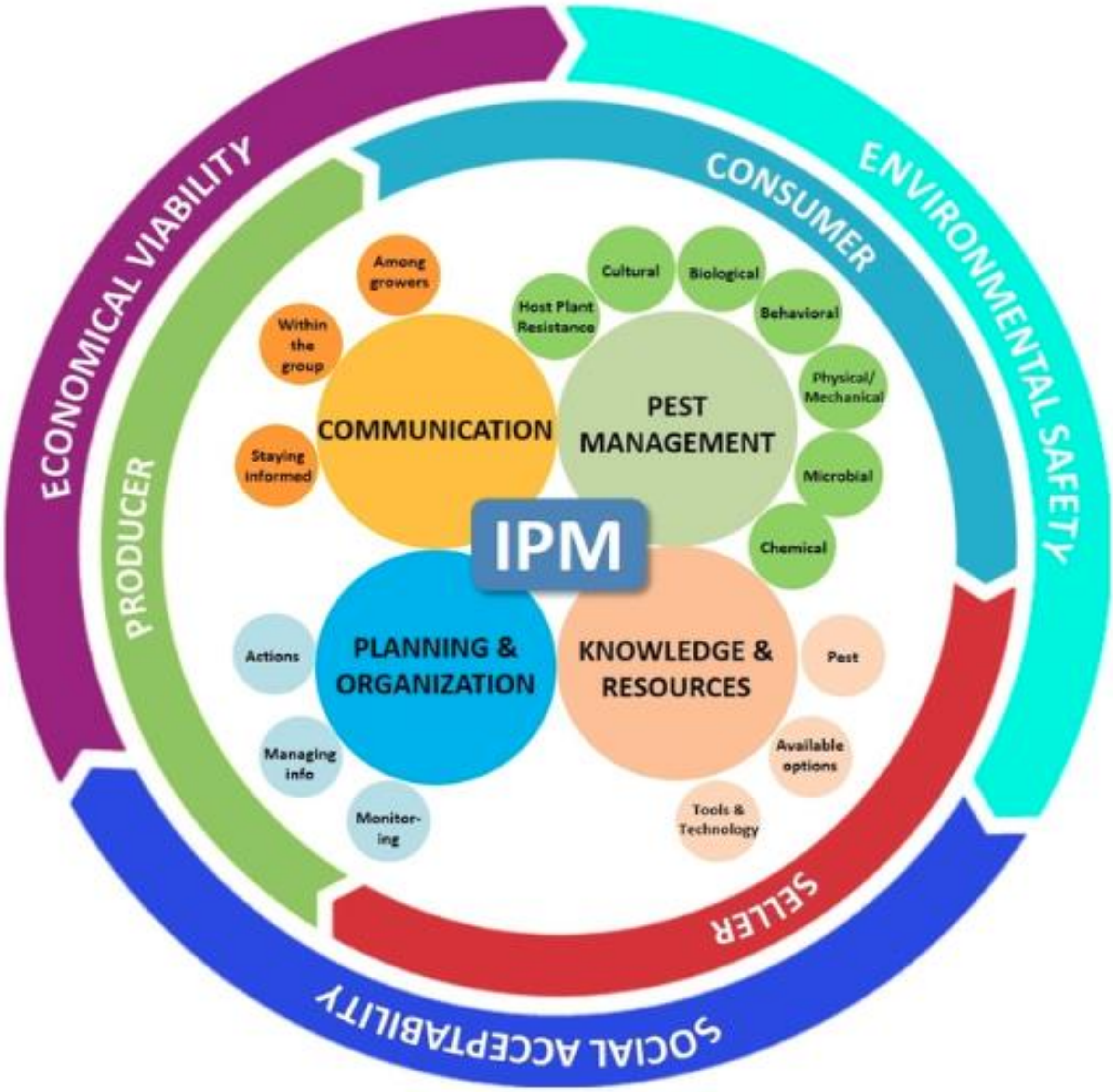
Those that added them to the general waste mentioned that it was only when the bottles were finished, and the containers had been rinsed. Croplife has a triple rinse policy before the disposal of containers which should be adhered to by all pesticide users.

Again, the practices of the participants in the study shows a different aspect of their knowledge as although they do not acknowledge knowing the regulations, most of them do practice within the confines of the law and dispose of pesticides correctly by either returning them to the supplier or sending them to a specialised chemical waste disposal company.

In March 2022, the *Extended Producer Responsibility* (EPR) was published for agricultural packaging in accordance with the *Waste Act (2008)* which means that each producer of this type of waste (namely paper, packaging, and some single-use products) have the responsibility to “*ensure that there is a scheme in place for collecting and recycling such items. The Act will be applicable to all stakeholders in the agricultural value chain, from supplier to farmer*” (Croplife, 2022).

