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# Aspects of the sustainability of the cultivated honeybush tea industry, South Africa

Thesis submitted in fulfilment of the requirements for the degree of

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by

**Tafadzwa Lainah Makhuza**

Department of Geography

Faculty of Science

South Africa

Supervisor

**Dr. Gillian McGregor**

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RHODES UNIVERSITY

## DECLARATION

This dissertation, submitted for the degree of Master of Science in the Department of Geography, Rhodes University, represents original work by the author and has not been submitted in any form to any other institution. Where mention has been made of the work of others, it has been duly acknowledged in the text.

Signed: Date:

__________________________________ _________13 January 2025_________

Tafadzwa Lainah Makhuza

**Author**

I certify that the above statement is correct.

Signed: Date:

__________________________________ _________13 January 2025_________

Gillian Kathleen McGregor

**Supervisor**

## ABSTRACT

Honeybush tea (*Cyclopia* genus) is a nutraceutical, naturally-sweet herbal tea species that is endemic to the Fynbos biome in the Eastern and Western Cape Provinces of South Africa. There are 23 *Cyclopia species* that are distinguished by their adaption to survive after natural, recurrent Fynbos fires. The two main fire survival strategies are (i) resprouters (which resprout stems from lignotubers) and reseeders (which regenerate from seeds). Species of commercial importance are (i) *C. genistoides, C. intermedia*, and *C. sessiliflora* (resprouters) and (ii) *C. maculata, C. subternata* and *C. longifolia* (reseeder).

In the past, the bulk annual production of honeybush (approximately 85%) was derived from wild populations, leading to the growing need for cultivation to supplement the wild-harvested plant material. However, for the first time in the industry's history, the annual harvest from cultivated stands surpassed that of wild-harvested populations in 2022–2023. This was pivotal for the industry which had previously seen the decline of *C. intermedia* and *C. subternata* (which previously contributed to approximately 95% of wild-harvested crops) due to factors such as unlawful harvesting, fires, overharvesting, urban expansion, and IAP encroachment. There is now an increasing demand to keep reducing pressure on wild honeybush populations while ensuring a consistent supply of high-quality cultivated honeybush products.

This research, underpinned by sustainability science and a mixed-method approach, aimed to investigate the nature of successful and unsuccessful cultivated honeybush tea enterprises (using a sustainability lens). The goal was to contribute to a potential way forward for the cultivated industry. The objectives of this research were: (i) to create an updated inventory of the cultivated honeybush tea industry, (ii) to investigate the environmental, economic, and social practices in successful cultivation enterprises, (iii) to investigate the challenges experienced by unsuccessful, transitioning and community enterprises and, (iv) to develop a sustainable resource use framework considering environmental, economic, and social aspects which might be useful for the honeybush cultivation industry.

The cultivated honeybush industry’s inventory was updated and mapped for 2023. The sustainable aspects of five successful enterprises (located between Bredasdorp and Kurland in the Western Cape) were investigated (through semi-structured interviews, mapping (LULC change analysis and Maxent species distribution mapping), plant surveys, biodiversity surveys, soil surveys and estimates of yield costs for the species of commercial importance). Semi-structured interviews were conducted with nine key participants (who have exited the industry or are part of the community enterprises) to determine the current challenges within the industries. Key challenges included the lack of; (i) market awareness for the industry, (ii) financial and natural capital, (iii) dissatisfaction with prices for wet honeybush tea) and (iv) the scale of enterprises.

This research harmonises the social, economic and environmental aspects of the cultivated honeybush tea industry (using a geographic lens) into a cultivated honeybush tea industry sustainable framework to ensure that the cultivated industry is better understood (at the forefront of its gradual evolution).

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| | |
|---|---|
| **ARC** | Agricultural Research Council |
| **BMP** | Biodiversity Management Plan |
| **BTI** | BioTrade Initiative |
| **CBA** | Critical Biodiversity Area |
| **CBD** | Convention of Biological Diversity |
| **CFK** | Cape Floristic Kingdom |
| **COP** | Conference of Parties |
| **DEADP** | Department of Environmental Affairs and Development Planning |
| **DEDEAT** | Department of Economic Development, Environmental Affairs and Tourism |
| **DEAT** | Department of Environmental Affairs and Tourism |
| **ESS** | Ecosystem services |
| **FAO** | Food and Agriculture Organisation |
| **GBIF** | Global Biodiversity Information Facility |
| **GDP** | Gross Domestic Product |
| **GDPR** | Gross Domestic Product by Region |
| **GIS** | Geographical Information Systems |
| **GPS** | Global Positioning System |
| **HI** | Harvest Index |
| **IAP** | Invasive Alien Plant |
| **IPM** | Integrated Pest Management |
| **INM** | Integrated Nutrient Management |
| **IUCN** | International Union for Conservation of Nature |
| **LULC** | Land use and land cover |
| **MA** | Millenium Assessment |
| **MAP** | Medicinal Aromatic Plant |
| **MCDA** | Multi-Criteria Decision Analysis |
| **NBA** | National Biodiversity Assessment |
| **NBSAP** | National Biodiversity Strategy and Action Plan |
| **NWFP** | Non-Wood Forest Product |
| **PPE** | Personal Protective Equipment |
| **PPECB** | Perishable Products Export Control Board |
| **PTY** | Proprietary Company |
| **PVC** | Polyvinyl Chloride |
| **RS** | Remote Sensing |
| **SA-GAP** | South African Good Agricultural Practices |
| **SAHTA** | South African Honeybush Tea Association |

| | |
|---|---|
| **SANBI** | South African National Biodiversity Institute |
| **SANLC** | South African National Landcover |
| **SDG** | Sustainable Development Goal |
| **SES** | Social-ecological systems |
| **SOM** | Soil Organic Matter |
| **UEBT** | Union for Ethical Biotrade |
| **UN** | United Nations |
| **UNCTAD** | United Nations Conference on Trade and Development |
| **WHO** | World Health Organisation |
| **ZAR** | South African Rand |

# CHAPTER 1

## 1.1) Introduction

The global complex challenges of modern agriculture which include resource depletion, economic pressures, environmental degradation and biodiversity loss can be addressed through 'Sustainability Science' (Bettencourt & Kaur, 2011). Sustainability Science is a fast-growing, interdisciplinary field that addresses the interactions throughout human social-ecological systems (SESs) to foster sustainable development (where society meets present needs without hindering the future generations' ability to meet their own needs) (Bettencourt & Kaur, 2011; Clark & Harley, 2020). Anchored in the 1987 Brundtland Report, sustainability science provides the necessary frameworks, tools, and methodologies to make agricultural practices socially equitable, economically viable and environmentally responsible (Clark & Harley, 2020; Dönmez et al., 2024). The field, therefore, encourages countries to embrace sustainable agricultural practices to safeguard their social, economic, and environmental future (FAO, 2017; Robinson, 2024). This is essential for Southern Africa, where an estimated 224 million people heavily rely on the agricultural sector, particularly rain-fed agriculture, to meet their livelihood and food needs (Mutengwa et al., 2023). The sector contributes approximately 17% of the region's Gross Domestic Product (GDP) and further supports approximately 60% of its population (Nhemachena et al., 2020). However, this region is heavily threatened with food insecurity due to its multi-stressor context, which includes extreme weather and climate events, rapid urbanisation, invasive alien plant (IAP) infestations (Mutengwa et al., 2023). Therefore, understanding the interplay between the interconnected SESs within the agriculture sector is essential for further sustainable development in Southern African countries.

This research focuses on South Africa which has a notable history of utilising and commercialising indigenous vegetation in the fynbos biome within the megadiverse Cape Floristic Kingdom (CFK), located in the Western and Eastern Cape Provinces (Karsen et al., 2022). These fynbos products, some of which have nutraceutical benefits (i.e., provide health benefits), are widely used as cut flowers, essential oils and herbal infusions (Le Maitre et al., 1997; Privett et al., 2014). One of the auspicious, endemic genera is *Cyclopia,* whose flowers, leaves and stems have historically been used to produce a caffeine-free, naturally sweet, herbal infusion called 'honeybush tea' (du Toit et al., 1998). Over the past century, honeybush tea has evolved from an exclusively wild-harvested to a commercially cultivated product, earning increasing recognition in local and international markets (Joubert et al., 2011; Koen et al., 2017). There is a growing demand for honeybush tea products in the pharmaceutical, cosmetic, and health industries, especially from developed nations such as Germany, Japan, and the Netherlands (Joubert et al., 2011). The plants have thus become vital to the local livelihoods of farmers, processors and harvesters involved in the industry (Joubert et al., 2011). The genus comprises 23 species with distinct geographical distributions within the fynbos spanning from the Cederberg Mountains in the north and Cape Peninsula in the south (both in the Western Cape) to Gqeberha in the east (Eastern Cape) (Schutte, 1997). The 23 species can be divided by their plant form as 'reseeders' (plants that regenerate through seed germination post-fire) or 'resprouters' (plants that regenerate through underground structures post-fire) (van Blerk et al., 2021; Karsen et al., 2023).

Honeybush species of commercial importance are (i) *Cyclopia genistoides, Cyclopia intermedia*, and *Cyclopia sessiliflora* (resprouters) and (ii) *Cyclopia maculata, Cyclopia subternata* and *Cyclopia longifolia* (reseeders) (Joubert et al., 2011). In the past, approximately 80% of bulk honeybush production was harvested from the wild – sometimes unsustainably (Karsen et al., 2022). The wet material was processed at one of the five processors and sold to local and export markets (McGregor, 2024). Over the years, the industry has seen a fluctuation in honeybush production. Based on Perishable Products Export Control Board (PPECB) figures (for export tonnage), honeybush tea exports grew from 50 tonnes in 1999 to a peak of 632 tonnes in 2011 (Karsen et al., 2022). In 2016, approximately 800 tonnes of wet material harvested from the wild produced about 400 tonnes of dry honeybush tea (Table 1) (McGregor, 2024). There was a substantial decline in 2017 to 195 tonnes and a later increase to 584 tonnes in 2019 (Karsen et al., 2022). However, a notable breakthrough in the industry occurred in 2022–2023 whereby 53% of the bulk annual harvest mainly came from cultivated stands (Table 1) of *C. subternata, C. genistoides and C. longifolia*. The remaining 47% of the annual harvest, 585 tonnes of wet tea, which produced 292.5 tonnes of dry tea (McGregor, 2024), came from wild-harvested populations of *C. intermedia* and *C. subternata,* with a small share from *C. maculata, C. sessiliflora* and *C. plicata* (McGregor, 2024).

**Table 1:** An estimation of change (according to processor estimates) in annual production volumes in the cultivated industry relative to the wild industry (derived from original values from McGregor, 2024).

| Year | *Dry tea (total tonnes) | *Wet tea (total tonnes) | Wild-harvested material (wet tea; tonnes) | Cultivated material (wet tea; tonnes) |
|---|---|---|---|---|
| 2016 | 400.02 | 800.04 | 544.27 (≈ 85% *C. intermedia*)<br>64.05 (≈ 10% *C. subternata*)<br>32.03 (≈ 5% other) | 159.7 (≈ 20%) |
| 2023 | 292.50 | 585.00 | 261.21 (≈ 95% *C. intermedia*)<br>13.75 (≈ 5% *C. subternata*) | 310.04 (≈ 53%) |

***Moisture loss is calculated at 50%, although *Cyclopia subternata* moisture loss and cultivated tea moisture loss may be as high as 60%. **Wet tea refers to the biomass delivered to the processor.**

As the honeybush tea industry grows, it is important to understand the interplay between the different honeybush species and the surrounding fynbos environment. The biome currently has the highest number of threatened ecosystem types (Skowno et al., 2018), and is also threatened by IAPs, rapid urbanisation, flooding, inappropriate fire regimes and unsustainable flower harvesting practices (Heydenrych et al., 1999). Therefore, in a rapidly changing world, the honeybush tea industry (which forms part of the agriculture sector, which underpins global food security and well-being) needs to also shift to more sustainable forms of production to ensure that it is viable in the long term (Voora et al., 2022).

## 1.2) Motivation

There is a growing market for tea, which after water, is the most frequently consumed beverage in the world (Prathibhani et al., 2018). The global tea trade is valued at approximately USD 9.5 billion with global tea production amounting to over USD 17 billion annually (FAO, 2022). Honeybush tea, whose nutraceutical benefits align with growing health-conscious lifestyles (Joubert et al., 2011), has the potential to gain greater recognition in the global tea market. Additionally, honeybush tea is a 'BioTrade' resource (i.e., a product derived from biodiversity and traded from agricultural, forestry and wildlife production systems) (Lusweti et al., 2020; Ortiz et al., 2021). It is governed by BioTrade initiatives (BTI) that ensure that the "collection, production, transformation, and commercialisation of goods and services derived from native biodiversity are environmentally, socially and economically sustainable" (Stamboulakis & Sanderson, 2020: 509). In a presentation to honeybush stakeholders at a workshop organised by George municipality, in Uniondale in 2014, Professor Richard Cowling (fynbos botanist and globally renowned conservationist) emphasised the need for the cultivated honeybush industry to develop, in ways that did not impact the remarkable biodiversity of the fynbos, and produce a desirable locally adapted product and would open export markets based on environmentally-friendly practices (George Municipality, 2014). Cowling further cited the significant damage to fynbos diversity (specifically, endangerment of 149 fynbos taxa) resulting from the development of lands for rooibos cultivation in previously undisturbed montane vegetation communities as a lesson of what not to do (George Municipality, 2014). However, to further promote honeybush tea cultivation, the challenges that hindered the industry need to be understood.

In the past, the bulk annual production of honeybush was derived from wild populations, placing pressure on wild resources and leading to the urgent need for cultivation to supplement the wild-harvested plant material (McGregor, 2017; Joubert et al., 2019). Additionally, thirty years after the commercialisation of the honeybush tea industry, the cultivated sector was still not as successful as anticipated despite extensive research, effort and financial commitment by both private and state stakeholders (McGregor, 2024). Only a few farmers had successfully established economically viable cultivation farms (McGregor, 2024). However, for the first time in the industry's history, the annual harvest from cultivated stands surpassed that of wild-harvested populations in 2022–2023. This is pivotal for the industry, which had previously expressed concern about the decline of wild *C. intermedia* and *C. subternata* (which previously contributed to approximately 95% of wild-harvested crops) due to factors such as unlawful harvesting, fires, overharvesting, and IAP encroachment (DEFE, 2022; Joubert et al., 2011; Karsen et al., 2022). There is now increasing pressure from environmentally conscious agencies to keep reducing pressure on wild honeybush populations while ensuring a consistent supply of high-quality cultivated honeybush products. This research gap will be explored based on McGregor's (2024) recommendation to assess four cultivation models for the species *C. subternata*, *C. longifolia, C. genistoides,* and *C. intermedia,* highlighted in Table 2, to help effectively investigate the cultivation sector.

**Table 2**: The basic 'models' identified through cultivation approaches and honeybush tea species cultivated (McGregor, 2024).

| Survival strategy | Species | Intensity | Water | Cropping |
|---|---|---|---|---|
| Reseeder | *C. subternata* | Intensive, conventional cultivation | Rainfed and/ or irrigated | Every year |
| | *C. longifolia* **(also a resprouter)** | Intensive, conventional cultivation | Rainfed and/ or irrigated | Every year |
| Resprouter | *C. genistoides* | Low density | Rainfed | After at least 2 years |
| | *C. intermedia* | Moderate density | Rainfed | After at least 3 years |

## 1.3) Research aim and objectives

This research aimed to investigate the nature of successful and unsuccessful cultivated honeybush tea enterprises (viewed through the lens of sustainability). The goal was to contribute to a better understanding of a way forward for the cultivated industry.

The objectives of this research were:

1. To create an updated inventory of the cultivated honeybush tea industry.
2. To investigate the environmental, economic, and social practices in successful cultivation enterprises.
3. To investigate the challenges experienced by unsuccessful, transitioning and community enterprises.
4. To develop a sustainable resource use framework considering environmental, economic, and social aspects which might be useful for the honeybush cultivation industry.

## 1.4) Study area

Figure 1 illustrates the geography of the five study sites (Enterprise 1–5) in the Western Cape Province of South Africa. The furthest west site is Enterprise 1 in Bredasdorp and the easternmost is Enterprise 5 in Kurland. A number of honeybush tea enterprises also occur in the Eastern Cape, however, they were not considered for this research. The selection process is further explained in Chapter 3.


**Figure 1:** Location of the five study sites, in the Western Cape Province of South Africa.

This study investigated the research question through a geographical lens. Therefore, it was important to note the geography of the surrounding area of each site from a physical perspective. Physical characteristics (i.e., elevation, geology, lithology, dominant vegetation type and rainfall) were derived from Geographical Information Systems (GIS) datasets. Table 2 summarises the physical characteristics found at each of the study sites. The study sites cover a range of plantation sizes, with the largest being Enterprise 5 in Kurland (67 ha) and the smallest being Enterprise 3 in Sedgefield (5 ha). All the enterprises cultivate at least two different honeybush tea species, except for Enterprises 1 and 3, which cultivate four and three different honeybush tea species, respectively. The enterprises cover a range of elevations from a low elevation of 15 m (Sedgefield) to a high elevation of 461 m (Barrydale) (Council for Geoscience, 2008). All the enterprises are located within the Cape Fold Region, with varying local geology ranging from Bokkveld geology at the westernmost part of the Western Cape, Malmesbury, Kango, and Gariep geology at Sedgefield and Table Mountain geology in the easternmost part of the Western Cape (Council for Geoscience, 2008). The soil composition varies across the study sites. The two sites in the west have shale and sandstone (Council for Geoscience, 2008). Sedgefield has a more complex mix of soils, including phyllite, greywacke, conglomerate and sandstone. The two sites in the east have quartzitic rock, shale, tillite, and sandstone (Council for Geoscience, 2008). The dominant vegetation types for the sites are Mountain Fynbos Vegetation (Enterprises 1 and 2) and Afromontane Forest (Enterprises 3–5) (SANBI, 2018). Finally, regarding rainfall at the enterprises, Enterprises 1 and 2 experience 300–500 mm of rainfall per annum, while Enterprises 3–5 experience higher rainfall, ranging from 900–1 050 mm annually (SANBI, 2018).

**Table 3**: Physical description of study sites and the honeybush tea species cultivated on the five case study enterprises (the research's species of interest is in bold).

| Enterprise | Location | Plantation (ha) | Honeybush species | Elevation (m) | *Geology | *Lithology | ***Vegetation Type | **** Rainfall per annum (mm) |
|---|---|---|---|---|---|---|---|---|
| Enterprise 1 | Bredasdorp | 60 | ***C. genistoides***<br>*C. longifolia*<br>*C. maculata*<br>*C. subternata* | 158 | • Cape Fold Region<br>• Bokkeveld geology<br>• Low mountains<br>• (450–900 m) | Shale and sandstone | Mountain Fynbos Vegetation | 300–500 |
| Enterprise 2 | Barrydale | 8 | ***C. intermedia***<br>*C. subternata* | 461 | • Cape Fold Region<br>• Bokkeveld geology<br>• High mountains<br>• (> 900 m) | Shale and sandstone | Mountain Fynbos Vegetation | 300–500 |
| Enterprise 3 | Sedgefield | 5 | *C. longifolia*<br>*C. maculata*<br>***C. subternata*** | 217 | • Cape Fold Region<br>• Malmesbury, Kango and Gariep geology<br>• Plains and hills<br>• (30–210 m) | Phyllite, greywacke, conglomerate, sandstone, limestone, shale, arenite, dolomite, andesite, basalt, quartzite, arkose, and diamictite | Afromontane Forest | 900–1 050 |
| Enterprise 4 | Plettenberg Bay | 31 | *C. longifolia*<br>***C. subternata*** | 15 | • Cape Fold Region<br>• Table Mountain geology<br>• Coastal forelands<br>• (130–450 m) | Quarzitic, shale, tillite and sandstone | Afromontane Forest | 900–1 050 |
| Enterprise 5 | Kurland | 67.2 | ***C. longifolia***<br>*C. subternata* | 244 | • Cape Fold Region<br>• Table Mountain geology<br>• Coastal forelands<br>• (130–450 m) | Quarzitic, shale, tillite and sandstone | Afromontane Forest | 900–1 050 |

***Geology data was derived from the Council for Geoscience (2008). ** Lithology data was derived from the Council for Geoscience (2008). *** Vegetation Type data was derived from SANBI (2018). **** Rainfall per annum (mm) was derived from Schulze (2007).**

Socio-economic characteristics surrounding the study sites also needed to be discussed to understand the socio-economic context of the study (summarised in Table 4). The 2011 South African National Census was used to describe the population demographics of the towns where the study sites occurred. This dataset was used instead of the 2022 Census data, as it was more detailed. Updated data for the district municipalities was obtained from the 2024–25 Municipal Economic Review & Outlook report for the Overberg and Garden Route Districts. It was important to note the unemployment rate (compared to the provincial rate of 22% (Western Cape Government, 2024b)) and dominating sectors (focusing on the agricultural sector) in the regions.

**Table 4:** Socio-economic characteristics of the population makeup of the municipalities that house the five case study enterprises.

| Enterprise | District & local municipality | Municipality population | Population makeup | *Unemployment rate* | Source |
|---|---|---|---|---|---|
| 1 | Overberg District Municipality (Cape Agulhas Local Municipality) | 37,352 | Coloured (65.7%)<br>Black (14.7%)<br>White (18.2%) | Low | (Western Cape Government, 2024b) |
| 2 | Overberg District Municipality (Swellendam Local Municipality) | 326,975 | Coloured (83.3%)<br>Black (11.9%)<br>White (5.6%) | Low | (Western Cape Government, 2024a) |
| 3 | Garden Route District Municipality (Knysna Local Municipality) | 81,958 | Black (42.3%)<br>Coloured (38.8 %)<br>White (18.5%) | High | (Western Cape Government, 2024a) |
| 4 and 5 | Garden Route District Municipality (Bitou Local Municipality) | 78,845 | Black (52.6%)<br>Coloured (29.2 %).<br>White (18.2%) | High | (Western Cape Government, 2024a) |

***Unemployment rate compared to the Western Cape unemployment rate (22.2% in 2023) (Western Cape Government, 2024b).**

### 1.4.1) Enterprise 1

Bredasdorp is the main economic hub in the Agulhas region, which includes the Agulhas Plain (a species-rich area that is covered in different forms of coastal renosterveld and fynbos (Heydenrych et al., 1999; Bredasdorp, 2022). The R316, R317 and R319 run through Bredasdorp, connecting the town to Arniston in the East, Agulhas in the south and Napier in the west (Bredasdorp, 2022). Bredasdorp falls within the Cape Agulhas Local Municipality. Bredasdorp has a total of 15 524 people (Stats SA, 2011a). Unemployment in the municipality is low at 12.4 % (compared to the Western Cape rate of 22.2%) (Western Cape Government, 2024b). Regarding income, 8.8% of the population have no income, 1% make between ZAR 1–ZAR 9,600 and the bulk of the population (39.8%) make between ZAR 19,601–ZAR 76,400 (Stats SA, 2011a). The economy is dominated by insurance real estate, finance, and business, providing the largest GDPR share (27.8 %) (Western Cape Government, 2024b). Primary production in agriculture, forestry and fishing comprised 7.2 % of the Agulhas GDPR, representing a decline in production for 2022–2023 (Western Cape Government, 2024b). The decline has been attributed to climate-related impacts, poor infrastructure, a skilled labour shortage and vandalism (Western Cape Government, 2024b). Nonetheless, the agricultural sector is significant in employment terms (creating 2,805 new jobs along the agricultural value chain in 2023), representing a growth of 8.0% (Western Cape Government, 2024b). In total, primary agricultural activities support around 14 000 jobs in the Agulhas municipality (Western Cape

Government, 2024b). The export of cut-flowers and foliage from the fynbos (valued at ZAR 85 million in 2023) serves as the area's top agricultural export (Western Cape Government, 2024b).