Creating your own IPM policy

You are now ready to create your IPM policy document for your workplace and see how best you can achieve SDG 6 and 12 (we directly relate these to pesticides but others also influencing pesticides practices are 3,13 and 15. The activity 6.10 that you should already have completed will help you with this task. \use the following table to help you as shown in Part 1 of the manual and also in the following figure sourced from ***(Dara, Surendra, 2018) https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=28210)***


ECONOMICAL VIABILITY
ENVIRONMENTAL SAFETY
SOCIAL ACCEPTABILITY
PRODUCER
CONSUMER
SELLER
IPM
COMMUNICATION
Among growers
Within the group
Staying informed
PEST MANAGEMENT
Host Plant Resistance
Cultural
Biological
Behavioral
Physical/ Mechanical
Microbial
Chemical
PLANNING & ORGANIZATION
Actions
Managing info
Monitor-ing
KNOWLEDGE & RESOURCES
Pest
Available options
Tools & Technology

Activity 6.12 *Fill in the table below for the different parts of your workplace that use pesticides*

Title	*Best Management Practice for PESTICIDES (IPM strategy)*	
Date	Business address	Contact details
Stakeholders and partners	*List those involved e.g., environmental officer:*	
Section on business	*List (e.g., admin, planting, selling, logistics, spraying etc.)*	
Type of document *(Tick the most relevant choice)*	☐ Worksheet ☐ Standard operating procedures ☐ Policies guidelines ☐ How to … (training guides)	☐ Review document (monitoring report) ☐ Information sheet ☐ Educational poster
Target Audience *(tick relevant boxes)*	☐ Worker ☐ Team leader ☐ Supervisor ☐ Manager	☐ Manager ☐ Workplace owner ☐ Other
Purpose of document		
Relevant area in business	*List (e.g., Inside, outside, delivery bay, hothouse etc.)*	
Document structure	Description of initial situation and problem	
	Good practice being addressed	
	Time schedule	
	Risks to be addressed	
Stakeholders and partners	*List those involved and benefitting from best practice implementation*	
Methodological approach	*Describe business practices and process to be addressed and adapted*	
Validation	Monitoring and recording changes both positive and negative	
Impacts	Environment	
	Economical	
	Individual	
Innovation	*List new technologies applied*	
Success factors		
Constraints		
Lesson learned		
Targeted SD goals		
Repeatability and adaptability for other areas in business		
Conclusion	Impact and usefulness	
Contact details		
Related websites		
Related resources		

PESTICIDE OUTCOMES checklist

	Became aware of the pesticide crisis globally and the consequences of irresponsible application of pesticides and the resultant pollution	
	Gained knowledge about pesticide use within your workplace	
	Created a pesticide-storage policy, an integrated pesticide management strategy, and a PPE usage policy for the different parts of your workplace	
	Shared the policy with others and obtained feedback	
	Implemented the policy and got more feedback	
	Created an opportunity for behaviour change within your workplace	
	Reduced the pesticide-related input costs within your workplace	
	Improved your environmental footprint by responsible pesticide use or use of biologicals	
	Helped your fellow co-workers and peers become more environmentally friendly and aware of the dangers in working with pesticides	
	Developed and applied an IPM strategy to update policies annually to maintain environmental sustainability and promote health and safety within your workplace	

Module 7

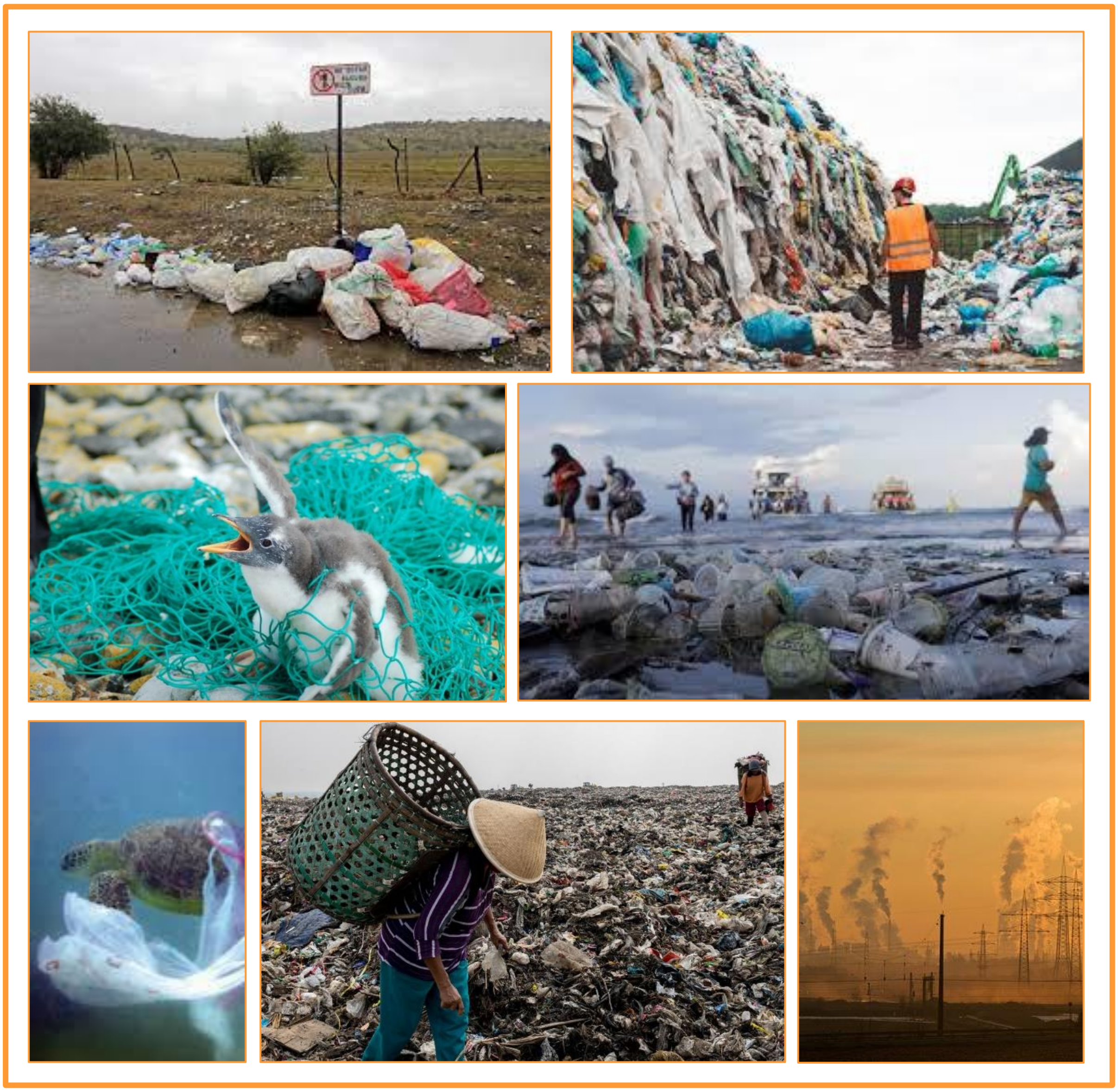
Waste and waste management

In each business waste is generated. The reduction and reuse of this waste is essential to current business practices, not only for the environment but as part of cost-saving too. The amount of waste generated varies greatly, from production farm to production farm, plant variety to plant variety, open-field nurseries to tunnels and sheds, garden centre to garden centre with restaurant, each is different. The inputs also vary which alters the output e.g., one grower has open fields with a few sheds and uses chickens for pest management, compared to another who has controlled growing environments with tunnels. Their level of input is considerably different in terms of plastic and substrates used (Nicese and Lazzerini, 2012), thus leading to different priorities in terms of environmental concerns.

Previously in the manual, nature-based solutions were mentioned. If you look towards nature, have you ever seen any waste occur in the natural environment? It is only humans in the name of development, industrialization and our consumptive and consumer-based habits that have polluted shopping centre and some suburbs, filled landfill sites, and created plastic islands in the ocean. As the OHISA, we have an opportunity to showcase how we can successfully reduce our waste and use nature-base solutions to reuse, rot, repurpose and recycle waste products created during the production and sale of a healthy plant.

The global waste crisis

It would be very difficult in today's world of media to ignore the fact that there is a global crisis in the biosphere, both terrestrial and aquatic. Nothing escapes - humans, animals, plants, the environment and while many animals die, waste picking is something saving the lives of the desperately poor.



South Africa's situation with regards to waste and waste management

The waste problem is no different in South Africa, and many pictures on the previous page could have been taken here. In the information box below you will find some selected statistics (3Smedia, 2022; Department of Statistcis South Africa; Dept of Fisheries and the Environment Parlimentary Monitoring Group, 2022).

INFORMATION BOX

- South Africa generates about 108 million tonnes of waste each year, about 21% going to landfills.
- Almost 93% of hazardous waste went to landfills, and about 65% of general waste.
- Organic waste was the largest contributor to general waste, about a third coming from the sugar and paper industry's biomass.
- South Africa has both a terrestrial and an aquatic plastic waste problem, with the Covid pandemic causing a huge rise due to discarded personal protective equipment (PPE) and single-use plastic wrapping.
- A survey from 2002-2016 showed self-reported recycling from 13% of metropolitan households.

Wastes in the ornamental horticulture industry

Many different waste products are generated in the ornamental horticultural industry. Many of these products are common to most businesses, for example, office supplies (paper, printer cartridges, etc.) and wooden pallets, vehicle parts, kitchen waste, food packaging etc.

Those specific to the ornamental horticultural industry are:

- Growth media which we have already mentioned
- Plant material, most of which gets composted and used in landscapes and gardens
- Plastic for tunnels and greenhouses,
- Woven plastic or weedguard for flooring
- Plastic pots, plastic bags, seedling trays and polystyrene trays
- Pesticides, fertilizers, and chemicals which we have also already mentioned.

Another sustainability suggestion to reducing waste is creating a circular economy – we are all familiar with the life cycle of the pests as described in Module 6. Similarly, each product manufactured or grown also has a lifecycle and if we can change our mindset as to how to make it a circular lifecycle, rather than a linear one, we would be on the right track. The diagram on the following page gives examples of how to change our thinking from linear to circular starting from the design and materials used in the manufacturing of the product to its last days and where it eventually ends up. It describes the 9R framework (nine words beginning with R that describe the various ways in which waste management can be handled. You may have heard of several older versions – the 4R, the 8R etc. This system will be explained in more detail later in this module.