### 1.4.2) Enterprise 2

Barrydale falls within the Swellendam Local Municipality. Swellendam, rich in diverse agricultural activities such as the production of a variety of crops, citrus, canola and vegetables, leads in global youngberry production (Western Cape Government, 2024b). The town, supported by a moderate climate and fertile soil, also thrives in sheep and dairy and farming (Western Cape Government, 2024b). Barrydale has a total population of 4 156 people (Stats SA, 2011b). Regarding income, 4.6% of the population have no income, 4.7% make between ZAR 1–ZAR 9,600 and the bulk of the population (50.2%) make between ZAR 19,601–ZAR 76,400 (Stats SA, 2011b). Swellendam has the lowest unemployment rate (10.6% in 2023) in the Overberg District (Western Cape Government, 2024b). It is also substantially lower than the Western Cape's rate. Swellendam contributes 13% to both GDPR and employment in the Western Cape (Western Cape Government, 2024b). The economy is dominated by insurance real estate, finance, and business, providing the largest GDPR share (32.1%), followed by accommodation, catering and retail trade (15.6%) (Western Cape Government, 2024b). Primary production in agriculture, forestry and fishing comprised 10.5 % of Swellendam's GDPR (Western Cape Government, 2024b).

Within Swellendam's employment landscape, most jobs are in the primary agriculture, retail sectors and tertiary wholesale sectors (Western Cape Government, 2024b). Over the years, the agriculture sector has grown (mainly for trees, nuts, and bush fruits) to 1 655 jobs in 2023 (Western Cape Government, 2024b). However, in 2023, the agricultural sector saw an overall decline at negative 0.6% (Western Cape Government, 2024b). These trends have been attributed to climatic conditions, mechanisation, market demand, and farming technique improvements (Western Cape Government, 2024b). Overall, in the Overberg District, it has been noted that the "vulnerability of the agriculture industry to climate change underscores the importance of diversifying the economic base while fostering resilience and sustainable growth" (Western Cape Government, 2024:91). Regardless, the agricultural sector positively contributes to economic stability and rural employment (Western Cape Government, 2024b).

### 1.4.3) Enterprise 3

Sedgefield falls within the Knysna Local Municipality. It has a total population of 8 286 people (Stats SA, 2011e). Regarding income, 17.7% of the population have no income, 5.8% make between ZAR 1–ZAR 9,600 and the bulk of the population (43.5%) make between ZAR 19,601–ZAR 153,800 (Stats SA, 2011e). Unemployment is quite high in the Knysna Local Municipality at 27.7 % (compared to the Western Cape rate) (Western Cape Government, 2024a). The economy is dominated by insurance real estate, finance, and business, providing the largest share of the GDPR (35.1 %), while tourism-related industries (i.e., accommodation, retail trade and catering) are the second largest contributor (15.9 %) (Western Cape Government, 2024a). Primary production in agriculture, forestry and fishing made up only 4.0% of the GDPR, representing a decline in production for 2022–2023 (Western Cape Government, 2024a). The agricultural sector is a key employer in the municipality, accounting for most new employment opportunities (7.8 % growth) in mixed farming, melon and cereal cultivation, which created close to 150 new jobs in 2023 (0.6% of the total new jobs in the municipality for 2023) (Western Cape Government, 2024a).

### 1.4.4) Enterprise 4 and 5

Kurland is 20 km away from Plettenberg Bay. The village was named after Baron Ulrich Behr von Kurland, who owned and resided in the area in the 1950s (Stats SA, 2011d). His family planted pine plantations and fruit orchards, providing employment opportunities to residents (Stats SA, 2011d). Kurland falls within the Bitou Local Municipality (Stats SA, 2011d). Kurland has a total population of 4 033 people (Stats SA, 2011d). Regarding income, 16.6% of the population have no income, 4.4% make between ZAR 1–ZAR 9,600 and the bulk of the population (50.6%) make between ZAR 9,601–ZAR 38,200 (Stats SA, 2011d). Enterprise 5 falls on the coastal forelands in Bitou, Western Cape. The town also falls within the Bitou Local Municipality. The town has a total population of 4 954 people (Stats SA, 2011c). Regarding income, 8.9% of the population have no income, 3.1% make up ZAR 1–ZAR 9,600, the bulk of the population (30.4%) makes between ZAR 38,200–ZAR 153,000 and 15.4% make between ZAR 153,801–ZAR 307,600 (Stats SA, 2011c).

Unemployment is high in the Bitou municipality (compared to the Western Cape rate at 32.4 %, which is close to the national average of 33.5%) (Western Cape Government, 2024a). The economy is dominated by finance, insurance real estate and business, providing the largest share of the GDPR (37.4%), while tourism-related industries (accommodation, retail trade and catering) are the second largest contributor (Western Cape Government, 2024a). Despite the seasonal nature of the Bitou Local Municipality, tourism is a key feature of the economy in terms of job creation and economic activity (Western Cape Government, 2024a). Primary production in agriculture, forestry and fishing comprised only 5.5% of the Bitou GDPR, representing a decline in production for 2022–2023 (Western Cape Government, 2024a). The decline was attributed to environmental challenges such as a variable climate (Western Cape Government, 2024a). The agricultural sector showed an 8.2% growth in employment for the same period, second to the transport, storage, and communication sectors (Western Cape Government, 2024a). This is significant because it mainly employs unskilled workers. Furthermore, agricultural products from the area, largely high-value fresh fruit, dominate the export market (Western Cape Government, 2024a).

## 1.5) Research Outline

**Chapter 1: Introduction**

This chapter introduced the overarching theme that underpinned this thesis: *sustainability*. Embedded in this theme was the cultivated honeybush tea industry. This chapter presented the industry's potential to play a significant role in the expanding global tea market. The challenges and benefits associated with the industry were also briefly presented. This chapter ensured that the research gap was identified, and intentions (aim and objectives) to fulfil the research gap were presented. This chapter concluded with a presentation and summary of the study area, highlighting the five study sites' different physical and socio-economic characteristics.

**Chapter 2: Literature review**

This chapter will explore the literature (from scientific, grey literature, and popular sources) that pertains to situating and understanding the aspects of the sustainability of the cultivated honeybush industry. The overarching theme, which also served as a conceptual framework for the research, is 'sustainability'. In particular, the sustainability framework from the Union for Ethical BioTrade (UEBT) is used. Major themes pertinent to understanding the research include *agriculture* (sub-themes: land-use and land-cover change (LULCC), regenerative agriculture, agriculture challenges and agriculture regulations), *sustainability* (sub-themes: biodiversity, ecology, and geography) and *sustainable agriculture* (sub-themes: livelihoods, 'BioTrade', and standards). Finally, this chapter explored the philosophical and methodological frameworks necessary for the research.

**Chapter 3: Methods of data collection and analysis**

This chapter will present how the data for each objective were collected and analysed. Before conducting this research, the cultivated honeybush tea industry's inventory for the Eastern and Western Cape will be updated. Using Desktop GIS, the following data will be updated: the number of farms, processors, the status of each farm, types of species per farm, the number of hectares per farm, the proximity of the closest processor to each farm and whether the farmer has a processor. Five successful enterprises will be selected, and their environmental, economic, and social practices will be investigated (using a range of mixed methods to collect and analyse the data). The challenges experienced by unsuccessful, transitioning and community enterprises will be investigated. Finally, a sustainable resource use framework, considering environmental, economic, and social aspects, will be created and explored in Chapter 5.

**Chapter 4: Results**

This chapter will explore the results of this research's objectives. For Objective 1, the map of the cultivated honeybush tea industry's inventory will be analysed. For Objective 2, the semi-structured interviews conducted at the five successful enterprises will be analysed. The land cover and species distribution maps of the study sites will be analysed. Regarding the quantitative results, the plant allometry measurements and biodiversity and soil surveys will be analysed. For Objective 3, the challenges experienced by unsuccessful, transitioning and community enterprises will be analysed.

**Chapter 5: Discussion and conclusion**

The final chapter will synthesise the findings from all the chapters into a comprehensive discussion and provide a sustainable resource use framework. This chapter will also recognise the research's limitations and present a potential way forward for the industry.

**KEY FINDINGS**

**CHAPTER 1**

There is a growing tea market, which is the most frequently consumed beverage in the world after water. The South African agricultural sector can benefit from this opportunity using its growing honeybush tea industry. The industry has the potential to gain greater recognition in the global tea market due to;

- its vast geographical range and ecology that allows for different cultivation approaches
- its nutraceutical benefits which align with growing health-conscious lifestyles
- being a unique, indigenous 'BioTrade' resource
- contributing to the local livelihoods of farmers, harvesters and processors.

For the first time in the industry's history, the annual harvest from cultivated stands surpassed that of wild-harvested populations in 2022–2023. This was pivotal for the industry which saw the decline of two fundamental species (that previously contributed to approximately 95% of wild-harvested crops) due to factors such as unlawful harvesting, fires, overharvesting, urban expansion, and IAP encroachment.

**RESEARCH GAP:** There is now an increasing demand to keep reducing pressure on wild honeybush populations while ensuring a consistent supply of high-quality cultivated honeybush products.

Findings from the study area highlighted the diverse environmental and socioeconomic characteristics across the five study sites, located between Bredasdorp and Kurland in the Western Cape, which could influence the cultivated honeybush tea industry. The spatial variability of environmental factors (such as elevation, geology, soil composition, vegetation type, and rainfall) could lead to understanding the interplay between vegetation types, terrain and rainfall patterns in shaping the agricultural potential for honeybush tea (especially in regions with high unemployment rates). It could also help provide valuable insights into sustainable cultivation practices in different geographical contexts.

# CHAPTER 2

## 2) Literature review

This chapter reviewed existing literature on the sustainability of the cultivated honeybush tea industry to identify knowledge gaps and motivate this research. It has been established that, historically, the majority of annual honeybush production was sourced from wild populations, which placed pressure on wild resources (Joubert et al., 2011). This led to the urgent need for cultivation to supplement the wild-harvested plant material (Joubert et al., 2019; McGregor, 2017). Thirty years after the commercialisation of the honeybush tea industry, the cultivated sector is still not as successful as anticipated (McGregor, 2024). However, for the first time in the industry's history, the annual harvest from cultivated stands surpassed that of wild-harvested populations in 2022–2023. This was pivotal for the industry, which had previously seen the decline of two major honeybush species (which previously contributed to approximately 95% of wild-harvested crops) (DEFE, 2022; Joubert et al., 2011; Karsen et al., 2022). *Reducing pressure on wild honeybush populations while ensuring a consistent supply of high-quality cultivated honeybush products* is a logical approach to developing the industry. With this research gap identified, this research aimed to investigate the nature of successful and unsuccessful cultivated honeybush tea enterprises, analysed through the lens of sustainability.

This literature review focuses on the three pillars of sustainability: social, economic and environmental. This approach aligns with the research's second objective, which focused on investigating the social, economic, and environmental practices in successful cultivation enterprises. While the third objective seeks to investigate challenges experienced by unsuccessful, transitioning and community enterprises. Understanding these challenges could therefore help understand how to sustain successful enterprises. This chapter is thus framed by the conceptual model presented in Figure 2. This diagram illustrates a sustainability framework for the cultivated honeybush tea industry, which was used to explore how the various relevant concepts were aligned or interconnected. The diagram is a comparison based on the 'wild honeybush landscape' conceptual model developed by McGregor (2017) to develop the wild honeybush harvesting guidelines.

Figure 2 consists of two major components: overarching knowledge, which is positioned over the cultivated honeybush tea industry. The first component is the overarching theme of this research: sustainability. This foundation further branches into the major concepts: social, economic and environmental sustainability. Other areas of conceptual knowledge include land use/land cover (LULC), livelihoods (shared between social and economic sustainability), BioTrade (shared by social and environmental sustainability), regulations, agriculture, sustainable agriculture practices, and the cultivated honeybush tea industry (shared by social, economic and environmental sustainability) and fynbos, ecology, biodiversity, natural resource management, and GIS applications (environmental sustainability). The lower half of the diagram depicts the cultivated honeybush tea industry, consisting of a supply chain from cultivated honeybush resources harvested by enterprise staff and delivered to processors. They all depend on the landowners, farmers, and land uses, including private land and community enterprises (who control the use of the land resource in a private or community context) at the base. The overarching goal is to achieve a consistent, quality supply of cultivated honeybush tea, which could be achieved by harmonising social, economic, and environmental aspects within a formal sustainability framework (such as the UEBT Framework, which will be discussed later in this chapter). The conceptual model illustrates the relationship between social and economic well-being, sustainable resource use, and environmental conservation, which must be maintained for the long-term viability of the cultivated honeybush tea industry.

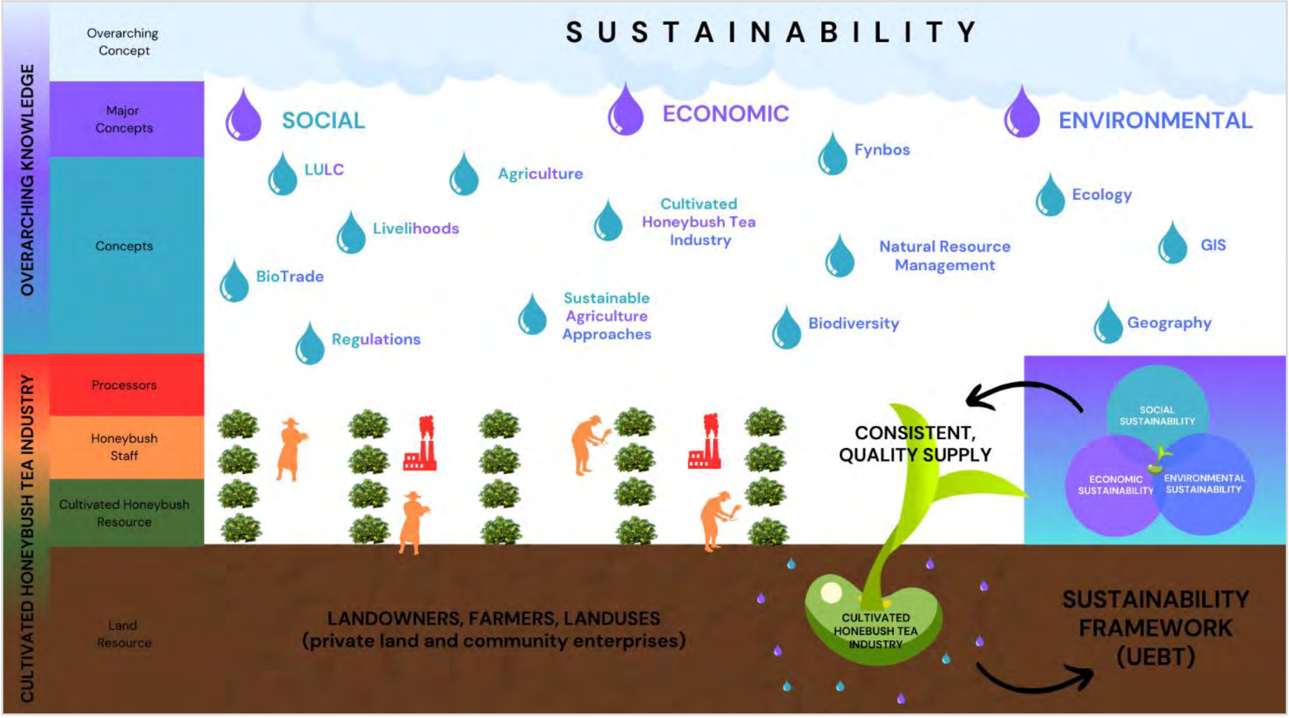


**Figure 2:** Conceptual model to guide understanding of the literature review. The model presents the overarching, major and general concepts that form the overarching knowledge foundation of the research. Beneath is the cultivated honeybush tea industry's main supply chain (which consists of the cultivated honeybush resource, harvesters, and processors). The diagram illustrates how the relationship between social and economic well-being, sustainable resource use, and environmental conservation works together for the long-term viability of the cultivated honeybush tea industry.

This literature review will be broken down into three main sections: (A) Overarching knowledge (social, economic and environmental sustainability), (B) Cultivated honeybush tea industry, and (C) Literature on research philosophy and methodology. As illustrated in Figure 2, environmental sustainability is a substantial element of the sustainability framework. It is worth exploring how historical environmental practices led to key aspects such as biodiversity preservation, sustainability and resource conservation. Therefore, addressing this component first will contribute to a better understanding of social and economic sustainability.

**Component A: Overarching knowledge**

## 2.1) Biodiversity

### 2.1.1) The concept of 'biodiversity'

Since the 1970s, human impacts on the earth have drastically increased to keep up with the increasing demands (which subsequently began to exceed supply) for food, timber, and energy (Lambin et al., 2003; Minta et al., 2018; Díaz et al., 2019). In the 1980s, global alarm arose at the rate at which species loss occurred within different ecosystems (Cardinale et al., 2012). Furthermore, global assessments reported that the average rates of population extirpations and population extinctions were increasing (Lewis & Maslin, 2015). It was estimated that 705 vertebrate species and 571 plant species were driven to extinction since the 1500s (Díaz et al., 2019). Research showed that species loss led to the alteration of ecosystem structures and functions (Cardinale et al., 2012). This led to the adoption of the concept of 'biological diversity' and a widely cited definition of the time was, "the variety and variability among living organisms and the ecological complexes in which they occur" (CBD, 1999). Additions to the definition were made by Norse (1986) who added three levels to the concept which were genetic diversity (diversity within an organism), species diversity (diversity within a species) and ecological diversity (diversity within a community) (Yankelevich, 2007).

In 1985, the term "biodiversity", a contraction of 'biological diversity', was coined, prompting a surge of research in the 1990s that focused on the effects of biodiversity loss on ecosystems and their ecosystem services (ESS) (Yankelevich, 2007; Cardinale et al., 2012). Noss (1990) proposed using a hierarchical characterisation of biodiversity as a conceptual framework to assess and monitor its overall changes at different levels of organisation, spatial scale and temporal scales. It recognised three major components of ecosystems: (i) structure (pattern or physical organisation of a system), (ii) function (evolutionary and ecological processes) and (iii) composition (variety and identity of elements that are found in a collection) (Noss, 1990). Although the term biodiversity has evolved, a current comprehensive definition which extends from the early definition is, "The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part" (Díaz et al., 2015: 16). Furthermore, the definition also considers "the variation in genetic, phenotypic, phylogenetic, and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems" (Díaz et al., 2015: 16).

### 2.1.2) Global biodiversity regulations and frameworks

In 1992, the issue of biodiversity loss was addressed at the Earth Summit, involving 178 participating countries, which signed documents and treaties that addressed biodiversity loss (Cardinale et al., 2012). Several bodies and instruments, supplemented by regional and national laws, were established to promote and regulate biodiversity (Stamboulakis & Sanderson, 2020). One of these bodies was the Convention on Biological Diversity (CBD), a global legal framework and governance placed to protect natural resources (Stamboulakis & Sanderson, 2020). Countries that are signatories to the CBD need to produce a National Biodiversity Strategy and Action Plan (NBSAP), an integrated national strategy for the management, conservation, and sustainable use of biodiversity (Government of South Africa, 2015). Another body is the Nagoya Protocol of 2010, an international agreement which aims to ensure that benefits from genetic resources are fairly and equitably shared (Stamboulakis & Sanderson, 2020). The Nagoya Protocol was an achievement in international biodiversity policymaking for global environmental governance (Buck & Hamilton, 2011). Additionally, a 10-year flexible framework, known as the Strategic Plan for Biodiversity 2010-2020, was established, comprising 20 Aichi Biodiversity Targets (Stamboulakis & Sanderson, 2020). The Aichi Biodiversity Targets are divided into five strategic goals below:

A) "Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society"
B) "Reduce the direct pressures on biodiversity and promote sustainable use"
C) "Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity"
D) "Enhance the benefits to all from biodiversity and ecosystem services" and
E) "Enhance implementation through participatory planning, knowledge management and capacity building" (CBD, 2010; Buchanan et al., 2020; Stamboulakis & Sanderson, 2020).

However, it is noted that none of the Aichi Biodiversity Targets to halt biodiversity loss were achieved by the 2020 target date (Ortiz et al., 2021). During the United Nations Conference on Sustainable Development in 2012, the Sustainable Development Goals (SDGs) were developed to create global goals that address environmental, political and economic challenges (Ortiz et al., 2021). Two goals that apply to biodiversity are to address maintaining life on land and in the water (Ortiz et al., 2021). In 2022, the COP15 summit was held, and the Kunming-Montreal Global Biodiversity Framework (GBF) was established (CBD, 2022). This framework was designed to guide global efforts toward minimising biodiversity loss and sustainably using natural resources (especially while preserving ecosystem health) (CBD, 2022). It presented new targets to be achieved by 2030, which included restoring 30% of degraded ecosystems, conserving 30% of land and marine areas, and halving invasive species introductions (CBD, 2022).

### 2.1.3) Issues of biodiversity loss

Since 2001, the International Union for Conservation of Nature (IUCN) Red List (the standard utilised for evaluating species extinction risk) has classified 8 688 species as threatened or near threatened (Maxwell et al., 2016). Approximately 21 000 species of plants and animals are threatened with extinction due to drivers such as land-use change, habitat fragmentation, overexploitation, pollution and invasive species (Tilman et al., 2017; Ortiz et al., 2021). The two major drivers of biodiversity loss are overexploitation (where reproduction and regrowth of harvested species in the wild cannot compensate for the rate at which they are being harvested) and habitat fragmentation (due to agriculture to produce food, fibre, fodder, and fuel crops) (Maxwell et al., 2016). In 2016, 72% of species were exploited for commerce, subsistence, or recreation, leading to overexploitation (Maxwell et al., 2016). Additionally, the intensification and expansion of agricultural activities impacted 62% of species (Maxwell et al., 2016). Globally, agricultural-driven land-use change is especially recognised as being associated with biodiversity loss, whereby the loss and degradation of habitats are linked to direct threats to mammals and birds (Tilman et al., 2017). In 2017, 80% of the threatened species were especially endangered by habitat loss caused by agriculture (Tilman et al., 2017). In Southeast Asia, for instance, oil palm cultivation has contributed to substantial habitat loss (Tilman et al., 2017).

### 2.1.4) Ecosystem services (ESS)

The interplay between nature and society has a substantial history and cannot function in isolation from each other (Folke et al., 2011). This paradigm shift was acknowledged and supported by the Millennium Ecosystem Assessment (MA) of 2005 (Folke et al., 2011) with the understanding that humans are embedded in complex social-ecological systems (SESs) (Ostrom, 2009). Complex SESs can further be divided into subsystems: resource system, resource units, users, and governance structure and these components operate amongst and within each other (Ostrom, 2009). Within these systems, humans rely on the natural resources derived from nature to provide for their basic needs, and thus their well-being (Prip, 2018). These resources are called ecosystem services (ESS) and are a key concept in sustainable development (Prip, 2018). ESSs are divided into four categories which include; (i) *provisioning services* which are direct products derived from an ecosystem (e.g., food, water and fuel), (ii) *regulating services* which are the benefits that are derived through the regulation of the processes of ecosystems (e.g., water purification, flood attenuation and pollination), (iii) *supporting services* which are the benefits that are vital for all the ecosystems to function (e.g., soil formation and nutrient cycling and soil formation) and (iv) *cultural services* which are the non-tangible benefits derived from ecosystems (e.g. tourism and aesthetic enjoyment) (Prip, 2018). These services contribute to the well-being of humans and according to the MA, biodiversity is significant in terms of provisioning ESSs (Prip, 2018).

### 2.1.5) Biodiversity and BioTrade

The global population is set to increase to 10 billion people in 2050, prompting more research and policies for sustainable ways to feed and sustain the population (Ortiz et al., 2021). In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released an assessment report noting that biodiversity is still declining at unprecedented rates (Stamboulakis & Sanderson, 2020). Stamboulakis and Sanderson (2020) note that many Aichi Biodiversity Targets would not be achieved if these trends continued. Since biodiversity underpins services and functions essential to anthropogenic practices (i.e., agriculture), impacts on nature should be addressed (Ortiz et al., 2021). However, nature and its governmental regulation aren't the only factors that should be considered in the context of biodiversity (Stamboulakis & Sanderson, 2020). The authors argue that consumer concerns regarding where natural ingredients are sourced to improve biodiversity should also be considered, especially with the overarching CBD policies

(Stamboulakis & Sanderson, 2020; Bakouan & Sawadogo, 2024). In this regard, public (i.e., government legislature), private (i.e., private bodies and their standards) and markets should regulate the natural resource-sourcing practices that promote and achieve biodiversity (Stamboulakis & Sanderson, 2020).

The marrying of the components was aided by the United Nations Conference on Trade and Development (UNCTAD) by introducing the BioTrade Initiative (BTI). BioTrade comprises products derived from biodiversity and traded (i.e., food, timber, ornaments, instruments, souvenirs, and non-wood forest products (NWFPs) from agriculture, forest and wildlife) (Lusweti et al., 2020; Ortiz et al., 2021). The products are sourced through cultivation (in domo) or from protected areas and natural forests (in situ) (Lusweti et al., 2020). The goal of the BTI is to ensure that 'activities of collection, production, transformation, and commercialisation of goods and services derived from native biodiversity under the criteria of environmental, social and economic sustainability' (Stamboulakis & Sanderson, 2020: 509; Ortiz et al., 2021). The BioTrade industry is dominated by medicinal plants (used to consume, improve health or heal diseases) which are recognised by the World Health Organisation (WHO) (Lusweti et al., 2020).

In 2011, the global annual trade in medicinal plants was approximately USD 2.2 billion and comprised 50,000 to 70 000 medicinal and aromatic plant (MAP) species in traditional and conventional medicine (Lusweti et al., 2020). In 2002, countries with substantial MAPs were China (4 941 MAPs), India (3 000), USA (2 564), Vietnam (1 800) and Indonesia (1 200) (Schippmann et al., 2002). Biotrade of MAPs is also important for African countries which housed approximately 5 400 MAPs in 2015 (of which 80 MAPs are commercially valuable and traded on international markets) (Van Wyk, 2015). Some African countries have an abundance of MAP species and thus BioTrade potential (i.e., Kenya which had approximately 1 200 MAP species in 2020) (Lusweti et al., 2020). Notable MAPs from South Africa are; *Adansonia digitata* (Baobab; used for its dry fruit pulp to make antioxidants), *Agathosma betulina* (Round leaf buchu; used for its leaves as a urinary antiseptic and food flavourant), *Aloe ferox* (Cape aloe; used for its leaf gel for laxatives, gel drinks and flavourants), *Aloe vera* (Aloe vera; used for its leaf gel for tonic drinks and cosmetic wounds), *Aspalathus linearis* (Rooibos tea; leaves used as an antispasmodic, cosmetics and a health tea), *Cyclopia genistoides* (honeybush tea; leaves used as a mangiferin and a health tea), *Helichrysum odoratissimum* (Imphepho; leaves used for ritual incense) (Van Wyk, 2015). However, many wild MAP species are being overexploited, which has prompted agents to place them into cultivation systems to protect them (Schippmann et al., 2007). It is important to note that a negative externality could be environmental degradation (through conventional agricultural practices) and loss of genetic diversity (Schippmann et al., 2007).

The BTI enables countries to marry biodiversity conservation and economic development through trading biodiversity-based goods and services (Ortiz et al., 2021). It utilises the market to encourage innovation that meets sustainability and environmental concerns while maintaining respect for people and nature (Stamboulakis & Sanderson, 2020; Bakouan & Sawadogo, 2024). To understand the complex positive (indicated by a (+)) and negative (indicated by a (-)) connections between biodiversity, agriculture, trade, climate and drivers of biodiversity loss, Ortiz et al. (2021) provide an environmental-agriculture-trade framework illustrated in Figure 3. BioTraded goods and services exist in a complex system which includes negative impacts. For instance, BioTrade has had a role in exacerbating global income inequality, as seen in the study by Bakouan et al. (2024), through investigating the effect of BioTrade on income inequality across 131 countries from 2010 to 2019. The authors noted that trading biodiversity-based products could exacerbate socio-economic disparities between countries. They further recommend that governments invest in promoting research and development to harness the dividends of BioTrade in reducing income inequality (Bakouan & Sawadogo, 2024)

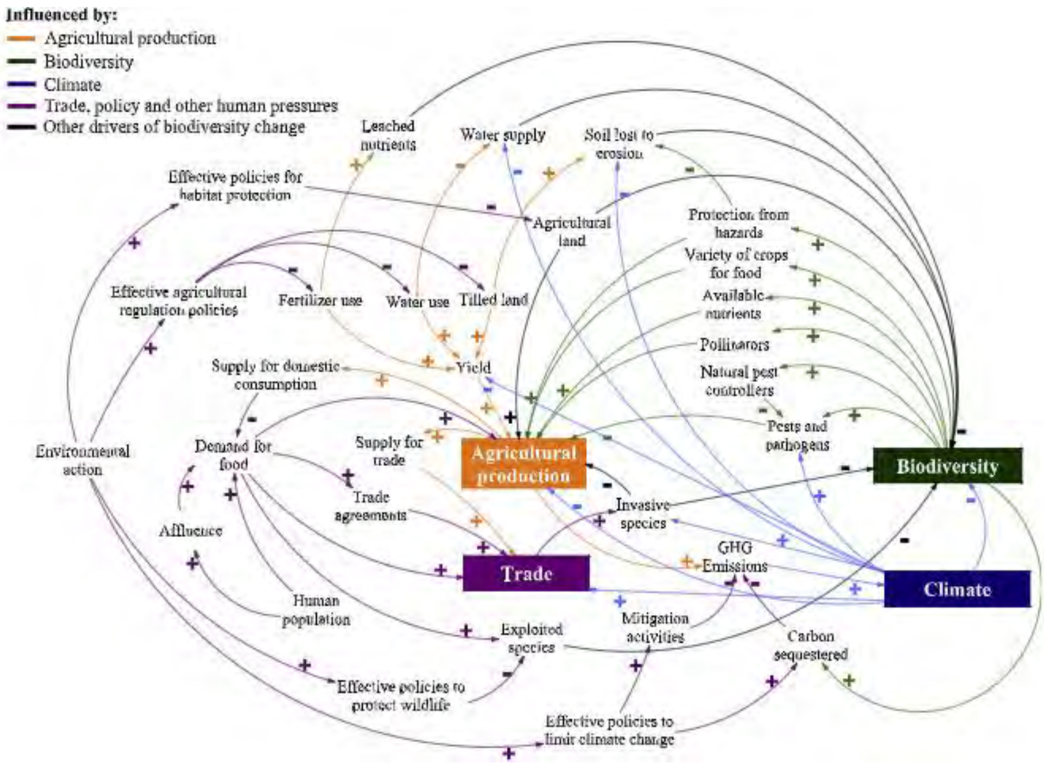


**Figure 3:** Environment-agriculture-trade framework illustrating the influences and connections between 'Agricultural production', 'Trade', 'Biodiversity' and 'Climate' (Ortiz et al., 2021).

The South African Constitution and Bill of Rights indicate that all citizens have the right to have their environment protected, for current and future, use through measures that prevent pollution and environmental degradation as well as promote conservation, sustainable development and use of its rich and unique natural resources (Biggs et al., 2008). Since the country was a participating signatory to the 1992 treaty alongside the CBD, it complies with its policies (Cardinale et al., 2012). Its three major goals are to conserve biodiversity and ensure that the components of biodiversity are used sustainably as well as fairly and equitably shared (Schippmann et al., 2002). One of the policies was the development of a national framework for the integrated management of biodiversity (Biggs et al., 2008). South Africa has exceptional biodiversity and ESS due to its high endemism, species richness and ecosystem types (Skowno et al., 2018). Biodiversity in South Africa is therefore imperative to the economic well-being of citizens since there are approximately 480 00 jobs (which contribute to poverty alleviation, rural development, labour absorption and inclusive growth) directly linked to it (Skowno et al., 2018). In 2002, the CBD adopted the Global Strategy for Plant Conservation, which provided policies that addressed conservation challenges (Schippmann et al., 2002). South Africa follows these policies to ensure the preservation of its plant species (whereby 70% out of approximately 9 600 flora were endemic) (Stoll-Kleemann & O'Riordan, 2002). However, South Africa's biodiversity is substantially threatened. In 2018, the National Biodiversity Assessment (NBA) found that from a species perspective, of the 20 410 plants and 2 911 animals assessed, 14% and 12% were categorised as threatened, respectively (Skowno et al., 2018). The NBA (2018) also found that almost half of the assessed ecosystem types (i.e., terrestrial, river, wetland, marine, estuarine, coastal and sub-Antarctic) were threatened. As a result, approximately two-thirds of ecosystems were placed under protection (Skowno et al., 2018).

South Africa contains the Cape Floral Kingdom (CFK) (one of the world's 25 most endemic-rich hotspots) in the Western Cape, Eastern Cape and Northern Cape provinces. The CFK is largely found in the Fynbos biome, ecologically known to provide stable slopes and reliable water supplies (Stoll-Kleemann & O'Riordan, 2002). The Fynbos is one of the 14 recognised global terrestrial biomes and has substantial importance (Mace et al., 2014). Biomes are considered global-scale systems, distinguishable from each other by their ecosystem collections and species assemblages (Mace et al., 2014).

If a biome can maintain its key functions and structures over the long term, it is considered functionally secure (not just for nature but for human well-being) (Mace et al., 2014). In 2002, species in the CFK supported approximately 300 000 jobs (Stoll-Kleemann & O'Riordan, 2002). The CFK, however, is under threat due to the spread of urban settlements and agriculture (through habitat destruction, fragmentation and degradation) (Stoll-Kleemann & O'Riordan, 2002) In 2017, agriculture contributed to 22.8% of land transformation in South Africa (Dudley & Alexander, 2017). Additionally, unsustainable farming regimes and the misuse of natural resources led to high rates of biodiversity loss (Egoh et al., 2009). South Africa, which holds approximately 1 000 000 species (many of which are endemic), is vulnerable to agricultural expansion and overexploitation (Turpie et al., 2017). Changes in land, therefore, need to be addressed.

## 2.2) Sustainability

### 2.2.1) Sustainable development

According to Randall et al. (1999), the goal of sustainable development is to ensure the present use of ecosystem services (air and water quality and natural resources) meets current needs without being detrimental to the environment, nor hindering the economy and future use by generations (Sneddon, 2000). There is an additional focus on ensuring that the livelihoods of marginalised people are at the forefront of sustainable development discourses (Sneddon, 2000). This focus is relevant to South Africa, which has a history of marginalised people. For instance, in most developing countries, programmes are set to help emerging farmers establish themselves; however, in South Africa, efforts have been unsuccessful (Vink & Kirsten, 2022). South Africa, under the Apartheid government, had an extensive support system for farmers (predominantly white), which helped many agricultural industries grow (Vink and Kirsten, 2022). At present, there are subsidies for black farmers aimed at correcting the former racial biases (Vink and Kirsten, 2022). The authors state that there needs to be an agricultural support framework that is more broad-based, comprehensive, and flexible to enable black farmers to reach higher commercial success and sustainability. Achieving sustainable development requires the balancing of environmental, economic, and social systems, which is also supported by Munasinghe & Schwab (1993). According to Goldman (1995), elements that may need to be sustained within the above systems are; (i) qualities (i.e., soil fertility, species diversity, productivity level, environmental quality, rate of resource offtake or utilisation), (ii) agricultural practices or components (i.e., plant species, cropping systems, cultural knowledge, renewable resource stocks), (iii) social formations (resources use systems, cultures, institutions) and (iv) ecological systems (i.e., biological regions, systems or zones and ecological communities).

### 2.2.2) Sustainable agriculture

In the 20th century, agricultural productivity increased due to fossil fuels becoming cheap and deemed an unlimited energy source (Gomiero et al., 2011). This led to the production of chemical pesticides and fertilisers as well as the mechanisation of agriculture (Gomiero et al., 2011). As a result, agriculture in the United States of America was highly successful. Forty years after World War II, annually setting global records in terms of labour efficiency and crop production (Reganold et al., 1990). Farms were highly mechanised, specialised and largely reliant on fertilisers, borrowed capital and fossil fuels (Reganold et al., 1990). However, many of the farms are currently associated with deteriorating environmental quality, declining soil productivity, threats to human and animal health and reduced profitability (Reganold et al., 1990). As a result, society began investigating conventional agriculture's environmental, economic, and social impacts, pursuing alternative, sustainable practices (Reganold et al., 1990). Sustainable agriculture accounts for several nonconventional agriculture variants, often called 'alternative', 'ecological', 'low input' or 'regenerative' (Reganold et al., 1990). However, for a farm to be sustainable, it must be environmentally profitable and safe, and provide high-quality food in sufficient amounts, while protecting its resources (Reganold et al., 1990; Reganold & Wachter, 2012). Furthermore, farms should rely on renewable resources and ideal natural processes drawn from the farm itself as opposed to relying on purchased materials such as fertilisers (Reganold et al., 1990). Additionally, sustainable agriculture addresses obstacles to global food production such as fossil fuel depletion, high-energy costs, groundwater contamination, human, plant and animal health risks, low farm income and soil erosion (Reganold et al., 1990).

Sustainable agriculture combines traditional conservation-minded farming practices with modern technology, with the central component being the rotation of crops (Reganold et al., 1990). Farmers who practised sustainable agricultural practices reported that their production costs were lower than conventional farms (Reganold et al., 1990). Although the yields from sustainable farms are often lower than those of conventional farms, they often have greater net returns due to the reduced production costs (Reganold et al., 1990). The authors found that yields increased from 10 to 15% more than yields within monoculture farms (farms that only farm one crop). In the agricultural sector, goals for sustainability involve enhancing and maintaining the natural environment, meeting food security needs, contributing to social welfare, and ensuring that there is economic viability (Praneetvatakul et al., 2011). The agricultural sector is especially important to South Africa as it plays a direct and indirect role in socioeconomic development and growth (Mulder and Brent, 2006). There is a general scarcity of agricultural and natural resources in South Africa, which necessitates the implementation of sustainable management practices (Mulder & Brent, 2006). However, to maintain agricultural sustainability over time, agricultural practices need to be assessed (Praneetvatakul et al., 2001).

#### 2.2.2.1) Environmental sustainability

Gomiero et al. (2011) state that agricultural practices (which serve as one of the largest terrestrial biomes occupying 50% of the land surface) will shape the surface of the earth, including its biochemistry, species, and utility to society. Humans are already living beyond sustainability (Gomiero et al., 2011). Furthermore, modern agricultural practices have increased environmental impact and decreased overall efficiency. Environmental costs from agriculture include threats to biodiversity, reduction of water supply and agrochemical pollution and loss of soil fertility (Gomiero et al., 2011). Praneetvatakul et al. (2011) propose environmental sustainability indicators to cover soil, water and human resources at the household and village level, which include soil erosion, water shortage and health impact from pesticide use. Other factors that can be considered are water resources (quantity and quality), soil resources (conditions or loss), plant resources (management, production and biodiversity) and waste management (generation and disposal) (Mulder & Brent, 2006). According to Velten et al. (2015), agricultural environmental sustainability can be production-specific (ecosystem function conservation, natural resource conservation and productive capacity) or non-productive-specific (animal well-being, environment conservation and improvement, and harmony with nature).

**Soil:** Reganold et al. (1990) highlight the significance of soil in agriculture, which is responsible for housing microorganisms (actinomycetes, algae, bacteria, and fungi) whose role is to decompose organic matter, which releases nutrients and generates humus. Bacteria in the soil or the roots of plants (mostly legumes) are responsible for nitrogen fixation, which influences soil production (Reganold et al., 1990). Approximately 40% of global croplands are overgrazed, which reduces fertility and soil erosion (Gomiero et al., 2015). Soil erosion has led to a decrease in approximately 16% of agricultural croplands (particularly in Africa) (Gomiero et al., 2011). Erosion is contributing to the modification of the biogeochemical cycles of carbon, nitrogen and phosphorus (Gomiero et al., 2011). It was found that conventional farming practices tend to leave soil uncovered for long periods, which impacts the Soil Organic Matter (SOM) found in the topsoil (Gomiero et al., 2011). Sustainable practices can protect the soil (Agomoh et al., 2021; Jiang et al., 2022; de Bruyn et al., 2023).

**Water:** In 2011, agriculture used approximately 70% of water, and it was expected to increase by 13% by 2050 (Gomiero et al., 2011). Intensive irrigated agriculture can lead to sanitation and waterlogging, which has led to the loss of approximately 1.5 million ha of global arable land (Gomiero et al., 2011). Agriculture has also led to the contamination of drinking water due to pesticides and fertilisers, eutrophication, leaching and invasive alien species (Gomiero et al., 2011). It is therefore important to use efficient irrigation or rain-fed agriculture (if conditions are favourable) (Gomiero et al., 2011).

**Agrochemicals**: the production of cheap pesticides and chemicals has led to leaching, loss of runoff and volatilisation (Gomiero et al., 2011). Pesticides have led to poisonings (26 million) and deaths (220 000) (Gomiero et al., 2011). Integrated Pest Management (IPM) as well as more organic practices are needed in the future (Gomiero et al., 2011). Jiang et al. **(2022)** found that effective organic fertilisation and crop rotation systems reduced fungal pathogens by over 20%. Regarding biodiversity, there has been a general loss of native habitats and biodiversity due to agricultural expansion and intensification (Gomiero et al., 2011). This is due to the displacement of native, diverse species and the planting of genetically uniform, high-yielding crops (Gomiero et al., 2011).

#### 2.2.2.2) Economic and social sustainability

The technological and economic environment can benefit or constrain agricultural practices (Yunlong & Smit, 1994). Farmers need to consider the costs of inputs, outputs, technologies, transportation, markets and prices to sustain production (Yunlong and Smit, 1994). Additionally, to be technically feasible, there needs to be a project plan with schedules, budget layouts, quality management, risk management and appropriate technology (Mulder & Brent, 2006). They also need to consider whether they will receive sufficient returns for their labour and if they can maintain investments (Mulder & Brent, 2006; Yunlong & Smit, 1994). Economic sustainability focuses on the long-term benefits to the agricultural producers, which focuses on sustaining yields (Yunlong and Smit, 1994). Additionally, it focuses on the viability and economic performance of the farm (Yunlong and Smit, 1994). Farms cannot be sustained with higher costs of production, reduced yield and low farm prices (Yunlong and Smit, 1994). The authors stress the longevity and health of the environmental conditions to help maintain and sustain yields. According to Mulder and Brent (2006), agricultural economic sustainability should also entail a return on the environment, return on investment, community contribution, and profitability. Praneetvatakul et al. (2011) propose economic sustainability indicators at the household and village level, which include productivity of yield, land size and farm labour. According to Velten et al. (2015), agricultural economic sustainability includes development, livelihood, provision of products and a thriving economy (Velten et al., 2015).

#### 2.2.2.3) Social sustainability

There has been interest in improving the lives of marginalised people within the discourses of sustainable development (Sneddon, 2000). According to Yunlong and Smit (1994), social sustainability should address the continual satisfaction of basic human needs such as food, water, and shelter as well as higher necessities such as equity, freedom, education, employment, and recreation. Gomiero et al. (2011) highlight the importance of population dynamics, market forces, agricultural research, access to credit, subsidies and commodity price distortion, availability of natural resources, and production loss in post-harvest storage and management. Mulder and Brent (2006) highlight the importance of representation, community participation, leadership, household food security, employment opportunities and skills development. Velten et al. (2015) highlight the need for acceptability, cultural preservation, equity, justice, fairness, fulfilment of human needs, good working conditions, human health, nourishment, quality of life and strong communities.

#### 2.2.2.4) Sustainable agriculture that keeps nature in mind

Gomiero et al. (2011) propose the use of agroecology (also encouraged by Manyevere & Masarirambi (2023) and Rudolph & Muchesa (2023)), integrated agriculture, organic agriculture, precision agriculture and perennial crops as part of a sustainable agricultural system. Agro-ecology is the holistic study of agro-ecosystems (communities of animals and plants that are integrated with their chemical and physical environment which have been altered by humans to produce fibre, food, or fuel), including the human and environmental elements (Gomiero et al., 2011). Integrated agriculture is a farming method that integrates management practices from organic agriculture and conventional agriculture (Gomiero et al., 2011). For instance, instead of fertiliser, manure can be used (Gomiero et al., 2011). Additionally, pest management can be controlled by releasing parasitoids, crop rotation and cultivating pest-resistant crops (Gomiero et al., 2011; Agomoh et al., 2021; Jiang et al., 2022; de Bruyn et al., 2023). Crop diversification and cultivars can help manage weeds (Gomiero et al., 2011). Organic agriculture follows a strict set of norms that forbid the use of agrochemicals and genetically modified crops (Gomiero et al., 2011). This practice supports the environment by preserving the soil, reducing erosion, and conserving biodiversity, ecological functionality, landscapes, and water (Gomiero et al., 2011). The goal is to produce authentic and fresh agri-food products while respecting the environment and nature (Patarlageanu et al., 2022). Furthermore, the practice is supported by the European Union (who allow foods to be classified as 'organic' if they are 95% organic) (Patarlageanu et al., 2022). However, cons to organic agriculture are lower crop yields and the need for higher land requirements (Lorenz & Lal, 2016). Precision agriculture entails tailoring crop and soil management to fit the different conditions found in each field using drones, Geographical Information Systems (GIS), Remote Sensing (RS), and Global Positional Systems (GPS) to identify, analyse and manage temporal variability, soil spatiality and protecting the environment (Gomiero et al., 2011). Due to the extreme consequences of soil ploughing, perennial crops (long-lived) have been encouraged instead of annuals (Gomiero et al., 2011). This would help reduce the effects of agrochemical use and soil tillage (Gomiero et al., 2011).