One of the greatest concerns within the OHISA is the use of plastic, particularly single-use, often virgin plastic pots which aren't reused or recycled. Another plastic which causes concern is our tunnel covering which must be replaced every 8-10 years. The plastic used by the industry is illustrated in the table on the next page, sourced from *(Association of Professional Landscape Designers, 2020).*

The 9R Framework. Adapted from Potting et al. (2017, p.5) cited in (Kirchherr, Reike and Hekkert, 2017)

Circular economy ↑ Increasing circularity ↓ Linear economy		Strategies	
	Smarter product use and manu-facture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
		R1 Rethink	Make product use more intensive (e.g. by sharing product)
		R2 Reduce	Increase efficiency in product manufacture or use by consu-ming fewer natural resources and materials
	Extend lifespan of product and its parts	R3 Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
		R4 Repair	Repair and maintenance of defective product so it can be used with its original function
		R5 Refurbish	Restore an old product and bring it up to date
		R6 Remanufacture	Use parts of discarded product in a new product with the same function
		R7 Repurpose	Use discarded product or its parts in a new product with a different function
	Useful application of mate-rials	R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
		R9 Recover	Incineration of material with energy recovery

Ornamental horticulturalists also use plastics, and the reuse and recycling of some of the products can be challenging. The table below shows how the South African industry does reuse its polypropylene pots successfully. Even second-hand tunnels are reused by schools and charities in the building of their own tunnels where they grow vegetables to share.

PLASTICS USED IN HORTICULTURE IN THE US				
Plastic	**Resin Identification Code**	**Pros**	**Cons**	**Recycled Uses**
High Density Polyethylene (HDPE)	#2	Rigid durable plastic used for outdoor trees and shrubs. Resists breakage, does not degrade quickly under UV light; thermally and chemically resistant.		Plastic timber, picnic tables, railroad ties.
Low Density Polyethylene (LDPE)	#4	Relatively inexpensive; used to cover greenhouses; mulching material.	Requires special recycling if in contact with pesticides; some companies offer wash line systems for cleaning.	Plastic composite lumber for decks; floor tiles; reusable grocery bags; compost bins and trash cans.
Polypropylene (PP)	#5	Plant containers for greenhouse production; durable; lightweight and resists breakage; not prone to leaching.	Yield losses are pretty high and standardized packaging in PP is low.	Typically not recycled.
High Impact Polystyrene (HIPS)	#6	Flats and trays for seedlings and small plants; inexpensive and lightweight.	Most often discarded or recycled rather than reused.	Can be recycled back into trays.

(Association of Professional Landscape Designers,

Activity 7.1 Complete *the checklist for waste creation areas within your business*

Waste Checklist						
Areas of workplace which create waste	Example of waste	Waste not efficient - still needs attention	Slightly waste efficient	Waste efficient within the constraints of the workplace	Waste sustainability achieved -zero waste to landfill	Not applicable
Storage area						
Office / Admin area	Cardboard					
	Printer cartridges					
	Paper					
	Other					
Production area	Growth media					
	Pots and trays					
	Flooring					
	Pesticides and fertilizers part used					
Tunnels	Plastic covering					
	Metal infrastructure					
	Irrigation not used					
Kitchen and lunch area	Water bottles					
	Food waste					
	Packaging e.g., crisp packets					
Garage and vehicle location area	Tyres					
	Oil					
	Diesel spill					
	Vehicle parts broken					
Dispatch Area	Broken stackers					
	Labels not used					
	Packaging for plants *e.g., cellophane, plastic wrap*					
	Pallets					
Receiving area	Broken bags					
	Old pots					
	Used bricks					
	Damaged concrete					
	Poor quality plants					
On sales floor	Rubbish from customers					
	Receipts					
	Cooldrink tins					
	Labels					
	Plant material					
Marketing, poster, and labelling	Posters					
	Signage / POS					
	Leaflets / Newsletters					

Legislation about waste management in South Africa

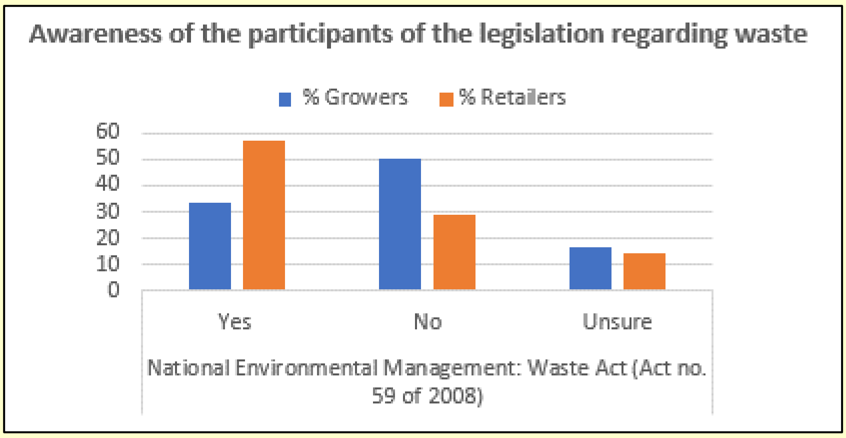
Now that you have an idea of waste areas in your workplace, let's address your knowledge of the legislation for waste management as well as international policies and goals related to it.