Goldman (1995) and Reganold & Wachter (2012) provides a prescription for sustainable agriculture which includes (i) crop rotation, (ii) crop diversification, (iii) nutrient recycling, (iv) soil conservation, (v) low input use of fossil fuels, irrigation water, fertilisers and pesticides. It also highlights the importance of soil conservation and nutrient recycling. Additionally, it stresses the reduced input of fertilisers and pesticides, emphasising the use of natural pest control. Goldman (1995) states that the loss of crops in many African countries (particularly Nigeria and Kenya) is largely attributed to pests and diseases (Goldman, 1995). Additionally, regenerative agriculture could be used whose goal is to provide more from less (less land, greenhouse gas emission, chemical input, soil erosion risk, and energy-based inputs) (Lal, 2020). Lal (2020) provides tenets of regenerative agriculture, which are (i) conservation agriculture (i.e., no-till, residue mulch, cover cropping, complex rotation, IPM and integrated nutrient management (INM)) and (ii) restoration of soil health (i.e., land degradation neutrality, afforestation of denudated hills, wetland restoration).

## 2.3) Land-Use and Land-Cover Change (LULC)

### 2.3.1) Understanding LULC

The United Nations (UN) defines 'land' as a "delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soils and the terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity" (Tizora et al., 2016; Mesene, 2017). Land is an essential natural resource known for its biophysical, economic and social uses (Hailu et al., 2020). The realisation that land surfaces can influence the climate (through modifying surface albedo and thus influencing subsequent energy changes between the atmosphere and surface) sparked research on global environmental change (Lambin et al., 2001, 2003; Musetsho et al., 2021). There was a rise in research on 'land-cover' and 'land-use' however, they were often used interchangeably (Lambin et al., 2003). Table 5 illustrates a range of definitions for the terms.

**Table 5:** Multiple definitions for the terms 'land-cover' and 'land-use' in literature.

| Term | Definition | Source |
|---|---|---|
| Land-cover | "The attributes of the earth's land surface and immediate subsurface, including biota, soil, topography, surface and groundwater, and human structures" | (Lambin et al., 2003: 213) |
| | "Biophysical attributes of the earth's surface" | (Minta et al., 2018:28) (Lambin et al., 2001: 262) |
| Land-use | "Purposes for which humans exploit the land cover. There is high variability in time and space in biophysical environments, socio-economic activities, and cultural contexts that are associated with land-use change" | (Lambin et al., 2003: 216) |
| | "Human purpose or intent applied to these (biophysical) attributes" | (Lambin et al., 2001: 262) |
| | "Human purpose or intent applied to biophysical attributes of the earth's surface" | (Minta et al., 2018: 28) |

Land-cover change (i.e., the change of the biophysical attributes on the surface of the earth (Table 5) is the conversion of a land cover type into another one (Hailu et al., 2020). Additionally, land-cover changes are crucial components of global environmental change and evidence of human activity (Hailu et al., 2020). In contrast, land-use changes modify the land cover based on human decision-making (i.e., for settlement, manufacture, infrastructure, recreation, cultivation, mining and fishing) (Minta et al., 2018; Hailu et al., 2020). Compared to the past, LULC changes have been noted to have increased in intensity, degree and speed (Hailu et al., 2020). Since land use refers to the purposes that humans apply to the natural surfaces (Table 5), identifying the subsequent causes of land-use change, therefore, requires addressing and understanding the factors that are behind land-use decision-making (Lambin et al., 2003). Information on LULC changes is needed for policy-making as well as administrative or business purposes (Hailu et al., 2020). Decisions in this regard can be made according to past, current and future political, economic, social and environmental factors which happen at a local, regional, national or global level (Lambin et al., 2003; Tizora et al., 2016; Minta et al., 2018).

The impacts of land-use/cover change can negatively affect biodiversity and subsequent ecosystem services (through direct change), contribute to land degradation, and hinder the ability of ecosystems to support the needs and well-being of humans (Lambin et al., 2001, 2003; Minta et al., 2018). For instance, to meet the demands of food, fuel and fiber for the growing population, agriculture has expanded into natural biomes such as savannas and forests (Lambin et al., 2003). In 2003, it was estimated that from 1700 to 1900, global cropland had increased from 300–400 million ha to 1 500–1 800 million ha (Lambin et al., 2003). Additionally, the FAO estimated that during the 1990s, 12.2 million ha of forests were lost per year in Latin America for livestock-based agriculture, whereas smallholder farmers were responsible for cropland expansion in Africa (Lambin et al., 2003). Agricultural activity in Ethiopia (which supported the income of 85% of the population and small-holder farmers) contributed to natural resource degradation through deforestation (Hailu et al., 2020).

Additional negative impacts of LULC changes are reduced; stream water quality, forest conditions, ecosystem services, environmental health, and biodiversity conservation (Hailu et al., 2020). However, not all land-use impacts are negative. Land use can contribute to increasing food, fuel and fiber production, ensuring that resources are used efficiently and improving livelihoods (Lambin et al., 2003; Hailu et al., 2020). To understand land-use change, the complex SESs and biophysical drivers of land-use change need to be accounted for at various. Understanding the processes, patterns and impacts of LULC change is necessary to effectively plan biodiversity conservation at the forefront of climate change

(Jewitt et al., 2015). However, specific human-environment contexts in which the drivers of change occur (Lambin et al., 2001).

### 2.3.2) LULC in South Africa

In the case of land-use/cover change in South Africa, its political context (which entails its successive colonial and Apartheid governments that divided the land into separate areas for different race groups) has to be considered when addressing the country's interrelated environmental, economic, social and political environments (Hoffman, 2014). For instance, the environmental history of former black/homeland areas under communal tenure is different to that of white-owned farmland or state-owned conservation areas (Hoffman, 2014). The communally managed areas underwent different population pressures (often overcrowded), resource use, cultivation practices, and tenure arrangements and have thus environmentally developed differently since the Native Land Act of 1913 (Hoffman, 2014). Studies have shown these areas have deteriorated substantially due to over-use, demographic pressures, poor state support and land abandonment (Hoffman, 2014). Cropland abandonment within the homelands of KwaZulu, Transkei, Lebowa, and Venda occurred from 1950 to 2010 due to factors such as encroaching woody vegetation at the expense of grassland cover, rainfall variability and droughts, disinterested younger generations and lack of draught power (Blair et al., 2018). An additional homeland, Bushbuckridge, experienced LULC due to shortages of land, wood and grazing resources, population growth, drought, poor natural resource management governance institutional governance of natural resources (Giannecchini et al., 2007).Since land-use changes have a direct impact on biodiversity and ecosystem services, Biggs et al. (2008) identified and defined the following land-use classes for South Africa, illustrated in Table 6. The land-uses can cause minimal damage to the existing land cover, such as protected areas or moderately used areas. Other land uses may damage and completely alter existing land cover, such as degraded areas, cultivation, plantations and urban areas.

**Table 6:** Land-use classes defined by Biggs et al. (2008) to calculate the Biodiversity Intactness Index (BII) (which is a measure of the change in abundance across biodiversity relative to their pre-colonial state) for South Africa (Biggs et al., 2008: 279).

| Land-use classes | Description |
|---|---|
| Protected | "Minimal recent human impact on structure, composition or function of the ecosystem. Biotic populations inferred to be near their potential |
| Moderate use | Extractive use of populations and associated disturbance, but not enough to cause continuing or irreversible declines in populations. Processes, communities and populations are largely intact |
| Degraded | Extractive use at a rate exceeding replenishment and widespread disturbance. Often associated with high human population densities and poverty in rural areas. |
| Cultivation | Natural land cover replaced by planted crops. Most processes persist but are significantly disrupted by ploughing and harvesting activities. |
| Plantation | Natural land cover permanently replaced by dense plantations of trees. |
| Urban | Natural land cover replaced by hard surfaces such as roads and buildings. Most ecological processes are highly modified." |

Remotely sensed imagery has been a substantial tool in monitoring global LULC change (Jewitt et al., 2015). In South Africa, there were two South African National Land Cover (SANLC) maps that were developed through satellite imagery for the years 1994 and 2000 (both at a spatial resolution of 30 m) (Jewitt et al., 2015). This study analysed the LULC for the KwaZulu-Natal Province where it found that 7.6% of the original natural habitat was lost to anthropogenic transformation (Jewitt et al., 2015). On average, the study found that 1.2% was transformed per annum since 1994 (Jewitt et al., 2015). A 2018 SANLC map was released at 30 m resolution and 80% accuracy (Musetsho et al., 2021). It was used in a study by Musetsho et al. (2021) to analyse the LULC changes in a critical biodiversity area (CBA) in the Limpopo Province (Musetsho et al., 2021). The study found that in 1990, the dominant land cover was thickets and dense bush

(40% cover), woodland (24% land cover) and built-up areas (18% land cover) (Musetsho et al., 2021). However, in 2018, the dominant land cover was woodland (71% land cover) and built-up areas (20% land cover) (Musetsho et al., 2021). The study also found that subsistence agriculture was higher than surrounding waterbodies. The Western Cape Province experienced population growth, urbanisation, migration and development pressures which triggered LULC changes (Tizora et al., 2016). A study by Tizora et al. (2016) used the 1990 and 2013/4 SANLC datasets and found that in 24 years, there was a decrease in plantations, wetlands, grasslands, and barren lands. There was an increase in woodlands, shrubland, thickets, minds and quarries and the urban/built-up area (Tizora et al., 2016). There was a 12% increase in the built-up area in 2014 at the expense of 216 ha of cultivated land, 5 315 ha of low fynbos and 463 ha of plantation (Musetsho et al., 2021). This is an example of anthropogenic pressures at the expense of natural resources. Since the Fynbos biome is of significance to this dissertation, it is important to understand its abiotic and biotic factors.

## 2.4) The Fynbos Biome

The Fynbos Biome, located in the southwestern parts of South Africa, occupies a substantial amount of the Cape Fold Belt (Rebelo et al., 2006). The biome includes wet valleys, mountain chains that extend both north-south and east-west, and lowlands that lie between the mountains and the Atlantic Ocean or the Indian Ocean (Rebelo et al., 2006). The biome is part of the Cape Floristic Kingdom (CFK), which is globally recognised as one of the 'hottest' biodiversity hotspots (Privett et al., 2014). The land area of the CFK is approximately 90 760 $km^2$ of which 68% of the estimated 9 383 species are endemic (Privett et al., 2020). However, climate change and land use changes (i.e., land conversion for agriculture) and invasive species infestations have placed the CFK under pressure (Privett et al., 2020).

The biome comprises three unique, naturally fragmented vegetation types (fynbos, renosterveld and strandveld vegetation) (Rebelo et al., 2006). Within these vegetation types, there is an abundance and diversity of endemic plant species that are small-leaved, adapted to regenerate after fires, adapted to acidic, nutrient-poor sandstone and shale-derived soils, and thrive under wet, mild winters and hot, dry summers (Privett et al., 2014; Karsen et al., 2022). Many of these fynbos plants are commercially harvested or cultivated as cut plants (i.e., *Proteas, Leucospermums* and *Berzelia lanuginosa*), thatch (i.e., *Thamnochortus insignis and Thamnochortus erectus*), essential oils, medical or herbal products and teas (i.e., *Aspalathus linearis* or *Cyclopia*) (Privett et al., 2020; Conradie & Knoesen, 2009; Karsen et al., 2022).

The mean annual precipitation (MAP), averaged across the biome, is approximately 480 mm (Rebelo et al., 2006). The MAP for the fynbos, renosterveld and strandveld vegetation types are 540 mm, 370 mm, and 350 mm respectively (Rebelo et al., 2006). Figure 4 is a map that illustrates the rainfall seasonality, geology, and bioregions within the fynbos. Regarding rainfall seasonality, there is a winter-to-summer gradient from west to east (Schulze, 2007). An even distribution rainfall pattern spans the Western Cape to the Eastern Cape Province (Schulze, 2007). The second largest pattern is winter rainfall found in the Western Cape Province (Schulze, 2007). Energy availability is largely associated with winter rainfall conditions (Allsopp et al., 2014). Regarding the geology of the biome, the Cape Fold Region and Coastal Forelands occupy most of the fynbos area (DEAT, 2001).

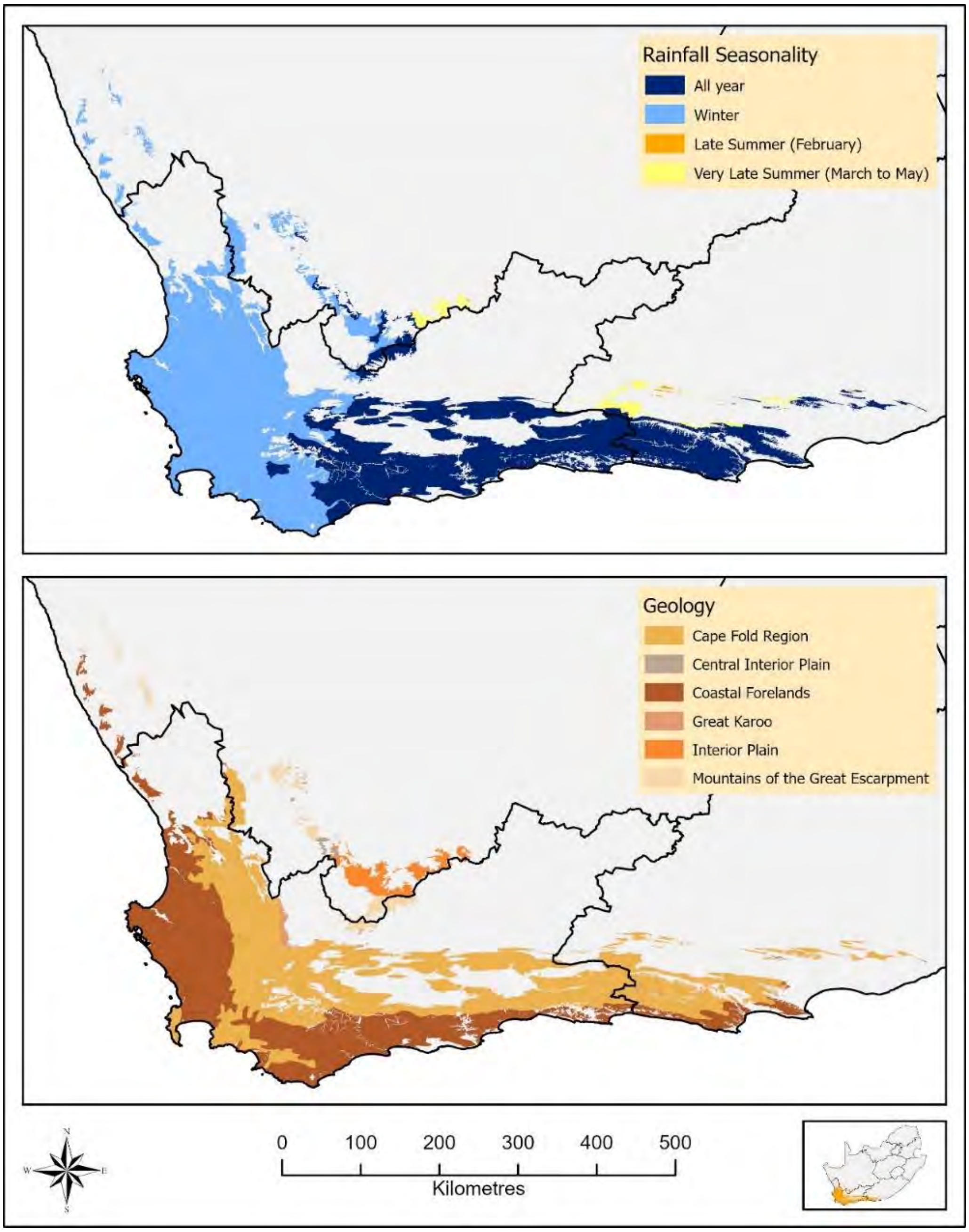


**Figure 4:** Rainfall seasonality (Schulze, 2007) and geology of the Fynbos (DEAT, 2001) in South Africa.

Across the fynbos, fires naturally occur in 10–15-year intervals (van Wilgen, 2013). Additionally, fires are strongly seasonal (concentrated to the west in summer and less seasonal in the east, where rainfall is more evenly distributed across the seasons) (van Wilgen, 2013). The prevalence of fires in the fynbos has resulted in its vegetation developing fire-adapted growth strategies known as sprouters (resprouters) or non-sprouters (reseeders) (Joubert et al., 2011; Allsopp et al., 2014). After a fire, sprouters can either reproduce from seeds (which are stored in the canopy- or soil-stored seedbanks) or they can regenerate from meristematic tissue found in above- or underground stems, branches, and lignotubers (Allsopp et al., 2014; Slabbert et al., 2019). Non-sprouters are fast-growing plants that are tall and thin, have a high biomass yield, and have a prolific seed set (Slabbert et al., 2019). Seedlings propagate from soil-stored seeds which are triggered by smoke and heat which promotes scarification and germination under favourable conditions (Slabbert et al., 2019).

Biodiversity in the fynbos is severely impacted by agricultural and urban expansion, invasive alien infestation, unfavourable fire regimes and unsustainable harvesting practices (Privett et al., 2014). Harvesting wild plant species is a significant economic activity in the CFR related to an increase in demand for fynbos products in local and foreign markets

(Privett et al., 2014). This has exacerbated pressure on natural populations, causing over-harvesting of fynbos species, with social, ecological, and economic consequences (Privett et al., 2014). Over-harvesting may lead to species extinction and negatively impact the ability of fynbos products to deliver to markets (Privett et al., 2014). This threatens the plant species within the biome which includes restios (Restionaceae), ericoid shrubs (fine-leaved Ericaceae) and proteoid shrubs (Proteacea) (Rebelo et al., 2006). Other important taxa within the Fynbos include *Aspalathus linearis* (common name Rooibos; family Fabaceae; tribe Crotalarieae) and *Cyclopia* Vent. *species* (common name Honeybush; family Fabaceae; tribe Podalyrieae) (Joubert et al., 2008; Rebelo et al., 2006). These tea species are important to the South African tea industry, which feeds into the global tea industry.

**Component B: Cultivated honeybush tea industry**

## 2.5) The tea industry

### 2.5.1) Global tea industry: overview, consumption, production and exports

After water, tea (known for its medicinal properties, flavour and brew) is the most frequently consumed beverage in the world (Prathibhani et al., 2018). The global tea trade is valued at approximately USD 9.5 billion with global tea production amounting to over USD 17 billion annually (FAO, 2022). More than 60 countries, primarily found in Asia, Africa, Eastern Europe and South America, cultivate tea (Bermúdez et al., 2024). China, from which tea originated, produces 47% of the world's tea, followed by India which produces 20.5% (Bermúdez et al., 2024; FAO, 2024). Overall, the global tea industry contributes to the emerging economies of tea-producing countries through employment, foreign exchange earnings and government revenue (Prathibhani et al., 2018).

Over the last decade, tea consumption has increased by 2.5% with Africa, East Asia, the Caribbean, Latin America, and the Near East leading the expansion (FAO, 2022). Since then, public interest in locally sourced, organic, and specialised premium teas has increased (FAO, 2022). The demand for organic and natural ingredients has increased leading to diversified blends, and flavours (FAO, 2022). Demand for tea is influenced by demographics such as age, cultural background, education, and occupation (FAO, 2022). Global tea production has increased by 3.2% annually to reach 6.7 million tonnes in 2022 (FAO, 2024). It is projected to rise by 2.0% by the next decade (FAO, 2022). Substantial growth is expected in multiple African and Asian countries (FAO, 2022). Over the last decade, world tea exports have increased annually by 0.5% (FAO, 2022). Exports have since recovered from the COVID-19 pandemic-related downturn in 2020 to an estimated 1.8 million tonnes in 2021 (FAO, 2022). Although the tea industry contributes to economies, many countries face sustainability challenges according to tea industry professionals (Prathibhani et al., 2018).

### 2.5.2) Issues within the tea industry

The tea industry, which forms part of the agriculture sector (which underpins global food security and well-being) needs to shift to more sustainable forms of production to ensure that it is viable in the long term (Voora et al., 2022). Therefore, to ensure the long-term sustainability of the tea industry, the issues of sustainability and climate must be addressed. The tea sector needs to be economically, environmentally, and socially sustainable. An estimated 13 million people depend on the tea industry for their livelihoods (Voora et al., 2022). Economic sustainability therefore needs to encompass the needs of these people, especially smallholder tea producers (who make up 60% of world tea production) and ensure that returns from tea-growing activities can cover household expenditures and production costs (FAO, 2022). Additionally, small-scale farm operations must remain viable (FAO, 2022). Environmental sustainability schemes must encompass biodiversity conservation and soil quality (FAO, 2022). To ensure social sustainability, social standards relating to gender, labour and equality must be adhered to (FAO, 2022). Product diversification and innovation are also required for market expansion (FAO, 2022). To ensure the continuation, resilience, and persistence of the tea industry, countries, therefore, need to preserve the three pillars of sustainability.

Climate needs to be addressed to ensure the long-term sustainability of the tea industry. As a species, tea has limited geographic suitability (related to the present climatic conditions, which include precipitation variability and rising temperatures) (Voora et al., 2022). The tea sector production is vulnerable to climate-related events such as global warming (and subsequent drought regimes) which can negatively impact tea quality and yields (FAO, 2022). Tea is often grown in mono-cropping, rainfed systems thus weather conditions (i.e., rainfall and temperature) can lead to unfavourable or favourable growth conditions or alter the properties, quantity and quality of the tea leaves (Chang & Brattlof, 2015). Adaption methods include diversifying production, organic cultivation, planting stress and drought-tolerant tea cultivars, intercropping tea with tree crops and investing in water conservation technologies (FAO, 2022).

## 2.6) Herbal tea industry: South Africa

Several plants in South Africa have traditionally been used as tea, however, only two Cape fynbos plants: rooibos (*Aspalathus linearis*) and the honeybush genus (*Cyclopia Vent. Species*) have achieved commercial success (Joubert et al., 2008) Both are indigenous herbal teas from South Africa relished for their aroma and taste (Joubert et al., 2008). *Athrixia phylicoides* (bush tea) has also generated interest as a species that could have commercial success (Joubert et al., 2008). The herbal tea industry in South Africa ranges from an established tea industry (rooibos), a developing tea industry (honeybush) and a product that is harvested for home use in predominantly rural areas (not commercialised) (Joubert et al., 2008). The uses of rooibos and honeybush tea originated from a medical perspective but evolved into more non-medical purposes (i.e., drinking for enjoyment) (Joubert et al., 2011). However, the focus has shifted back to tea's medical properties in the present day (Joubert et al., 2011). Compared to Rooibos, the potential for market expansion of honeybush lies in the diversity of the species (Karsen et al., 2022).

### 2.6.1) Case study: Honeybush tea

#### 2.6.1.1) Historical and current uses

In 1772, Carl Thunberg also came across *C. genistoides* (Coastal tea), which was the earliest *Cyclopia* species to be used in the Western Cape (Joubert et al., 2008). *C. longifolia* and *C. latifolia* were also historically used as tea by early colonists (Joubert et al., 2008). By the early 1900s, *C. genistoides* (from the Cape Peninsula) and *C. subternata* (from Caledon and George) formed the bulk supply of the genus (Joubert et al., 2011). Watt and Breyer-Brandwijk (1925) reported the medicinal properties of *C. genistoides* after a decoction of was used as an expectorant and restorative in pulmonary tuberculosis and catarrh in the 1830s (Joubert et al., 2011). Honeybush tea was praised for its ability to: aid weak digestive systems (without stimulating the heart), alleviate nausea and heartburn, stimulate breast milk production and treat colic found in babies (Joubert et al., 2008). However, the industry was a cottage industry.

Cultivation and propagation trials by SANBI's Dr Hannes de Lange in the mid-1990s led to the commercial production of honeybush tea (Joubert et al., 2008). The different species were evaluated in various locations across South Africa's Eastern Cape and Western Cape provinces (Joubert et al., 2008). The important factors used to determine cultivation suitability were soil type and rainfall (Joubert et al., 2011). *C. genistoides* (sprouter) and *C. subternata* (non-sprouter) were selected for commercial cultivation (Joubert *et al.,* 2008). Other species that were selected for cultivation were *C. maculata* and *C. longifolia.* Since *C. intermedia* grows slowly and can only be cropped every few years, it was not selected for cultivation purposes (i.e., harvesting crops annually) (Joubert et al., 2008). Cuttings or seedlings are used for propagation (Joubert et al., 2008). In 2011, approximately 200 ha of land were used for cultivation from the Overberg area (Western Cape) to the Langkloof area (Eastern Cape) (Joubert et al., 2011). In 2016, this area decreased to 148 ha, and then it later increased to 162 ha in 2019 (Karsen et al., 2022). The cultivated species, ranked from most cultivated to least cultivated, were *C. subternata, C. genistoides, C. longifolia, C. intermedia,* and *C. maculata* (Karsen et al., 2022). In terms of the sizes of the farming units, McGregor (2024) identified 24 that were 0–5 ha, seven that were 6–10 ha, four that were 11–40 ha and two that were 41–70 ha. The industry is supported by a range of horticultural programs (which investigate soil preparation techniques, nutrient requirements, plant improvement and harvesting practices) (Joubert et al., 2008). At present, honeybush is enjoyed as an infusion and is often mixed with other teas (Joubert et al., 2008).

### 2.6.1.2) Botanical description

The genus *Cyclopia* (Fabaceae) consists of 23 leguminous, long-lived perennial species that vary from small, sprawling shrublets to tall, tree-like woody shrubs (Schutte, 1997). All the species have sweet-scented, yellow flowers with needle-like to small leaves (Schutte, 1997; Joubert et al., 2011). The species grows in well-drained sandy to sandy loam with low pH, phosphorus and a low nematode count (Joubert et al., 2011). In mountainous areas, *Cyclopia* populations grow on cooler, wetter southern slopes (Joubert et al., 2011). These fire-evolved fynbos plants take on reseeder and respouter forms due to recurrent fires in the fynbos (Schutte, 1997). The seeds, which have a hardened seed coat, need scarification from the fires to germinate (Joubert et al., 2011). Most species flower in Spring (September to October), except for *C. sessiflora* which flowers in Winter (June – August) (Joubert et al., 2011). Species of commercial importance are (i) *C. genistoides, C. intermedia*, and *C. sessiliflora* (resprouters) and (ii) *C. maculata, C. subternata* (reseeders) as well as *C. longifolia* which also functions as a resprouter. This research focused on *C. genistoides, C. intermedia*, *C. subternata* and *C. longifolia* (Figures 5a to d).

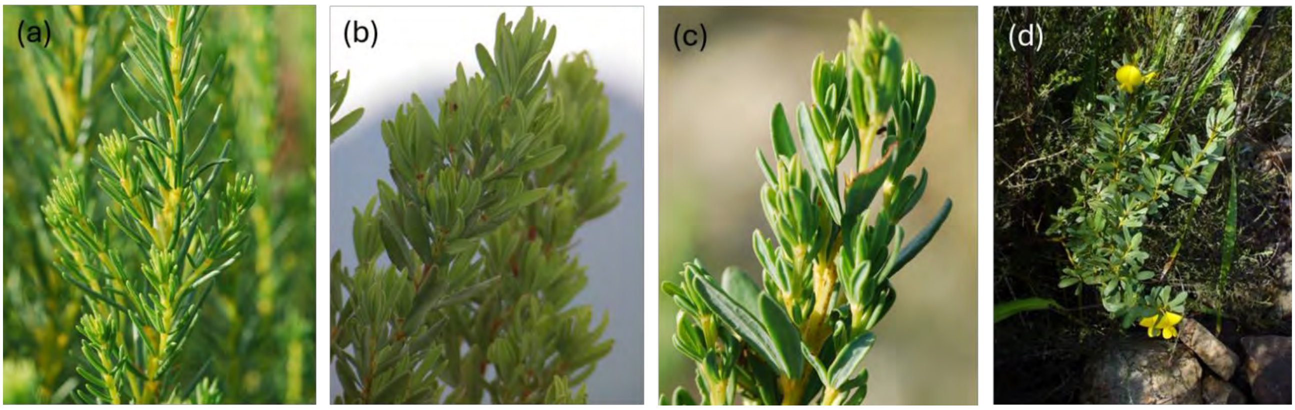


**Figure 5:** (a) *Cyclopia genistoides* (coastal tea), (b) *C. intermedia* (mountain tea), (c) *C. subternata* (marsh tea) and (d) *C. longifolia* (van Staden's tea) (Source: a–c, ARC, 2010; d - D. Raimondo, 2014).

*Cyclopia genistoides* is a multi-stemmed, erect, robust shrub that can grow up to 2 m (Schutte,1997). It resprouts from a woody rootstock (Schutte,1997). The trifoliate leaflets are terete with revolute margins (Schutte,1997). *Cyclopia genistoides* grows in (i) elevations between 60 m and 1 170 m and (ii) sandy soils (Schutte,1997). The species is found in the Albertina, Malmesbury-Darling area, Cape Flats and Cape Peninsula mountains, Betty's Bay, Bredasdorp, De Hop, Grabouw, Hermanus, Krogelberg and Swellendam (Schutte,1997). The species is currently near-threatened in the wild (Plummer, 2021). It is marked by the number '1' on the map in Figures 6a and b.

*Cyclopia intermedia* is a multi-stemmed, erect, robust shrub and can grow up to 2 m in the wild (Joubert *et al.* 2011). It has fine-trifoliate leaves with elliptic leaflets with recurved margins (McGregor, 2018). *C. intermedia* populations can withstand a range of environmental conditions occurring at (i) elevations between 500 m and 1 700 m, (ii) loamy, rocky, and sandy soils, and (iii) rainfall conditions between 250 mm (Anysberg mountains) and 1 500 mm per annum (Tsitsikamma mountains) (Schutte,1997; Joubert *et al.,* 2011). *C. intermedia* is the most widespread *Cyclopia* species, occurring in Anysberg, Baviaanskloof, Kammanassie, Kouga, Langeberg, Outenique, Rooiberg, Swartberg, Tsitsikamma, Touwsberg, Vanstadens, Waboomsberg, and Witteberg Mountains (Schutte,1997; McGregor, 2018). *C. intermedia* mainly grows on south-facing slopes, and much of its distribution falls within mountain catchment areas and in protected areas such as Towerkop Nature Reserve, Formosa Provincial Nature Reserve, Groot Swartberg Nature Reserve, Garden Route National Park, Baviaans Mega Reserve, and Anysberg Nature Reserve (McGregor, 2018). It is marked by the number '2' on the map in Figures 6a and b.

*Cyclopia longifolia* is an erect, single-stemmed shrub that can grow up to 3.5 m (Schutte,1997). The species lacks a rootstock and does not resprout after a fire (Schutte,1997). Its trifoliate leaflets are linear-oblanceolate, and its margins are slightly recurved (Schutte,1997). This rare, highly localised species is only known from the Van Stadens River Mountains near Gqeberha (Schutte,1997). The species (rare and localised) occurs on (i) elevations between 300 m and 360 m, (ii) sandy, moist soils, and (iii) high rainfall areas (Schutte,1997). The species is threatened by afforestation in the areas (mostly by pine plantations and alien vegetation) (Schutte,1997). It is marked by the number '3' on the map in Figures 6a and b.

*Cyclopia subternata* is an erect, single-stemmed shrub that can grow up to 3.2 m tall (Schutte,1997). The species lacks a rootstock and therefore does not resprout after a fire (Schutte,1997). Its trifoliate leaflets are obovate to oblanceolate with slightly recurved margins (Schutte,1997). The species occurs on (i) elevations between 160 m and 1 000 m and (ii) stony, loamy, well-drained soil (Schutte,1997). It mostly occurs on south-facing slopes. *C. subternata* is widely distributed on coastal mountain ranges such as the Langeberg, Outeniqua and Tsitsikamma mountains. (Schutte,1997). It is marked by the number '6' on the map in Figures 6a and b.

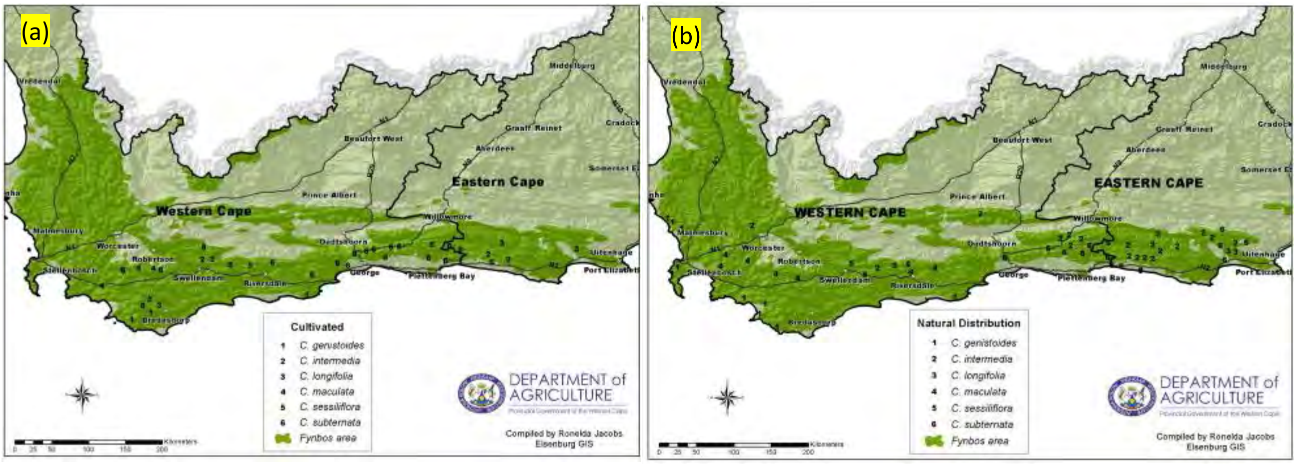


**Figure 6:** (a) Distribution of cultivated commercial *Cyclopia* species and (b) the natural distribution of commercial *Cyclopia* species in the Western Cape and Eastern Cape of South Africa; compiled by Ronelda Jacobs (Joubert et al., 2011).

### 2.6.1.3) Honeybush tea industry

Honeybush is not as popular as rooibos, and the demand for the tea was described as sporadic by Joubert et al. (2008). The industry lacked active marketing, and demand decreased after World War II (Joubert et al., 2008). Leading to a decline in processing except for a few activities in the Langkloof region (Joubert et al., 2008). 'Caspa *Cyclopia* Tea' was the first industry product in the 1960s (initiated by Benjamin Ginsberg). After rooibos became a commercial success, the Agricultural Research Council of South Africa (ARC) and South African National Botanical Institute (SANBI) initiated projects on commercial cultivation, health-promoting properties, and processing of honeybush tea to shift the industry from a cottage industry to a formalised commercial industry (Joubert et al., 2008). By 20211, six processors and four nurseries were established (Joubert et al., 2011).

As illustrated in Figure 7, the industry experienced significant annual production in 2010 (535 tonnes), 2011 (632 tonnes) and 2012 (641 tonnes). However, there was a significant drop in production in 2013 (252 tonnes) (McGregor, 2023). From 2014 to 2018, production remained under 306 tonnes. In 2019, this value was listed as 'unknown' from the PPECB statistics derived by McGregor (2023). Karsen et al. (2022) state that 584 tonnes were exported in 2019. The year 2020 saw the lowest production at 56 tonnes. This can be attributed to the global COVID-19 pandemic (Pers. Comm. G.K. McGregor, 2022). However, this production doubled the following year and was 303 tonnes in 2023. The average annual production since the boom in 2010 to 2020 was 352.7 tonnes. However, this figure is substantially lower than the rooibos industry which has produced more than 15 000–20 000 tonnes of rooibos products from 2006 to the present.

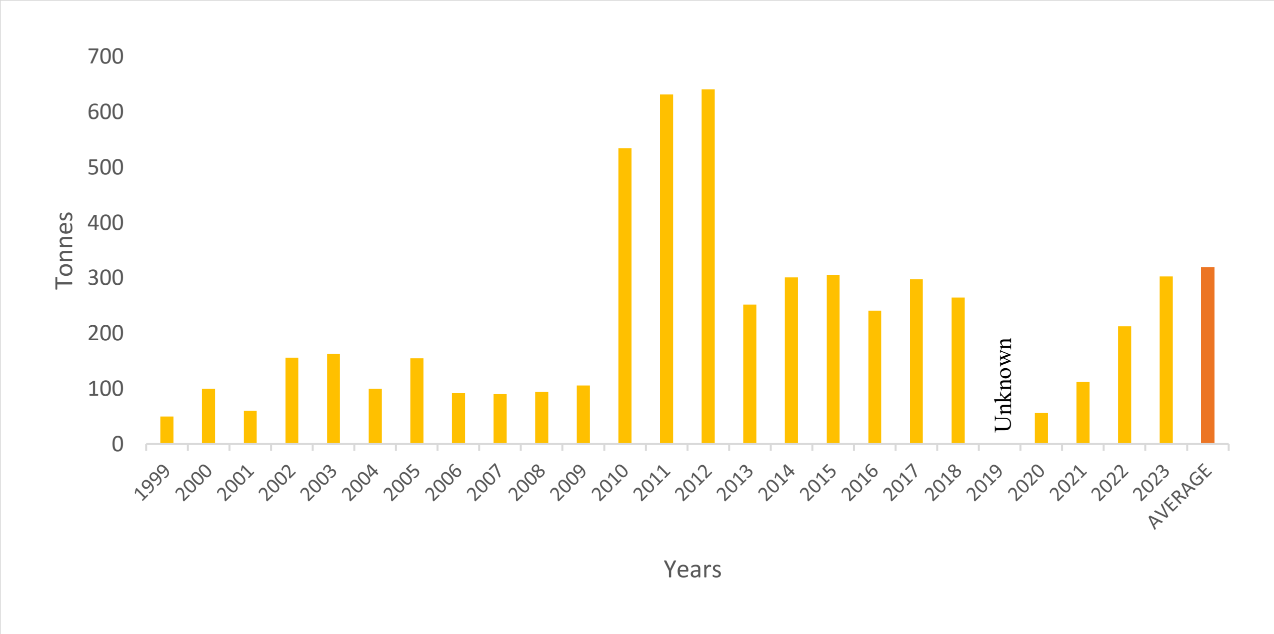


**Figure 7**: Honeybush tea production (tonnes) per year from 1999 to 2023 based on PPECB statistics (McGregor, 2023).

Initially, tea production was the focus of the industry. However, with new markets, there was demand for extracts from pharmaceutical, health, and cosmetic industries, especially from developed nations such as Germany, Japan, and the Netherlands (Joubert et al., 2011). In April of 2022, Japan imported 2 270 kg of product, Belarus imported 288 kg of product, Germany imported 1,650 kg of organic product and the United States of America imported 1 792 kg of organic product (McGregor, 2023)

At present, the international market accounts for 75% of honeybush tea production while the domestic market consumes 25% (McGregor, 2023). As a result, demand for the natural resource currently outstrips supply which places pressure on the species (Joubert et al., 2019). Before 2018, honeybush harvesting was largely sourced from species growing in the wild (McGregor, 2018). As illustrated in Figure 8, in 2016 and 2017, 82% and 85% of the honeybush species were sourced from the wild, respectively (McGregor, 2023). This figure dropped to 70% in 2019 when 70% (McGregor, 2023). At present, 47% of the product comes from the wild and the remaining 53% is cultivated (McGregor, 2023). This is the first time this has ever happened for the industry since its debut into a commercial industry from a cottage industry. This makes a significant shift in production from depending on the wild harvesting to the majority supply from cultivation.

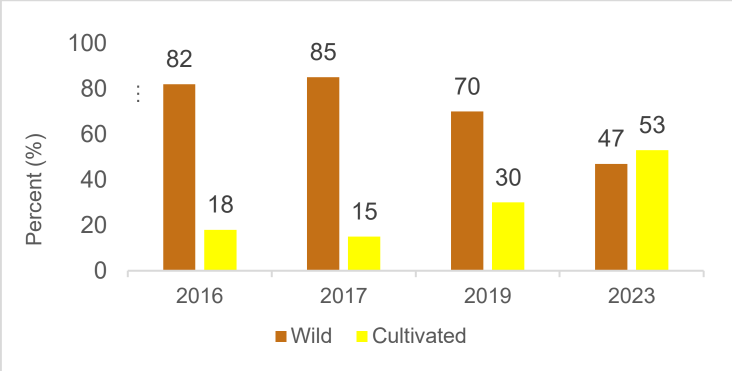


**Figure 8:** Source of the honeybush tea crop (wild versus cultivated) in 2016, 2017, 2019 and 2023 (McGregor, 2023).

In 2022, 85% of wild-sourced honeybush comprised *C. intermedia* and 10% was *C. subternata* (Figure 9a) (SAHTA, 2022). *C. intermedia* and *C. subternata* (which jointly contribute to approximately 95% of wild-harvested crops) are currently declining in the wild due to factors such as unlawful harvesting, overharvesting, urban expansion, and invasive alien plant encroachment (DEFE, 2022). As a result, both species have been placed in a draft BMP, serving as representatives of resprouters and reseeders to find sustainable practices for the genus (DEFE, 2022). According to Figure 9b, *C. longifolia* contributes to 50% of the cultivated product followed by *C. subternata* which contributes to 30% (SAHTA, 2022). *C. genistoides* contributes to 15% of the cultivated product (SAHTA, 2022).

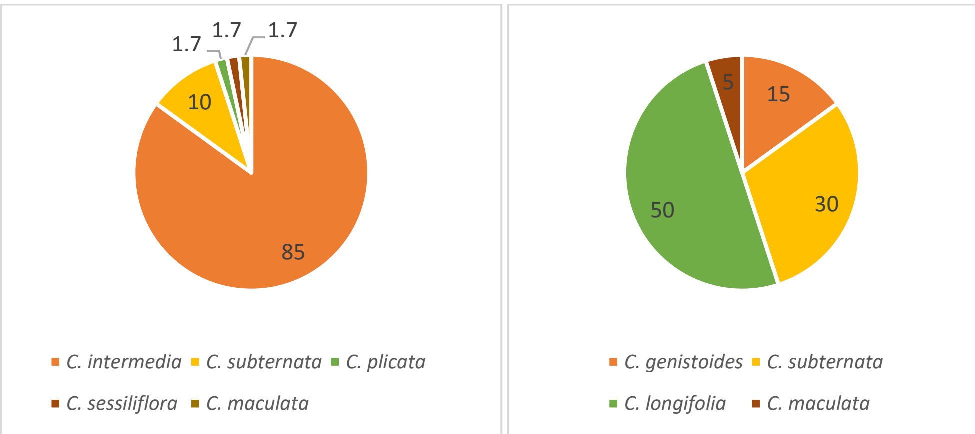


**Figure 9:** (a) Wild harvested honeybush tea composition and (b) Cultivated honeybush tea composition (%) (SAHTA, 2022).

Before 2022, the bulk annual production of honeybush (approximately 85%), was largely derived from wild populations, which saw the need for cultivation to supplement the wild-harvested plant material. However, despite (i) extensive research, (ii) effort and financial commitment by relevant private/state stakeholders, (iii) and the development of multiple cultivation approaches, the cultivated honeybush tea industry has not been as successful as expected (McGregor, 2024). It is noted that only a few farmers have successfully established economically viable cultivation farms (McGregor, 2024). It is therefore important to review the cultivated industry.

### 2.6.1.4) Harvesting practices

Resprouters, which are soil- and climate-dependent, can only be harvested every 2–3 years after planting (Joubert et al., 2011). The plants are cut back to soil level, emulating a natural fire, to allow for new shots from the rootstocks to be stimulated (Joubert et al., 2011). Under favourable conditions, *C. genistoides* can be harvested after 18 months after planting (between November and March) (Joubert et al., 2011). It can produce approximately 3 to 10 tonnes per hectare

(Joubert et al., 2011). Three types of *C. genistoides* (Overberg, Kirstenbosch, and West Coast) are being cultivated (Joubert et al., 2011). North et al. (2008) found that September to January was ideal for harvesting *C. genistoides* (Joubert et al., 2011). *C. intermedia* and *C. sessiliflora* can only be harvested after 2–3 years of planting. There is limited information on their cultivation practices as they are still harvested in the wild (Joubert et al., 2011). *C. subternata* is fast-growing and can be harvested in a planting (under favourable conditions) (Joubert et al., 2011). It is harvested from April to June when the plants have the highest yield (Joubert et al., 2011). It is harvested by cutting shoots back to between 30–50 cm above the ground (Joubert et al., 2011). Reseeders tend to live for 7–8 years while resprouters can live up to at least 10 years (Joubert et al., 2011).

#### 2.6.1.5) Input cost and break-even point

The cost of establishing 1 ha of honeybush is approximately ZAR 33,500 (Joubert et al., 2011). The largest expense of the cost is seedlings (whereby 8 000–10 000 seedlings or rooted cuttings are planted per ha after sufficient rain) (Joubert et al., 2011). Planting needs to occur no later than August for root establishment to occur (Joubert et al., 2011). Watering may be needed during the hot summer months (Joubert et al., 2011). One tonne of fresh honeybush is approximately ZAR 4,500 (Joubert et al., 2011). The break-even point for *C. subternata* in an ideal plantation is estimated to be 3 years (Joubert et al., 2011). The plantation will be re-established after approximately 7 years (Joubert et al., 2011). The break-even point for *C. genistoides* is 4 years (Joubert et al., 2011). The break-even point for *C. intermedia* and *C. sessiliflora* is 7 years (Joubert et al., 2011). Using cuttings to establish plantations is more expensive than seedlings (Joubert et al., 2011). It is also worth noting that there is no formal comparison of the potential profit based on the cultivation of different species of honeybush, and different cultivation approaches exist (McGregor, 2024). However, a simple profit calculation can be used to compare the potential profit under different scenarios.