Are you aware of the National Environmental Management Waste Act (59 of 2008)

Yes ☐ No ☐ Unsure ☐

CASE STUDY RESULTS

The respondents in the 2021-2022 study of the ornamental horticultural industry were asked whether they knew about this act. The percentage of responses from growers and retailers are shown below.



The premise of the Act is to "protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development" (South African Government, 2008b). As mentioned in the previous section on pesticides, this Act is evolving to incorporate more sustainable measures and corporate or company responsibility from the start to the end of a product's journey.

The principles of the Act and the policies related to it can be tailored towards the sustainable development goals and this is what South Africa is working towards.

Sustainable development goals	South African achievement (Statistics South Africa, 2019b)	OHISA (2021)
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Percentage of municipal waste generated and recycled (domesticated indicator) 1.3% (2015), 1.6% (2016), 7.5% (2017) NDP Environmental sustainability and resilience (5)	Opportunity for OHISA to apply nature-based solutions to improve air quality and showcase waste management strategies within the industry
12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse 12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Specific objectives of the National Development Plan include absolute reductions in the total volume of waste disposed to landfills each year (SDG 12.5), increased waste recycling (SDG 12.5), development of green products and services (SDG 12.2), and carbon-pricing to reduce carbon emissions (SDG 12.C)	All growers in the sample participate in some form of recycling waste and reusing by-products, 92.3% of the garden centre retailers recycle, reducing the amount of waste that is sent to landfills

To reduce waste and minimise the effects of pollution from a business there should be a policy whereby company employees know how to best manage the various waste products within the waste stream that they encounter within the company.

Do you have a policy on waste management in your business?

Yes ☐ No ☐ Unsure ☐

An interesting observation here is that although fewer **growers** are aware of the legislation, and 50% have a waste management policy compared to th**e garden centre retailers** where only 20% had one.

When creating a waste management policy, there are a few procedures to consider, and if you already have a policy and are evaluating it, see if you get some new ideas from the following activity.

Activity 7.2 Understanding *waste procedures and policy development*

Understanding waste					
		Yes	**No**	**Unsure**	**Recycle**
Do you have the following products as waste products and if yes, do you recycle them	By-product from boiler				
	Cardboard and paper				
	Concrete and old bricks				
	Electronic waste				
	Food waste				
	Glass				
	Metal				
	Plant waste				
	Plastic (other)				
	Plastic bags and pots				
	Polystyrene trays				
	Printer cartridges				
	Soil				
	Water				
Do you have a waste management programme?					
Are any of the waste materials you dispose of harmful to the environment?					
Have you ever had any training on waste management?					
When working with waste products, do you wear PPE?					
Has your workplace introduced any technology to reduce waste?					
If yes, please give examples					

Practices of waste management in workplace

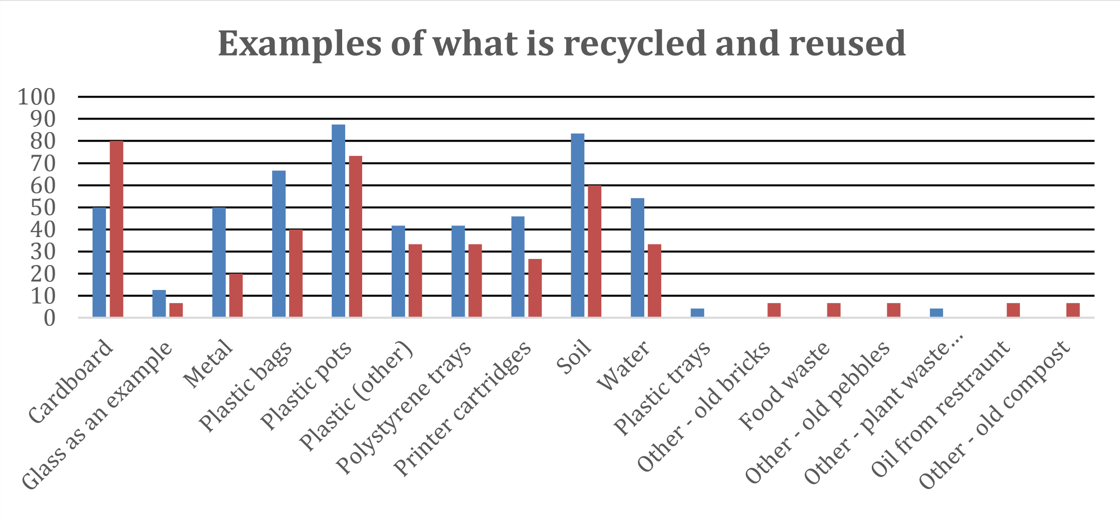
Having already completed the checklist and now understanding the sustainable development goals you are working towards, let's continue investigating policy development strategies.