#### 2.6.1.6) Policy and regulations relating to the cultivation of C. subternata and C. intermedia

*C. subternata* and *C. intermedia* were declining in the wild due to various challenges such as harvesting, overharvesting, urban expansion, and invasive alien plant encroachment (DEFE, 2022). As a result, both wild species have been placed in a Biodiversity Management Plan (BMP), serving as representatives of resprouters and reseeders to find sustainable practices for wild populations (DEFE, 2022). The BMP aims to "ensure the long-term survival of *C. subternata* and *C. intermedia* populations in the wild, whilst safeguarding and respecting the livelihoods of stakeholders" (Ackhurst et al., 2021:2). In this regard, there is more need for cultivation to supplement the declining wild populations.

The BMP objectives include:

- "Ensure that collection and management activities are carried out under legitimate tenure arrangements and comply with relevant laws, regulations, and agreements
- To ensure that through fair and equitable sharing of benefits derived from the biotrade and bioprospecting of *C. subternata* and *C. intermedia,* the conservation and sustainable use of honeybush species is promoted
- To ensure the protection/management of genetic *C. subternata* and *C. intermedia* resources" (Ackhurst et al., 2021: 2)

The BMP is underpinned by international and national legislation and policies, which can be found in Appendices A and B. These laws align with those of sustainability.

### 2.6.2) Rooibos tea industry

#### 2.6.2.1) Historical and current uses

In 1772, Carl Thunberg, a botanist, reported that he found South African Khoi people using rooibos as a beverage (Joubert et al., 2008). More than a century later, descendants of the Khoi (from the Western Cape province) were reported harvesting wild rooibos plants in the Clanwilliam mountains (Joubert et al., 2008). The species was later listed as a South African medicinal plant by Watt and Breyer-Brandwijk (1923), and it is currently the best-known South African herbal tea (Karsen et al., 2022). Presently, rooibos is used as an herbal tea and an alternative to Oriental tea (commonly used in the early 1900s) (Joubert et al., 2008). Rooibos has low tannin content, an anti-allergic effect, and no alkaloids, making it healthy (Joubert et al., 2008). It was found to reduce nervous tension, improve appetite, and promote sleep (Joubert et al., 2008). Rooibos has since been incorporated into the dermatological and cosmetic industry, increasing its success (Joubert et al., 2008).

#### 2.6.2.2) Botanical description

*Aspalathus linearis* is endemic to the South African Fynbos Biome (Joubert et al., 2008). The species naturally grows and is cultivated in the Cederberg area (predominantly in the Nieuwoudtville, Clanwilliam and Citrusdal regions) in the Western Cape (Joubert et al., 2008). Some are prostrate and grow up to 30 cm tall, while others grow erect and can reach 2 m (Joubert et al., 2008). The plants have needle-like leaves and produce hardened seeds that require scarification to germinate (Joubert et al., 2008). The species is divided into resprouters and reseeders depending on their biotype (Joubert et al., 2008). The red type (known as the Rockland type) is used for commercial processing, and it is divided into the wild-growing Cederberg type and the cultivated Nortier type is cultivated. In 2020, there were approximately 35 978 ha was cultivation (Karsen et al., 2022). Wild rooibos tea has a prostate growth form, is slow growing, has a low seed output post-fire, is resilient to droughts, pests and disease and is harvested every two years (Wynberg, 2017). Cultivated rooibos tea has an erect growth form, is fast growing, has a high seed output post-fire, is not resilient to droughts, pests and disease and is harvested every year (Louw, 2006; Wynberg, 2017).

#### 2.6.2.3) Rooibos tea industry

During World War II, there was a shortage of Oriental tea, increasing the demand for rooibos (Joubert et al., 2008). By 1953, rooibos production became uneconomic due to overproduction, decreased demand and inconsistent quality (Joubert et al., 2008). This resulted in the Rooibos Tea Control Board being established to ensure quality grading and improve marketing (Joubert et al., 2008). In 1995, 524 tonnes of rooibos were exported, increasing to 750 tonnes (1993) and then 7 200 tonnes (2007) (Joubert et al., 2008). Annual production of rooibos has seen a steady increase since 2015 and stands at 20 000 tonnes produced in 2020 (Rooibos Council, 2020). The major international markets include Germany, the Netherlands, the United Kingdom, Japan, and the United States of America (Joubert et al., 2008). Propagation of the species comes from seedlings, which are planted between June and August, and the first harvest occurs in the second summer (Joubert et al., 2008). Initially, the commercial lifespan was 7 years (Joubert et al., 2008). However, due to die-back problems, the lifespan is now 3 years after full production occurs (Joubert et al., 2008).

#### 2.6.2.4) Issues in the industry

***Biodiversity:*** Landscape degradation is one of the main environmental concerns that the cultivation of rooibos raises (Wynberg, 2017). Thousands of hectares of mountain fynbos are ploughed every year to cater for rooibos tea monoculture (Wynberg, 2017). In 2017, 60 000 ha was cleared for rooibos (Wynberg, 2017). As a result of rooibos cultivation, biodiversity was negatively impacted, increasing the number of species being threatened with extinction to 300% (Wynberg, 2017).

***Chemical:*** Although rooibos is a low-input crop (relying on little fertiliser and water), cypermethrin (an insecticide) is sprayed on rooibos crops by many commercial farmers (Wynberg, 2017). Although cypermethrin has been deemed a pesticide which is non-toxic to mammals, there is evidence that it contributes to developmental delays and suppresses the immune system (Wynberg, 2017).

***Issues species interference:*** Cultivated plantation seed selection and plantation expansion have inadvertently affected adjacent rooibos wild forms through "illegitimate" pollination across populations (Wynberg, 2017). This may introduce unfavourable genetic material into wild populations (Wynberg, 2017).

***Genetic:*** Of the four main types of rooibos, the industry relies on a single variety of rooibos (red), which comes from a narrow genetic base which is selected for commercial cultivation (Wynberg, 2017). This has reduced the plant's overall lifespan to the forefront of fungal infection (Wynberg, 2017).

***Unsustainable wild harvesting:*** One of the drivers of increasing harvesting pressures is the ongoing drought conditions, which have reduced yields in cultivated fields (Wynberg, 2017). This has increased pressure on the more resilient wild populations. Additionally, demand from international markets that provide premium prices for tea has placed pressure on the wild population (Wynberg, 2017).

## 2.7) The growing need for an "alternative crop"

An alternative crop is defined as "an agronomic crop that is not usually grown in a particular geographic area but is selected for use due to its potential high sale value or a specialized benefit to the farming system, which may involve both risks and opportunities" (Isleib, 2012). There has been a growing interest in cultivating alternative crops amongst organic producers and small-scale farmers. Organic producers tend to have a diversified system which can fit in alternative crops (Moncada et al., 2010). Alternative crops have environmental benefits such as enhancing water and soil use and quality; reducing herbicide and pesticide use, and promoting diversity in the wild (Moncada et al., 2010). Alternative crops also have economic benefits such as allowing producers to take advantage of novel markets and premium prices and strengthening local communities and economies (Moncada et al., 2010). An argument against alternative crops is that we now have all the crops we need and that we should rather alter existing crops with breeding and biotechnology (e.g., corn with a different starch) (Gardener, 1994). The benefits include avoiding domestication efforts (time-consuming) which arise with new crops (Gardener, 1994). Additionally, there is already farm equipment, registered biochemicals, and government support programs to stimulate production (Gardener, 1994). An argument for an alternative approach is that of the existing plant species available globally; using only a dozen or more in agriculture may lead to problems (Gardener, 1994). The landscape may snap under the lack of diversity. This approach calls for a renewed effort to increase the numbers and diversity of crops grown (Gardener, 1994).

To farm alternative crops, factors such as resource assessments, product requirements, information sources and marketing need to be considered (Moncada et al., 2010). Regarding resource assessments, farmers need to be aware of; (i) seed, cuttings and seedling availability, (ii) soil fertility and drainage characteristics, (iii) necessary climatic conditions, (iv) required labour and equipment for planting, cultivating and harvesting, (v) transport, (vi) marketing and (vii) financial investment/ capital (Moncada et al., 2010). Regarding production requirements, it is important to note the: (i) water, temperature and nutrient requirements, (ii) associated pests and diseases (and subsequent organic pest control) and (iii) production operation times (Moncada et al., 2010). Regarding sources of information, it is important to note; (i) information about the crop from reputable sources, (ii) networking with experienced producers and (iii) organisations, workshops and meetings about the alternative crop (Moncada et al., 2010). Finally, regarding marketing, it is important to ensure that; (i) there is a market, (ii) a marketing plan is created, (iii) crop varieties (for quality) and the associated demand are assessed, (iv) local infrastructure is available for the alternative crop (Moncada et al., 2010). In the context of the tea industry, honeybush tea can be viewed as an alternative crop to help relieve pressures on the rooibos tea industry.

## 2.8) Certification and standards for trading

BioTrade products are derived from biodiversity cultivation or natural areas (Lusweti et al., 2020). Most importing international countries interested in the products prefer or require 'activities of collection, production, transformation, and commercialisation of goods and services derived from native biodiversity under the criteria of environmental, social and economic sustainability' (Stamboulakis & Sanderson, 2020; 509; Ortiz et al., 2021). As such, the public (i.e., government legislature), private (i.e., private bodies) and markets should regulate the natural resource-sourcing practices that promote and achieve biodiversity (Stamboulakis & Sanderson, 2020) in the context of complying with overarching CBD policies (Bakouan & Sawadogo, 2024). There has been evidence of the use and exploration of certification and standardisation in the food and agricultural industries (Amekawa, 2013; Lemeilleur et al., 2013; Bellamy et al., 2016; Gather and Wollni, 2022). One of the earliest standard-oriented efforts, established in 2007 to improve biodiversity, is the Union for Ethical Biotrade (UEBT) (Stamboulakis & Sanderson, 2020). The UEBT, with other standards (i.e., South African Good Agricultural Practices, FairWild Foundation and Rainforest Alliance Sustainable Agriculture Standard) will be discussed. It is worth noting that these are international standards which may not necessarily be the best for South Africa.

### 2.8.1) Union for Ethical Biotrade (UEBT)

In 2007, a UNCTAD initiative to promote business engagement in biodiversity resulted in the launching of the UEBT standard (Stamboulakis & Sanderson, 2020). This standard was revised in 2012 and 2019 through input from evolving policy and legal frameworks, its users and public multistakeholder consultations (Stamboulakis & Sanderson, 2020). The UEBT standard, aligned with the CBD and SDGs, promotes product sourcing which regenerates local ecosystems and ensures a sustainable future for the producers and harvesters involved in cultivation and wild collection (Stamboulakis & Sanderson, 2020). Member companies that work with UEBT standards mainly work with; plant parts (i.e., leaves, roots, flowers, fruits, stems or bark), compounds (i.e., oils, waxes, butter, extracts, colourants, fragrances and flavours), microorganisms, beeswax and algae (Stamboulakis & Sanderson, 2020). The UEBT standard focuses on 'speciality ingredients' from nature which are used in small volumes (Stamboulakis & Sanderson, 2020). The UEBT standard is used for certification (i.e., once an audit is conducted and finds that sourcing from a cultivation or natural site is compliant with the UEBT standards, UEBT certification can be granted), general guidance (i.e., on goods and services practices on sourcing natural raw materials or research) and verification (i.e., companies that trade, buy or process UEBT-certified raw materials may acquire UEBT chain of custody certification) (UEBT, 2020). The UEBT abides by seven principles (whose explanations can be found in Appendix D):

1. Conservation of biodiversity
2. Sustainable use of biodiversity
3. Fair and equitable sharing of benefits derived from the use of biodiversity
4. Socio-economic sustainability (productive, financial and market management)
5. Compliance with national and international legislation
6. Respect for the rights of actors involved in BioTrade activities
7. Clarity about land tenure, right of use and access to natural resources

It is worth noting that, although the UEBT standard has good intentions for nature and people, it also has challenges such as credibility, capacity, and legitimacy issues (Stamboulakis & Sanderson, 2020).

### 2.8.2) South African Good Agricultural Practices (SA-GAP)

Global commercial markets have evolved through modern consumers and retailers establishing rigorous food safety and quality standards (DAFF, 2016). This development is mostly driven by concerns regarding the safety of consumable products, changing consumer preferences and overall improved standards of living (DAFF, 2016). Smallholder producers are therefore expected to produce products that meet the minimum food safety requirements (which ends up being their limiting constraint when aiming to access commercial markets if they do not meet them) (DAFF, 2016). The SA-GAP Certification Programme, approved by the Integrated marketing strategy for agricultural, forestry and fisheries products for the Republic of South Africa, therefore aims to assist South African smallholder producers access local and international markets by ensuring that they produce products that comply with food safety and quality required by the market (DAFF, 2016). The SA-GAP Certification Programme also ensures consumer health and safety, which will eventually help it gain recognition and acceptance from commercial markets (DAFF, 2016).

The SA-GAP Certification Programme provides a set of practices that support its four pillars: (i) social acceptability, (ii) economic viability, (iii) environmental sustainability and (iv) food safety and quality (DAFF, 2016). These practices ensure the production of safe and good quality food and non-food agricultural products (DAFF, 2016) It ensures traceability for its consumers (i.e., ensuring that fresh food production activities can be traced from production to retailer to the consumer) (DAFF, 2016). All records of activities are documented and audited (i.e., an auditor assesses the safety, quality and hygiene standards during the food handling procedures and production processes) during production, including the instances of hygiene, safety and responsible use of agrochemicals (DAFF, 2016). SA-GAP Certification Programme benefits producers, retailers and consumers in the ways illustrated in Table 7. In terms of obtaining SA-GAP certification, a producer is involved in the (i) application phases, (ii) pre-audit phase, (iii) workshops, (final audit and certification and (v) maintaining their gained certification process (DAFF, 2016)

**Table 7:** Benefits of the SA-GAP Certification for producers, retailers and consumers (DAFF, 2016).

| Producers | Retailers | Consumers |
|---|---|---|
| ● Promotes smallholder producer participation in the mainstream agricultural markets<br>● Creates and increases competitiveness by smallholder producers in local and eventually international markets<br>● Equips smallholder producers with efficient farm management skills<br>● Provides legislation on sustainability to smallholder farmers<br>● Helps build technical and managerial skills<br>● Helps mobilise financial means for necessary infrastructural investments in the agricultural value chain | ● Help retailers source and provide high-quality, safe, and hygienic food<br>● Increase consumer confidence<br>● Reduce non-compliance with food safety regulations<br>● Develop a network of reliable producers<br>● Ensure traceability of products in the event of a hazard detection | ● It provides high-quality and safe food at the farm and retail level<br>● The risk of diseases associated with improper handling techniques and food production is reduced |

### 2.8.3) FairWild Foundation

The mission of the FairWild Foundation (Version 3.0) is to "enable transformation of natural resource management and business practices to be ecologically, socially, and economically sustainable throughout the value chains of wild-collected products" (FairWild Foundation, 2023: 4). Their vision is to create a fair and wild world that; (i) employs sustainable harvesting that conserves biodiversity, (ii) ensures that harvesters, producers, workers and their communities are treated fairly and with respect and to (iii) create businesses that are resilient and participle in responsible value chains (FairWild Foundation, 2023). The FairWild Foundation abides by seven principles (FairWild Foundation, 2023: 4).:

1. Wild harvesting supports conservation of the collected species
2. Wild harvesting has a neutral or positive impact on the collection area and broader landscape

3. Human rights of wild collectors and workers are respected
4. Arrangements between operator, wild collectors, and workers are fair
5. Benefits and respect for customary rights for wild collectors and their communities are ensured
6. Harvest and trade of wild resources are legally compliant
7. Responsible business practices are applied

The FairWild Foundation covers natural products and ingredients that come from wild collections of plants (including wild plants, plant parts and plant products; wild fungi and lichens; wild seaweed and other algae) (FairWild Foundation, 2023). The FairWild Foundation requires commitment and cooperation from all actors who are involved in the product value chain (FairWild Foundation, 2023).

### 2.8.4) Rainforest Alliance Sustainable Agriculture Standard

Certification has drastically impacted the agricultural sphere by aligning sustainability and business decision-making to ensure that nature and people can harmoniously thrive (Rainforest Alliance, 2020). Certification through the Rainforest Alliance Sustainable Agriculture Standard uses social and market forces to improve the lives of farmers and forest communities while protecting nature (Rainforest Alliance, 2020). It has evolved and improved over the years. Rather than using its past pass/fail models in the certification process, the standard now strives for continuous improvement by adopting approaches that incentivise improvements (Rainforest Alliance, 2020). For instance, it uses 'Smart Meters' which measure the production performance of an enterprise against its own goals and thus support its progress (Rainforest Alliance, 2020). The Rainforest Alliance Sustainable Agriculture Standard employs the power of data and information. For instance, it uses geospatial data and subsequent analyses to address questions and practices on enterprises (Rainforest Alliance, 2020). It has also developed a Farm Intelligence App to provide producers with credible data, knowledge and tools to improve their practices (Rainforest Alliance, 2020). These improvements allow producers to measure their performances, analyse risks and learn new skills through new digital tools for efficient operations (Rainforest Alliance, 2020). Instead of using a one-size-fits-all model, the Rainforest Alliance Sustainable Agriculture Standard uses a contextualised approach (which works on problems at ground level between different types of farms, supply chain actors, countries and sectors of production (Rainforest Alliance, 2020). Finally, the Rainforest Alliance Sustainable Agriculture Standard promotes sharing responsibilities across the supply chain and encourages investment to users that are more sustainable in production (Rainforest Alliance, 2020). Sustainable agriculture is promoted through two framework documents: the *Farm Requirements* and *Supply Chain Requirements*. The Farm Requirements guide producers in adapting to climate change, increasing productivity, producing better produce and reducing costs (Rainforest Alliance, 2020). Overall, it promotes sustainable agriculture. The Supply Chain Requirements and supporting documents develop a comprehensive set of requirements that ensure sustainable investments at the farm level and ensure responsible business conduct to create cohesive supply chains (Rainforest Alliance, 2020). Additionally, it factors in the traditional traceability rules to ensure transparency between producers, retailers and consumers (Rainforest Alliance, 2020). This standard is explored in Lemeilleur et al. (2015) and Bellamy et al. (2016).

It can be concluded that the UEBT Standard, SA-GAP Standard, FairWild Foundation and Rainforest Alliance have agricultural sustainability (through cultivation or wild collections) in mind. This will be considered when drafting a conceptual framework for this research.

## 2.9) Conceptual Framework

There are key principles that need to be taken into consideration when attempting a sustainability assessment (Gomiero et al., 2011: 11):

- "Farming systems are not steady-state systems but highly adaptable and evolving systems.
- Any representation of these systems depends on a set of choices made by the observer when framing the identity of what is being observed.
- It is impossible to reach the best/ optimal solution to a problem of sustainability, we should address the issue of "sustainable/optimal for whom and in which sense", there is no solution that optimised all possible criteria of performance for all the relevant actors (who decides who are the relevance actors and how?).
- Any assessment implying a vague judgement (such as good or bad) cannot be made by the application of an algorithm within an optimisation protocol. Rather, vague judgements must be made within a participatory process of multi-criterial assessment" (Gomiero et al., 2011: 11).

With this said, farm systems need to be assessed using a multi-criteria approach or a multi-dimensional approach whereby many dimensions (i.e., environmental, economic, and social) and many levels (international, governments, and farmers) are considered simultaneously (Gomiero et al., 2011). Farm systems embrace several different indicators, criteria, and scales (Gomiero et al., 2011). According to (Gomiero et al., 2011: 14) "to pursue systemic changes in farming systems, research and development have to address multiple dimensions of sustainability (productivity, and environmental, economic, and social sustainability) and to explore agroecosystem properties, such as complex cropping rotations, integrated crop and livestock production, and enhanced reliance on ecological processes to manage pests, weeds, and diseases (recognizing their interconnectedness and interactions with the environment), that could make systems robust and resilient over time."

In the context of this research, sustainability will be framed using the UEBT Field checklist recommended by a consultant from Parceval Pharmaceuticals (Appendix A). This was decided after preliminary discussions with industry stakeholders when drafting the proposal. The UEBT Checklist is used to assess cultivation and wild collection sites (as well as local suppliers) to show the process towards positive impact on biodiversity and people (UEBT, 2022). Since the checklist is associated with stringent quality control across all facets of sustainability, it will be used to analyse the Honeybush Tea industry products. This dissertation focuses on aspects of the sustainability of the cultivated honeybush industry. Therefore, the "wild collection" portion of the checklist will be removed.

## 2.10) Research methods

### 2.10.1) Research epistemology

The school of thought used in this research was 'Realism' under the branch of 'Critical Science'. Realism investigates the underlying structures and mechanisms (i.e., policy and practice) that make social relations possible (Kitchin & Tate, 2013). It identifies causal mechanisms (how phenomena occur) and empirical regularity (a phenomenon's extent) (Kitchin & Tate, 2013). Realists aim to uncover what produces or allows change and what allows phenomena to occur (Kitchin & Tate, 2013). The main methodology used in Realism is mixed quantitative (handling numeric and predictable hard data) and qualitative (handling word-based, flexible data) (Ngulube, 2015).

This mixed-methods approach adds rigour to the research, harnessing strengths from both methods (Creswell et al., 2006; Hawthorne, 2017). This brings forth deeper meanings and understandings from the research that would be left out if one method were used: crucial for complex, multi-faceted studies (Hawthorne, 2017). Mixed-method approaches enable a more complex account of constructs, issues, phenomena or processes that are being researched (Hawthorne, 2017). Different research designs are used within a mixed-methods approach. an *Exploratory Design* is a two-phase design where qualitative data is first collected and analysed in phase 1. The results are then expanded in phase 2 of quantitative data collection and analysis (Creswell, 2014). This research will entail qualitative and quantitative data collection employing an exploratory design.

It is worth noting the challenges associated with the mixed-methods approach, namely encountering difficulties with integrating qualitative and quantitative data (Hawthorne, 2017). Three solutions arise which are (i) *merging data* (integrating qualitative data from interviews with numerical data from quantitative data), (ii) *connecting data* (analysing one method to inform subsequent analytical methods) and (iii) *embedding data* (utilising a primary method and supporting it a secondary dataset) (Creswell et al., 2006).

### 2.10.2) Qualitative research

Qualitative research allows for the analysis and provision of context-rich, subjective data (Ngulube, 2015). Qualitative methods are valued for their inductive manner, which allows for the context, individual-lived experience and meaning to emerge from the study through methods that capture an individual or a group's experience (i.e., case studies, ethnography, focus groups, interviews, observations) (Hawthorne, 2017). This method allows researchers to contextualise and understand geographic processes by researching individuals or groups, noting that their experiences are socially constructed in a certain place and time (Hawthorne, 2017). Key aspects that should inform qualitative data analysis, highlighted by Hair et al. (2011: 282), include (i) identifying common themes and patterns related to research focus and objectives, (ii) highlighting responses that are inconsistent with the themes and patterns, (iii) addressing the inconsistencies (accounting for any research expansions or redirection) and (iv) potentially collecting additional data according to the themes and patterns (Ngulube, 2015).

**Qualitative methods used**

#### 2.10.2.1) Case study approach

A case study approach involves studying a phenomenon within a real-world setting (Kitchin & Tate, 2013). These are studied in a particular space and time, allowing the present issues to be studied from multiple perspectives (Kitchin & Tate, 2013). This research focuses on individual case studies that factor in several integrated accounts of individuals (Kitchin & Tate, 2013). Objective 2 of this research is to investigate the environmental, economic, and social practices in successful cultivation enterprises, and a case study approach will be used at five different enterprises.

#### 2.10.2.2) Semi-structured interviews

Interviews are a common strategy for collecting qualitative data, and they are categorised as unstructured, semi-structured or structured (DiCicco-Bloom & Crabtree, 2006). Unstructured interviews entail researchers gathering data by observing participants, participating in their activities and taking notes (DiCicco-Bloom & Crabtree, 2006). Structured interviews are often used to produce quantitative data (DiCicco-Bloom & Crabtree, 2006). Semi-structured interviews allow the researcher to organise a set of prearranged, open-ended questions (which allow for additional questions and answers to emerge during dialogue) (DiCicco-Bloom & Crabtree, 2006). Semi-structured interviews are also scheduled in advance at designated times and locations.

#### 2.10.2.3) Thematic content analysis

According to Ngulube (2015), various methods are used to analyse qualitative data. There is *thematic analysis* whereby themes and patterns related to the research question are identified through theoretical coding or thematic coding (Ngulube, 2015). According to Braun and Clarke (2006), data is transcribed, items of interest are noted, the dataset is coded, themes are identified, reviewed and mapped (according to their relationships) and named and then the analysis is finalised (Ngulube, 2015). There are various tools and systems used to manage large volumes of data, particularly with software tools like Atlas.ti and NVivo (Ngulube, 2015). Atlas.ai uses grounded theory and theoretical coding to help model qualitative data (Ngulube, 2015).

### 2.10.3) Quantitative research

Quantitative methods are ideal because they are deductive, and objective and allow for the proposal, testing, and analysis of hypotheses. Here, statistical analyses (i.e., descriptive surveys and statistical analyses) are used to understand relationships across quantifiable variables (Hawthorne, 2017). Furthermore, measurable methods can be replicated across geographic settings and form generalisations from smaller samples to a larger population (Hawthorne, 2017). Additionally, geographic information systems (GIS) are a quantitative method that can be viewed as a mixed method (Hawthorne, 2017).

**Quantitative methods used**

### 2.10.3.1) Quadrat surveys

According to David (2005: 258), "quadrats are used to define sample areas where measurements of some sort are taken". Finding the ideal location for quadrats can be achieved randomly, systematically or through a judgment call (David, 2005). Quadrats can be used to survey plants, as it is a particularly effective method for sessile organisms (Walters & Scholes, 2017). With regards to vegetation, common recorded measurements are cover (area that plants cover in a small area) and density (number of plants in the quadrat) (David, 2005). A quadrat's size affects the measured values of the cover, density and frequency of organisms being surveyed (David, 2005). Regarding describing vegetation, a visual estimation of plant abundance or cover is often applied (David, 2005). Alternatively, a presence-absence of a species can be used (David, 2005). With regards to monitoring vegetation for estimates of density or cover, frame quadrats can be employed.

### 2.10.3.2) Biodiversity survey

Each species' contribution to a vegetation community can be sufficiently assessed through cover estimates (David, 2005). Cover estimates are also sensitive to seasonal or management fluctuations. "Cover can be assessed using different methods, such as the DAFOR (Dominant, Abundant, Frequent, Occasional or Rare), Braun-Blanquet (5 classes up to 100 % cover, not of equal size) and Domin (10 classes up to 100 % cover, not of equal size) scales" (Walters and Scholes, 2017: 94). An advantage of cover estimates is that they provide quantitative measures of different groups of plants (i.e., fungi, mosses, grasses and shrubs) which can all be evaluated in comparable terms (David, 2005). Cover estimates can be expressed as an amount of cover, a fraction or a percentage on an index or scale basis (David, 2005). Cover estimates require considerable time and expertise (to correctly identify the plants in the study area). Before conducting a cover analysis, key decisions need to be made; (a) optimum quadrat size (which can vary from 1 x 1 m to 4 x 4 m in species-rich areas to 10 x 10 m in species-poor locations) and (b) sampling strategy design ((i) systematically or randomly locating samples, (ii) optimisation of sampling and, (iii) getting the right amount of samples to represent the area) (David, 2005). Vegetation cover and density can be encapsulated in a belt transect illustrated in Figure 19. They are used to monitor changes in vegetation across a community boundary or gradient (David, 2005).

An example that encapsulates an altered version of the belt transect was conducted by Khoza (2021) to find out the percentage of canopy cover. A sampling plot was laid in the centre of the 150×150 m sites. In some cases, the plot was placed away from the centre of the site (in cases where the plot had a lower density of trees than the entire site) to ensure it was representative of the vegetation structure of the whole site (Khoza & Vetter, 2021). Each 15 m × 6 m sampling plot consisted of ten 3 × 3 m subplots laid out using 50 m measuring tapes. The herbaceous species in the subplots were identified, and their aerial cover was estimated (Khoza, 2021). "The percentage aerial cover of each species in each subplot was given a score of either 1 (<1%), 2 (between 1 and 10%) or 3 (>10%). Thus, for each of the 51 plots, the total abundance score of any species present could range from 1 (< 1% cover in only one subplot) to 30 (> 10% cover in all ten subplots)" (Khoza, 2021: 77–78). Khoza (2021) proceeded to use the vegan package in R to calculate species abundance, richness, and diversity.

### 2.10.3.3) Tree maps

Tree maps were developed in the early 1990s as a common graph to represent hierarchical information on flat surfaces (Long et al., 2017). Single or small groups of samples can be visualised by tree maps (Mehlan et al., 2013). Rectangles are commonly differentiated using different sizes and colours, or shading to illustrate a particular region (Long et al., 2017). The different colours are important factors as they play a role in swift decision-making (Long et al., 2017). Benefits of this include the efficient use of space and scale, while a disadvantage may be the low visibility of contents (Long et al., 2017). Tree maps have been used to visualise quantitative biodata (Mehlan et al., 2013). This tool can therefore be used in ecological or environmental fields.

### 2.10.3.4) Soil survey

Soil is responsible for housing important macro- and microorganisms whose role is to decompose organic matter and release nutrients (Reganold et al., 1990). Soil is therefore crucial in agriculture, and its contents are worth noting (often through laboratory tests). Soil test results typically include calcium, cation exchange capacity, magnesium, pH, organic matter, phosphorus and potassium, whose significance is noted in Table 8. Laboratories, however, do not typically include nitrogen tests because soils do not retain nitrogen (Daniel & Lerner, 2018).

**Table 8:** Soil nutrients and their importance within the soil.

| Element | Importance in soil |
|---|---|
| pH | Measures the alkalinity and acidity in the soil. A pH between 6.5 and 7 is ideal for nutrients to be readily available to plants (Daniel & Lerner, 2018). Soils that are more alkaline or acidic may lead to difficulties for plants to use present nutrients (Daniel & Lerner, 2018). For fynbos species, the soil should be slightly acidic and somewhat sandy or free draining (Contours Landscapes, 2024). |
| Calcium (Ca) | Calcium is a secondary macronutrient in soil crucial for plant growth and makes plants less susceptible to pests and diseases (Hassani, 2023). However, too much calcium may lead to soils that are too alkaline (Hassani, 2023). Calcium ions keep soil flocculated (Warrence et al., 2002) |
| Magnesium (Mg) | Magnesium is involved in many of a plant's catalytic reactions, and it helps produce chlorophyll (Biological Activated Cocktail, 2024). Magnesium ions keep soil flocculated (Warrence et al., 2002) |
| Phosphorus (P) | Phosphorus helps with roots and shoots (Biological Activated Cocktail, 2024). |
| Potassium (K) | Potassium helps with flowers and fruits (Biological Activated Cocktail, 2024). |
| Sodium (Na) | High sodium concentrations are linked to soil dispersion (Warrence et al., 2002). While salinity can improve soil structure, too much salt accumulation in the root zone negatively affects plant growth and crop yields (Warrence et al., 2002). |
| Copper (Cu) | Copper is vital for enzyme activity (Biological Activated Cocktail, 2024). |

Soil samples also need to be taken at different locations at the study site (Daniel & Lerner, 2018). Surface debris needs to be removed before collecting the soil sample (Daniel & Lerner, 2018). Soils can be collected from the field using a probe, auger, spade or trowel, and the same amount of soil must be removed from each sampling area (Daniel & Lerner, 2018). For grass, samples should be taken at a depth of 3 inches (7.6 cm) and for shrubs, samples should be taken at a depth of 6-8 inches (approximately 15–20 cm) (Daniel & Lerner, 2018). For smaller areas, 4–6 samples should be collected, and for large areas, 10–15 samples should be collected (Daniel & Lerner, 2018). Correctly labelled samples can be submitted to laboratories for testing.

### 2.10.3.5) Field allometry surveys

Plant allometry is the relationship that a plant's size has with its morphology, physiology and life history (Bradshaw & McMahon, 2008; Weiner et al., 2009). Growth and reproduction are two significant processes in plants (Weiner et al., 2009). West et al. (1999) state that size influences almost all the ecological, functional, and structural characteristics of organisms. After a plant produces biomass (total quantity/ weight of an organism), it allocates it to various plant functions or structures (Weiner et al., 2009). The relationship between the allocation of accumulated biomass to functions and structures makes up the core of plant life-history strategies (Weiner et al., 2009). Critical aspects of plant fitness and crop yield are biomass accumulation and partitioning (which is the way plants divide their energy amongst their roots, stems, leaves, and reproductive parts) (Sun et al., 2020; Vega et al., 2000). Ideally, the variation in a plant's body mass is used to predict aspects such as its survival predictability, dispersal capacity, fecundity and metabolic rate (Bradshaw & McMahon, 2008). Biotic factors (i.e., competition and successional stages) and climate (i.e., energy and water availability) can influence allometric relationships (Deng et al., 2020; Sun et al., 2020). Allometric models are typically used in natural resource management, such as estimating forest biomass and monitoring forest health using remote sensing technologies. (Sileshi et al., 2023). For instance, West et al. (1999) present an integrated model for the branching geometry of plants, based on applying a general theory of resource distribution through hierarchical branching networks concerning vascular plants. The model predicts "a fractal-like architecture and many known scaling laws, both between and within individual plants, including allometric exponents which are simple multiples of 1/4" (West et al., 1999: 664).

**The relationship between allometry and morphology (Mohler *et al.,* 1978).**

In a study by Mohler et al. (1978), three-pin cherry stands (aged four-, six-, and 14-year-old) were sampled in areas which were generally equivalent in aspect, slope and drainage in New Hampshire, United States of America. The stands were small (0.25–0.5 ha) to avoid patchy dispersion in larger stands and densely stocked with pin cherries (Mohler et al., 1978). The density was measured in randomly placed plots: 15 1 x 1 m plots in the 4-year-old stand and 20 2 x 3 m plots in the 14-year-old stand (Mohler et al., 1978). The dimension analysis (Whittaker & Woodwell, 1968) was used to measure the plant weight (Mohler et al., 1978). Approximately 25 sample trees in each stand were selected to span the range of trunk diameters observed in the plots (Mohler et al., 1978). They were excavated, including their roots (Mohler et al., 1978). Trunk wood plus bark, and roots of all sample trees were oven-dried and weighed without sub-sampling (Mohler et al., 1978). Branches were sub-sampled by age class, and their leaves, current twigs and older parts of each sample branch were weighed (dry), to allow for each of the tissues to be regressed on branch basal diameter for each branch age class (Mohler et al., 1978). After estimating the dry weights of branch parts on all sample tree branches, another set of regressions was calculated to relate the weight of each tissue (leaves, current twigs, older branch wood and bark, trunk wood and bark, and roots) to trunk diameter, and these equations were used to calculate the weight of each organ on each pin cherry plant in each plot (Mohler et al., 1978).

### 2.10.3.6) Yield measurements

**The relationship between allometry and yield (Vega *et al.,* 2000; Sadras and Calviño, 2001)**

Vega et al. (2000) sought to investigate the relationship between shoot biomass and yield within three cultivated, annual species with contrasting reproductive strategies: *Helianthus annuus L.* (sunflower), a single-inflorescence determinate species; *Zea mays L.* (maize), a determinate species which relies on resource availability to adjust the number of ears; *Glycine max L. Merrill* (soybean), an indeterminate species with a substantial capacity to adjust the number of inflorescences (Vega et al., 2000). The authors measured grain yield and shoot biomass for individual plants (Vega et al., 2000). The authors found that the proportion of dry matter partitioned to reproduction decreased for small or large plants and was stable for mid-size plants. Furthermore, the harvest index (HI) stability was the lowest in maize, intermediate in sunflowers and highest in soybeans (Vega et al., 2000).

Sadras and Calviño (2001) aimed to quantify grain yield responses to physical constraints to root penetration in a series of rainfed crops including indeterminate soybean, maize, sunflower and *Triticum aestivum L.* (wheat) The authors measured grain yield, shoot biomass, and harvest index in commercial fields of indeterminate soybean, maize, sunflower and wheat on five respective farms in south-eastern Pampas, Argentina (Sadras & Calviño, 2001). The farms were rainfed (940 mm average) and with an 8- to 15-year cropping and 3-year pasture (Sadras and Calviño, 2001). The population density for soyabean included 40–50 soybeans, 6–7.5 maize, 4–5 sunflowers, and 270–350 wheat (Sadras and Calviño, 2001). Plants were cropped at maturity where three shoot samples were taken at four points along a 200 m long transect of soil depths (Sadras and Calviño, 2001). The authors found that the average rate of grain yield reduction entailing decreasing soil depth was the smallest in soybean and wheat, intermediate in sunflower, and greatest in maize (Sadras and Calviño, 2001).

### 2.10.3.6) Mapping

#### 2.10.6.1) Geographical Information Systems

Geographic Information Systems (GIS) is an integrated collection of hardware, software, liveware, data and procedures to store, capture, manipulate, analyse, and display spatially referenced data to solve complex problems (Maguire, 1991). It is used in many natural resource management contexts (Eslami et al., 2011). For instance, GIS and high-quality land cover datasets were used in the study by Troy and Wilson (2006) to present a framework for the spatial analysis of the values of ESSs in Massachusetts, Maury Island, and Washington in California, USA. The authors mapped the spatial distribution of the topology of valuable land cover and aquatic resources (Troy & Wilson, 2006). GIS could therefore be used to map valuable land cover (i.e., the inventory of the honeybush industry). A study by Kazemi and Akinci (2018) used GIS and Multi-Criteria Decision Analysis (MCDA) to analyse where suitable land in the Golestan Province, Iran for rainfed farming performance. The authors used expert opinions and multiple environmental variables (i.e., soil, climate and topographic variables) to find suitable areas (Kazemi & Akinci, 2018). This form of GIS analysis can be used to identify suitable areas for honeybush cultivation. Another study by Mishra et al. (2015) used GIS and RS to find areas that were suitable for organic farming in Uttarakhand in India (in which 64% of the area is found under Himalayan Forests with substantial biodiversity).

#### 2.10.6.2) Land use and land cover (LULC) analysis

At the forefront of global socioeconomic transformation, contributing to rapid urban expansion, pressure on natural resources has increased, and vast amounts of productive land have been lost (Mansour et al., 2020). Remote sensing provides LULC information thus enabling the creation of accurate LULC mapping products (Wang et al., 2023). The authors found 56 global, 16 continental and 35 national LULC products, with spatial resolution ranging from 1 m to 100 km (Wang et al., 2023). A study by Musetsho et al. (2021) analysed the LULC changes in a critical biodiversity area (CBA) in the Limpopo Province. The authors found that in 1990, the dominant land cover was thickets and dense bush (40% cover), woodland (24% land cover) and built-up areas (18% land cover) (Musetsho et al., 2021). However, in 2018, the dominant land cover was woodland (71% land cover) and built-up areas (20% land cover) (Musetsho et al., 2021). A study by Mansour et al. (2020) analysed the dynamics of LULC from 2008–2018 and simulated urban expansion (2008–2038) in Nizwa City, Oman (Mansour et al., 2020). Geospatial techniques (using topographic spatial layers such as elevation, aspect, and terrain) were used to assess and project urban growth and land cover changes (Mansour et al., 2020).

In the context of this study, it is worth noting the LULC changes surrounding honeybush enterprises (especially at the forefront of encroaching invasive species).

**2.10.6.3) Species distribution modelling: Maxent**

In fields of biodiversity and ecology, the geographic distributions of species need to be accurately modelled (Phillips et al., 2008). There have been models that studied the spread of invasive species (Mainali et al., 2015; Srivastava et al., 2019), climate change-related changes to species distributions (Pearson & Dawson, 2003) and spatial patterns of species diversity (Phillips et al., 2008). The modelling applications require time and statistical fine-tuning of a range of data sources (Phillips et al., 2008). Maxent is a computer-based modelling technique that can achieve high predictive accuracy (Phillips et al., 2008). Phillips et al. (2008) used a comprehensive collection of data developed to compare species distribution modelling methods. One of the datasets contained presence-only data (i.e., geographic coordinates for the sites of recorded species and the environmental variables) (Phillips et al., 2008). The second dataset was presence-absence evaluation data (where each species contains a set of sites of observed presence and a set of sites of observed absence (Phillips et al., 2008). The authors concluded the tuning methodology based on presence-only data was effective, and the default parameters in Maxent's version 1.8.3 –3.1.0 are suited to a wide range of presence-only datasets (Phillips et al., 2008).

**KEY FINDINGS**

**CHAPTER 2**

The key findings of this chapter are summarised in the developed conceptual model in Figure 2. It served as a guide to the understanding of the important concepts within the literature review and how they related to each other. It presented two major components:

1) **Overarching knowledge:** the overarching theme of this research is sustainability which branches into the major concepts: social, economic and environmental sustainability. The core concepts are dispersed and shared amongst the major concepts which include land use/land cover (LULC), livelihoods (social and economic sustainability), BioTrade (social and environmental sustainability), regulations, agriculture, sustainable agriculture practices, and the cultivated honeybush tea industry (social, economic and environmental sustainability) and fynbos, ecology, biodiversity, natural resource management, and GIS applications (environmental sustainability).
2) **Cultivated honeybush tea industry:** cultivated honeybush supply chain (honeybush resources, harvesters and processors) that depend on the landowners, farmers, and diverse land uses (including private land, state land, and community enterprises). It was also important to note the history and progression of the cultivated industry (i.e., it was formerly overshadowed by the wild-harvesting industry) to see where it could be improved and sustained.

The overarching goal is therefore to achieve a consistent, quality supply of cultivated honeybush tea. This could be achieved by harmonising social, economic, and environmental aspects within a sustainability framework. This could be achieved through mixed methodologies comprising of (i) qualitative data collection (i.e., semi-structured interviews) and analysis and (ii) quantitative data collection (i.e., mapping, biodiversity surveys, soil surveys and field allometry surveys) and analysis.

# CHAPTER 3

## 3) Methods of data collection and analysis

Rooted in a Realism epistemology, this research employed a mixed-methods approach. This allowed for the rigorous integration of quantitative and qualitative methods, which, for a geographer, was appropriate (Creswell et al., 2006; Hawthorne, 2017). The approach was essential to address the complex, interconnected nature of the research aim and objectives, which were rooted in understanding sustainability (which has interconnected socio-economic and environmental facets) (Hawthorne, 2017). A summary of the various phases of data collection and analysis is presented in Table 9, starting with proposal development and ending with data analysis.

**Table 9:** The phases involved in the Exploratory Design approach of this research.

| Phases | No. | Task | Explanation |
|---|---|---|---|
| Pre-Exploratory Design | 1 | Proposal development | At a SAHTA meeting in Uniondale in 2022, the research topic ideas were proposed to a botanist and seven honeybush industry stakeholders (ranging from two academic experts, an export consultant, a government official, two small-scale farmers and one large-scale farmer). The advice was used to strengthen the proposal and methodologies. |
| Phase 1 | 2 | Inventory investigated (Objective 1) | The state of the cultivation honeybush industry was assessed. Enterprises were selected for case studies. |
| | 3 | Case studies investigated (Objective 2) | Five case studies were selected. On-site visitations occurred for some sites (for pilot study purposes). Qualitative and quantitative data were collected. |
| | 4 | Challenges investigated (Objective 3) | Nine stakeholders were selected. On-site qualitative data was collected. |
| Phase 2 | 5 | Data analysis | Data was analysed and synthesised |

### 3.1) Updated inventory of the cultivated industry

In biodiversity-related fields, the geographic distributions of species need to be accurately modelled for natural resource management purposes (Phillips et al., 2008). It is also important to establish an inventory of a resource's population distribution and abundance, especially regarding MAPs (Schippmann, 1997). Maps, which store, analyse, manage and visualise data, are ideal for showcasing inventory from a geographic perspective (Robinson et al., 2017). Such maps are therefore useful when managing the sustainable use of resources. This research focused on the sustainability of the cultivated honeybush sector, which in the past was overshadowed by wild resource harvesting (Joubert et al., 2011). This changed in 2023, whereby the cultivated sector contributed 53% of honeybush production (McGregor, 2024). The objective was to evaluate the state of the cultivated honeybush tea sector (to then further investigate the aspects contributing to some of the successes that caused the shift in the industry).

#### 3.1.1) Data collection and analysis

An inventory of the cultivated honeybush resources in the Eastern Cape and Western Cape was conducted using existing secondary data, from expert mapping by industry professionals from the ARC, Living Lands, Western Cape Department of Environmental Affairs and Development Planning (DEADP), Rhodes University and Eastern Cape records from the Department of Economic Development, Environmental Affairs and Tourism (DEDEAT) (McGregor et al., 2020). The inventory was last updated on the 6th of January 2020 by McGregor (2020). It entailed the following data: (i) the number of farms, (ii) the number of processors, (iii) the status of each farm, (iv) types of species per farm, (v) the number of hectares per farm, and (vi) proximity of the closest processor to each farm.

The map was updated for 2023 between 2019 and 2023. Industry professionals from the ARC, Living Lands and Rhodes University were contacted via email or personal communication. The email communication included an Excel template with the following required information: (i) Google Earth place-marker (for the general location of the farm), (ii) cultivation start date, (iii) total area in hectares, (iv) status (i.e., ended/ not in production/ in production/ deteriorated; new farms were also represented), (v) total area in production 2023, and (vi) species planted. All enterprise names and exact addresses were kept confidential. This exercise was not intended to be a detailed inventory for public use. It aimed to create a spatial distribution map of cultivation localities and their status (displayed on large-scale maps).