Do you recycle and reuse waste products within your business?

Yes ☐ No ☐ Unsure ☐

CASE STUDY

The percentage of respondents in the 2021-2022 study of the ornamental horticultural industry were asked about what they did with their waste products. Their answers are shown below for a range of products.



The variety of products that the participants reuse, repurpose, recycle and rot were recorded. The majority of what the growers recycle is a direct reflection of their business practices, such as pots, soil, and plastic bags. The **garden-centre retailers** have a much more varied recycling regime, but plastic pots, cardboard related to packaging are high and soil follows in the top three. One garden-centre retailer even bought an old Volkswagen beetle that would have gone to scrap metal and is using it as a planter and part of a display at the front of their garden centre. This gives an idea of what is being recycled and reused within the OHISA (2021), according to the research conducted.

In South Africa, much of the organic waste or plant material waste within the ornamental horticultural industry is disposed of by composting. In the United Kingdom a study investigated the environmental and economic lifecycle models best to treat this type of waste –and best method to dispose of it was not to create it in the first place, highlighting the importance of a circular lifecycle for the product, even green waste. If this was not possible then anaerobic digestion especially for soft green waste and food waste was recommended followed by in-vessel composting and incineration. These methods were all preferable to dumping on a landfill (Slorach, *et al,* 2019:16).

From one of the international best practices, the recommendation was to install an Onsite Container Cleaning Centre. This facility is where the sorting, cleaning, and sterilizing of containers would take place. The capital costs could be a problem but the saving in time, labour costs and reduction in purchasing of pots had a payback period of ±1 year.

Before making decisions, as with the other factors, it is wise to do a cost analysis first and then based your decisions on savings and figures, not only what is good for the environment.

(www.climatefriendlynurseries.org)

Use the worksheet on the next page as a template to help you to do that. Remember to make a copy in a spreadsheet programme like Excel so that you can expand the spaces as you need them to make your records.

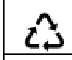
Activity 7.3 *Determine* *the disposal of waste costs (rands).*

Waste Costs													
Date:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Cost (rands)
Waste removal costs													
Staff costs for separation of waste products													
Recycling company invoices													
Sterilisation chemicals /equipment costs e.g., steamer													
Other													

After completing this assessment of costing, the next step in planning how to manage your waste is to see how you can reduce the waste you produce. Completing the table in Activity 7.4 will help you to assess whether you can change your workplace practices to make a difference for the environment.

***Activity 7.4 Indicate** whether you could implement the following changes.*

As for the other modules, there are four main reasons to make the changes.

	to minimize usage
	to reduce costs
	to create awareness
	to change behaviour

Changes to optimise usage and savings for waste						
Methods to implement change	Can we make this	Objective of change				Cost
		Minimise usage	Reduce costs	Create awareness	Change behaviour	
Cardboard						
Employees collect & sell waste	Yes			✓	Training	Low
Use recycle collection company / persons						Medium
Take to recycle depot						Medium
Compost it						
Use packing material for loading						Medium
Glass						
Recycle collection company						Low
Metal						
Employees collect it & sell it					Training	Low
Sold for scrap						Low
Recycle collection company/persons						Medium
Reused to build new equipment						Low
Used to make concrete products						Low
Old equipment used for displays						Low
Plant waste / green waste						
Separate plant material / growth media						Low

Separate soft green stems, leaves and flowers from woody branches						Medium
Use green waste as biofuel						
Reuse growth media but sterilise first (Mentioned in growth media module)						
Decompose green waste as compost						None
Plastic bags						
On-site collection						Low
Recycle collection company/persons						Medium
Reuse						
Use biodegradable bags (made from recyclable material)						
Given to schools or anyone in need						None
Plastic Pallet wrap (LDPE), strapping (PP), and fillers (pots)						
Recycle collection company						Low
Plastic pots						
On-site collection from customers and landscapers						Low
Washed & reused						
Cleaned, steamed & reuse						
Recycle collection company/persons						
Give to customers free						
Bin for customers to return old pots						Medium
Sent back to grower						
Give to schools /anyone in need						None
Plastic (other) - from tunnels						
On-site collection						Low
Recycle collection company/persons						Low
Recycle depot						Low
Place on ground for the blocks of plants						Low
Take back to grower						Medium
Use for displays						
Polystyrene trays						
Do an on-site collection (put out bins)						Medium

Clean & reuse						Low / None
Use as flooring in tunnels for insulation						None
E-waste / printer cartridges						
Computers, copiers, phones: if still working, donate						Medium
Cartridges on-site collection						None
Back to supplier						None
Cartridges refill						None
Soil						
Reuse in larger containers						None
Reuse – other						None
Make compost						None
Fumigate & use again						
Re-decompose						
Reuse in landscapes & gardens						
Sold to someone who makes compost						
Sterilize & reuse						
Sent back to grower						
Used in displays						
Machinery- and vehicle-related waste						
Batteries						Medium
Oil						Low
Tyres from vehicles and trolleys						Low
Water						
Reuse in trees						None
Recapture & use on-site						None
Goes back to the river						None
Dams						
Underground drainage						
Designated catchment area						
Wooden pallets						
Reuse in displays						None
Sell to customers						None

Send back to supplier						None
Other						
Plastic trays washed & reused						None
Old bricks sold for drainage						None
Food waste added to bokashi bins						None
Old pebbles bags used to sell bulk gravel						
Plant waste composted to sell as compost						
Oil from restaurant recycled to collection company / persons						
Other - provide only paper bags to customers, not plastic						

As can be seen, creating waste in your workplace is unavoidable, but growers and garden centres can make a change towards the environment by reducing, reusing, recycling, rotting etc. The ornamental horticultural industry must evaluate and rethink their business practices, as shown in the other modules in this "best practice" manual (energy, water, growth media, fertilizers, and pesticides). In the case of waste management, changes need to be made in the day-to-day activities of the business to decrease the amount of solid and liquid waste produced. Remember that if it leaves your business as waste, there is usually a cost to the company or to the environment.

Waste hierarchy: REDUCE, REUSE, RECYCLE, RECOVER, LANDFILLING

The waste treatment policy in Israel, as in the developed world, is based on sustainable materials management (SMM) - a systemic approach to productively using and reusing materials over their life cycles. This method is based on the waste hierarchy, made up of five steps:

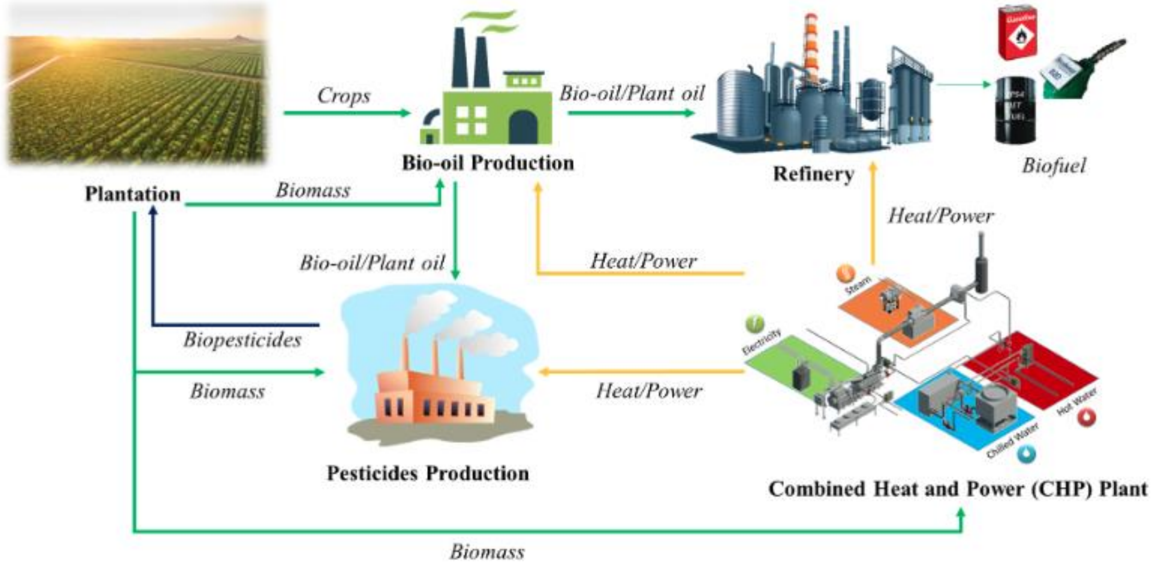
- **Reducing** waste at the source
- **Reuse** of materials
- **Recycling**
- energy **Recovery**
- **Landfilling**

The main objective of the *Ministry of Environmental Protection* waste policy is to turn waste from a nuisance to a resource.

https://www.gov.il/en/departments/guides/waste_treatment_hierarchy#:~:text=This%20method%20is%20based%20on,a%20nuisance%20to%20a%20resource.

Regarding the Rs of waste management, this section provides a little more detail.

- **Reducing** purchases: If you purchase less, there is less to throw away. This involves the REFUSE principle in which you, for example, refuse to buy products packaged in a certain way. Obviously, you must purchase enough to make the business function and have resources for production and sales but can some of the products we are throwing away be used for other purposes, as seen in the following diagram.



Conceptual design for biofuel processing complex (Foong et al., 2022)

Similarly ask your co-workers the following questions:

1. Do we need __________________ product to produce or sell healthy plants?
2. Can we change the processes within our businesses to improve productivity?
3. Can we ask our suppliers to reduce their packaging or ask that it is sourced from non-virgin plastics for example.

- **Reuse** - Within our industry there are numerous opportunities to reuse products. Examples have already been given in previous modules, for example, water (reticulation systems) and soil and containers (sterilisation facilities). *"By reusing as many purchased products as possible, you will reduce your operational costs while limiting the indirect emissions being created during the products' manufacture, and in the waste stream."* www.climatefriendlynurseries.org/resources

- **Recycle** - cardboard, metal and most plastics can be recycled by various companies offsite.

- **Rotting** - plant material and food waste can be composted, and by using other industries' waste. For example, we compost peanut shells and horse manure to mix with the industry's growing media and this is a way of forming environmental partnerships for the benefit of both businesses.

INFORMATION BOX

- **Reuse** - Within our industry there are numerous opportunities to reuse products, examples have already been given earlier e.g., water (reticulation systems) and soil and containers (sterilisation facilities). *"By reusing as many purchased products as possible, you will reduce your operational costs while limiting the indirect emissions being created during the products' manufacture, and in the waste stream."* www.climatefriendlynurseries.org/resources

- **Recycle** - cardboard, metal and most plastics can be recycled by various companies offsite.

- **Rotting** - plant material and food waste can be composted and by using other industries' waste e.g., peanut shells and horse manure we can compost them to mix with the industry's growing media and this is a way of forming environmental partnerships for the benefit of both businesses.

With all you have learned so far, use the table below as a template, as you did in the previous modules, to create policies and procedures for managing sustainable waste within your workplace.

Activity 7.5 *Fill in the table below for the different parts of your workplace*

Title	*Best Management Practice for waste management*	
Date	Business address	Contact details
Stakeholders and partners	*List those involved e.g., Environmental officer:*	
Section on business	*List (e.g., admin, planting, selling, logistics, spraying etc.)*	
Type of document *(Tick the most relevant choice)*	☐ Worksheet ☐ Standard operating procedures ☐ Policies guidelines ☐ How to … (training guides)	☐ Review document (monitoring report) ☐ Information sheet ☐ Educational poster
Target Audience *(tick relevant boxes)*	☐ Worker ☐ Team leader ☐ Supervisor ☐ Manager	☐ Manager ☐ Workplace owner ☐ Other
Purpose of document		
Relevant area in business	*List (e.g., Inside, outside, delivery bay, hothouse etc.)*	
Document structure	Description of initial situation and problem	
	Good practice being addressed	
	Time schedule	
	Risks to be addressed	
Stakeholders and partners	*List those involved and benefitting from best practice implementation.*	
Methodological approach	*Describe business practices and process to be addressed and adapted.*	
Validation	Monitoring and recording changes both positive and negative	
Impacts	Environment	
	Economical	
	Individual	
Innovation	*List new technologies applied*	
Success factors		
Constraints		
Lesson learned		
Targeted SD goals		
Repeatability and adaptability for other areas in business		
Conclusion	Impact and usefulness	
Contact details		

Activity 7.6 What *benefits have you noticed if you REUSE your products?*

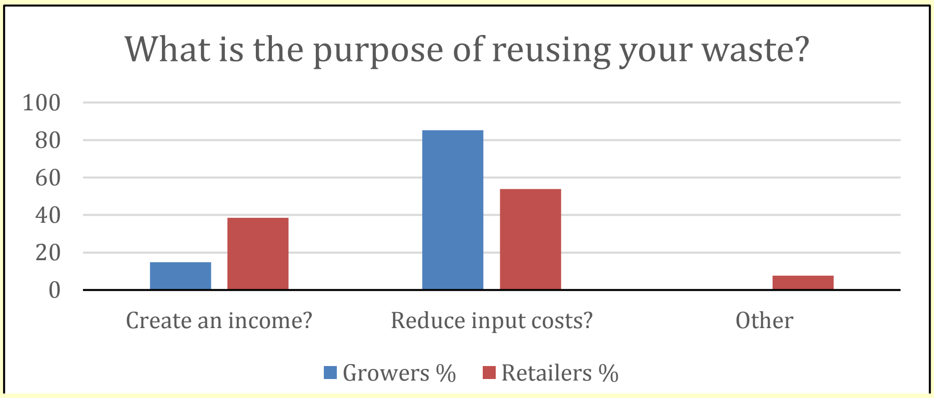
Created an income ☐ Reduced input costs ☐

List other benefits you have discovered.

Effective waste management can result in two different methods of saving on the bottom line. As can be seen from the following case study, the reduction of input costs was the preferred reason by the majority of both growers (85.2%) and garden centres retailers (53.8%). **Were your answers similar?**

CASE STUDY

The percentage of respondents in the 2021-2022 study of the ornamental horticultural industry who created an income source, and/or reduced their input costs.



Checklist of what you have done after completing this module (Tick in the box ONLY if that objective is achieved):

WASTE OUTCOMES checklist

	Became aware of the waste crisis globally and the consequences of irresponsible consumerism and waste accumulation	
	Gained knowledge about the use of waste within your workplace	
	Created a policy concerning waste usage in the different parts of your workplace	
	Shared the policy with others for feedback	
	Implemented the policy and got more feedback	
	Created an opportunity for behaviour change within your workplace	
	Reduced the waste-related output costs within your workplace	
	Improved your environmental footprint with regards to waste	
	Reduced your carbon footprint (decreasing nitrogen fertilizer usage and transport of wastes)	
	Helped your fellow co-workers and peers become more environmentally friendly with regards to the usage of waste	
	Developed and applied a strategy to update policies annually to maintain environmental sustainability within your workplace	

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