Using ArcGIS Pro Version 3.0.3, the inventory (i.e., spatial and attribute data of the cultivated resources) for 2020 was mapped using an Albers Equal Area projection with a central meridian of 24 with standard parallels of -24 and -33 (this projection was ideal for the wide east-west extent of South Africa). The following aspects were represented spatially: (i) the number of farms, (ii) the number of processors, (iii) the status of each farm, (iv) the number of hectares per farm and (v) the number of processors. Using primary data from relevant stakeholders, the above spatial data was updated and digitised for 2022. The updated inventory presented enterprises to conduct sustainability investigations.

### 3.2) An investigation into the environmental, economic, and social practices in successful cultivation enterprises

This objective constituted the bulk of the research data collection and analysis. It involved selecting successful enterprises from the inventory map to investigate their sustainability. A purposive sampling method was also employed to identify willing participants. Once identified, four models of honeybush tea cultivation based on successful, commercial enterprises, listed in Table 10, were investigated. An additional enterprise was investigated, but it was small-scale in comparison. A case study approach was employed at the five enterprises. A case study approach was employed across the five enterprises, as it allowed a detailed investigation of a range of phenomena, incorporating multiple perspectives, within a defined space and time frame (Kitchin & Tate, 2013). This approach has been widely used in agricultural research related to sustainability (Creswell, 2014). The case studies comprised qualitative data collection (i.e., semi-structured interviews) and quantitative data (i.e., land cover mapping, field allometry surveys at cultivated sites, biodiversity surveys and soil sample collections).

**Table 10:** The basic 'models' identified through cultivation approaches and species cultivated (McGregor, 2024).

| Survival strategy | Species | Intensity | Water | Cropping |
|---|---|---|---|---|
| Reseeder | *C. subternata* | Intensive, conventional cultivation | Rainfed and/ or irrigated | Every year |
| | *C. longifolia* (also a resprouter) | Intensive, conventional cultivation | Rainfed and/ or irrigated | Every year |
| Resprouter | *C. genistoides* | Low density | Rainfed | After at least 2 years |
| | *C. intermedia* | Moderate density | Rainfed | After at least 3 years |

#### 3.2.1) Semi-structured interview

Participants (i.e., enterprise managers or owners) were interviewed using informal, semi-structured interviews based on the UEBT Checklist (Appendix C). This approach allowed additional questions and answers to emerge during the open-ended dialogue (DiCicco-Bloom & Crabtree, 2006). This provided valuable insights into the complex experiences within the cultivated honeybush tea industry. Once the interviews were conducted and transcribed, Atlas.ai Version 24.2.0.32043 was used to manage the transcribed interviews. Since the data were qualitative, thematic analysis was applied whereby themes and patterns related to the research question were identified through thematic coding (Ngulube, 2015). The software allowed themes to be identified, reviewed and mapped according to their relationships (Ngulube, 2015). Interpretational analysis was also applied to the interviews. This allowed the qualitative data to be broken into constituent parts, placing them into similar classes or categories (Kitchin & Tate, 2013). These two methods helped identify and draw out divergences and commonalities within the responses (Kitchin & Tate, 2013).

### 3.2.2) Mapping

Globally, vast amounts of productive land have been lost due to increasing global socioeconomic transformations and pressures on natural resources (Mansour et al., 2020). These have been fuelled by rapid urban expansion, expanding agricultural practices and LULC changes (Mansour et al., 2020). In the context of this research, it was worth noting the LULC surrounding the honeybush enterprises (especially at the forefront of encroaching invasive species). Various spatial data were collected for analysis. Secondary spatial data for the five enterprises in the Western Cape province were derived from the Chief Directorate: Cadastral Spatial Information (http://csg.drdlr.gov.za/data.htm) to make boundaries for the enterprises. South African National Land Cover (SANLC) secondary data were sourced from the EGIS website (https://egis.environment.gov.za/sa_national_land_cover_datasets) to map the land cover for the study area. The datasets were for 1990, 2013-2014, and 2022.

Regarding data analysis, outlined in Figure 10, the SANLC datasets were projected to an Albers Equal Area projection (ideal for land masses that extend in an east-to-west orientation near or at the mid-latitudes, i.e., South Africa) (Albers, 2022) with a central meridian of 25 and Standard parallels of 24ºE and -33ºS. The enterprise boundaries (Farm Portion) were clipped from the Western Cape cadastral data, projected to the same projection and given a 1 km buffer. The SANLC datasets were extracted by mask (to maintain the land cover classes) to the enterprise boundaries. The 1990 and 2013-2014 datasets were resampled to the resolution of the 2022 dataset (20 m resolution).

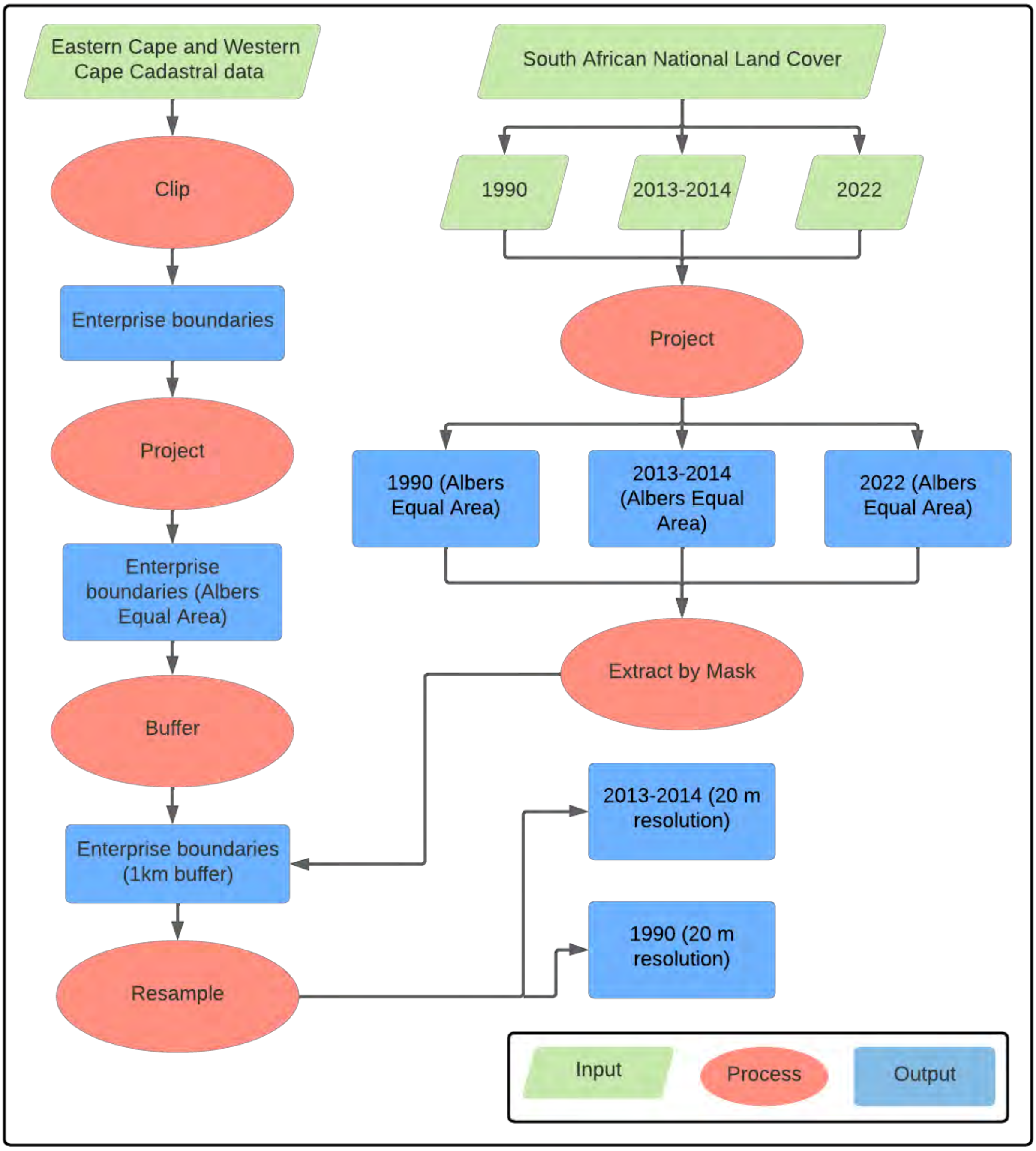


**Figure 10:** Cartographic model for landcover analysis for the research using ArcGIS Pro.

### 3.2.3) Plant survey

In natural resource management, the concept of plant allometry refers to the relationship that a plant's size has with its morphology, physiology and life history (Bradshaw & McMahon, 2008; Weiner et al., 2009). This concept is essential for understanding how plants adapt, function and grow in their environment (Weiner et al., 2009). This concept allows for the understanding of plant fitness, crop yield and how plants divide their energy among their organs (Vega et al., 2000; Sun et al., 2020). Allometric models are typically used in natural resource management (Sileshi et al., 2023). This method was therefore necessary to investigate the allometry of the different cultivated honeybush plants (which have different plant growth forms).

In this research, the physical characteristics (i.e., elevation, slope and characteristics of the surrounding vegetation) were recorded at each cultivated site (Appendix E). Within the cultivated sites, 5 x 25 m belt transects were laid out using a tape measure, and individual plants were marked and quantified for population surveys (Kitayama & Mueller-Dombois, 1994). Belt transects were ideal because they cover large areas and allow for accurate measurements of species cover and richness (McCune & Lesica, 1992). Within the transects (whose sample sizes and ages are captured in Table 12), the allometry of individual plants was collected by measuring the: (i) height of the plant (cm), (ii) width and length of the crown (cm), (iii) basal circumference (cm) and (iv) quantifying the stems. An example of on-site field measurements is represented in Figure 11. Finally, (vii) the diameter of 13 random stems from each plant was quantified. Half of the plants in the transect were cut and weighed using a small field scale accurate to 2 g. Descriptive statistics in Excel were used to analyse the allometry measurements of the plants at each cultivated site for the different ages. ANOVA was used to assess for significant differences across the above variables (Bevans, 2020). This allowed for the statistical assessment of variations within and between groups (across the five enterprises) (Bevans, 2020).

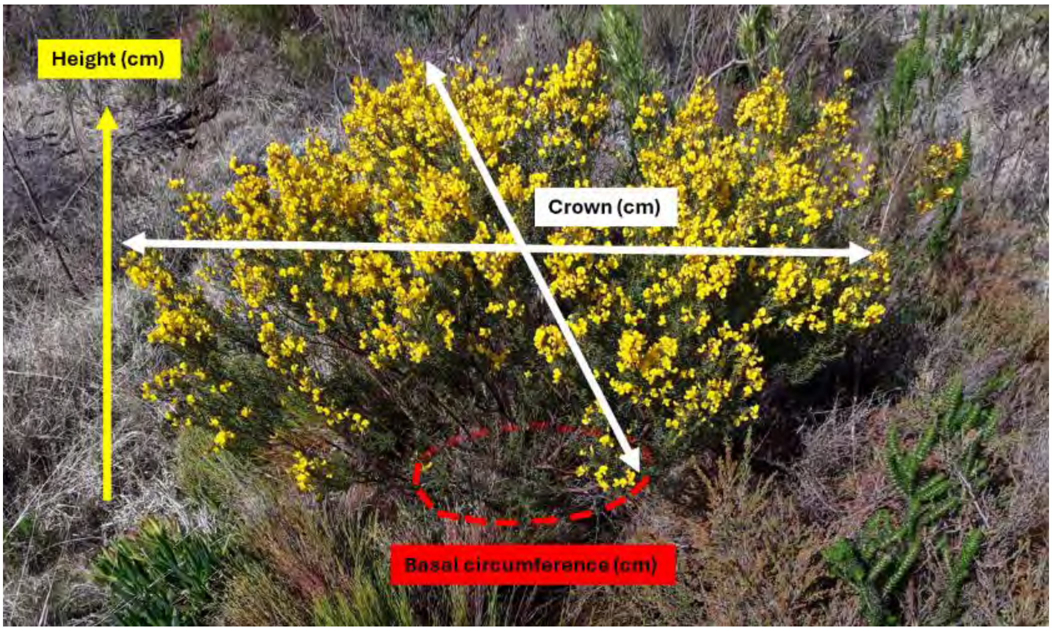


**Figure 11**: Illustration of allometric plant survey measurements conducted in the field, demonstrated on a single *Cyclopia genistoides* plant.

**Table 11**: Sample sizes and ages of plants measured at each cultivated site at each enterprise.

| Sites | Enterprise 1 | Enterprise 2 | Enterprise 3 | Enterprise 4 | Enterprise 5 |
|---|---|---|---|---|---|
| **1** | 29 (14 years old) | 65 (16 years old) | 21 (7 years old) | 20 (7 years old) | 30 (6 years old) |
| **2** | 40 (7 years old) | 30 (11 years old) | 20 (4 years old) | 20 (6 years old) | 30 (4 years old) |
| **3** | 30 (3 years old) | 30 (6 years old) | | 25 (4 years old) | |

### 3.2.4) Biodiversity survey

In a world that has growing concerns about biodiversity loss, there is a call for public, private and market sectors to regulate the natural resource-sourcing practices that promote and achieve biodiversity (Stamboulakis & Sanderson, 2020). This is especially important in practices such as agriculture, which often significantly impact the environment (Ortiz et al., 2021). This method aimed to evaluate the impact of honeybush cultivation on biodiversity (with a focus on vegetation communities). This was necessary to understand how cultivation practices influence an environment's structure, composition, and function (Noss, 1990). Assessing the relationship between honeybush cultivation and surrounding vegetation allowed this research to identify practices that minimise biodiversity loss while promoting sustainability. A vegetation community can be assessed and evaluated through cover estimates, which provide quantitative measures of different groups of plants (David, 2005). Cover estimates can be expressed as a cover amount, fraction or percentage (David, 2005). However, they require considerable time and expertise (especially with plant identification).

As a researcher with limited botanical knowledge, a rapid survey was employed as described by Khoza (2021). At each enterprise, two 6 x 15 m transect biodiversity surveys were conducted in the cultivated and non-cultivated sites, respectively. There were 10 3 x 3 m quadrats within the transect, illustrated in Figure 12 (quadrats are noted as a particularly effective method for sessile organisms (Walters & Scholes, 2017). Concerning vegetation assessments, common recorded measurements are cover and density (David, 2005). Therefore, within each quadrat, the percentage aerial cover of each species was given a score of either 1 (<1%), 2 (between 1 and 10%) or 3 (>10%) according to the method described by Khoza (2021). Unknown species were collected for identification. Descriptive statistics in Excel were used to analyse the biodiversity cover at the cultivated and non-cultivated sites at each enterprise. Tree maps (generated in Excel) will be used to display the biodiversity composition at the cultivated and non-cultivated sites. This is an effective method to display hierarchical information using rectangles in different sizes and colours (Long et al., 2017). They can also legibly display a lot of information (Long et al., 2017).

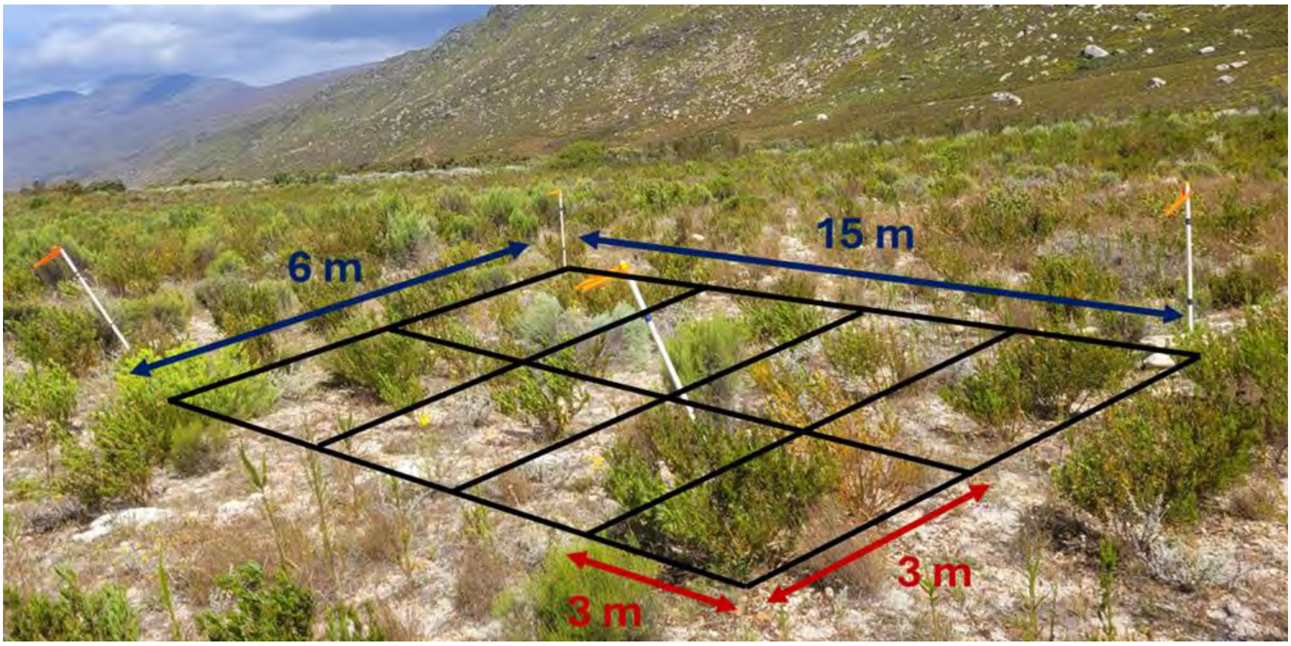


**Figure 12**: Biodiversity transect, illustrated in the field, divided into a 6 x 15 m transect with ten 3 x 3 m blocks (adapted by Khoza, 2021: 43).

### 3.2.5) Soil survey

Soil is valuable in agriculture as it hosts important macro- and microorganisms that play a role in decomposing organic matter, releasing nutrients and supporting plant growth (Reganold et al., 1990). For this research, soil testing was important to understand the nutrient health and composition of the soil within honeybush cultivation enterprises. These insights would help inform how soil quality affects honeybush success and sustainability. At each enterprise, five soil samples (combined to make a bulk sample) within a 1 x 1 m quadrat were collected at randomly selected locations within the cultivated and non-cultivated sites (10 samples in total). Figure 13 illustrates how soil was collected, within the corners and centre of a 1 x 1 m quadrat. The soil was collected from a depth of 15–20 cm (Daniel & Lerner, 2018). These soil samples were tested at a credible laboratory facility called BEMLAB, and the results were analysed using descriptive statistics in Excel.

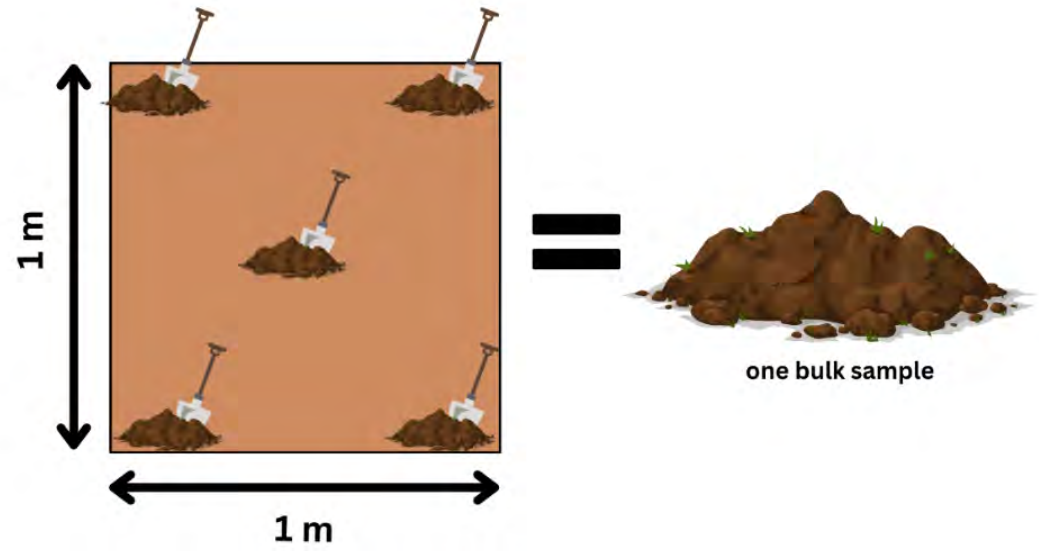


**Figure 13:** Representation of a 1 x 1 m quadrat and locations of a single soil sample collection.

**3.2.6) Estimating costs and yields per hectare for different species**

Understanding the economics of an enterprise requires consideration of input costs relative to profit (FAO, 2016). No formal comparison of the potential profit based on the cultivation of different species of honeybush and different cultivation approaches exists, but a simple profit calculation can be used to compare the potential profit under different scenarios. The inputs for these calculations were based on data available on production costs sourced from the farmers, field surveys and some published material. Longer-term yield figures, available in publications or from farmers' records, were used as input to calculations of average yields per year for the different species to calculate potential revenue. The figures obtained were used to determine the relationship between costs and revenue (i.e. profit) and the break-even point for the different species. Depending on the species, calculations could be run for as many years as the crop continues to produce before replanting is required.

Profit may be expressed as the difference between total revenue and total costs (Debertin, 2012) for each of four scenarios investigated in this research:

$$\boldsymbol{\pi} = \mathbf{R} - \mathbf{C}$$

where **R** is total revenue and **C** is total cost.

Revenue depends on the market prices of wet harvest material:

$$\mathbf{R_{wet}} = \mathbf{Q} \times \mathbf{P_{wet}}$$

where **Q** is the harvest volume in kilograms and $\mathbf{P_{wet}}$ is the price per kilogram of wet material.

Total cost is the sum of all the input costs (made up of production factors):

$$\mathbf{C} = \mathbf{L} + \mathbf{W} + \mathbf{S} + \mathbf{H}$$

where **L** is land preparation, **W** is weed control, **S** is seedling cost and **H** is the cost of harvesting.

The break-even point as defined by (Paff, 2021) is the level at which **Total Cost = Total Revenue**. The two values were plotted on a line graph, relative to time, to identify the break-even point. This point represents the year in which the enterprise has recovered all variable and fixed costs through revenue generated by sales of the product. Beyond this point, the enterprise is profitable.

### 3.3) An investigation into the challenges experienced by exiting as well as community enterprises

The cultivated industry inventory, developed in this research's first objective, identified private or community enterprises. It also identified enterprises that had exited the industry or were simply not producing. Purposive sampling was used to select willing participants to share their experiences, particularly why they decided to exit the industry. The participant makeup consisted of three enterprise owners who left the industry, an enterprise owner changing the honeybush species they cultivate, a community nursery owner, a community enterprise owner and an industry entrepreneur wanting to establish a community enterprise.

These participants were interviewed using informal, semi-structured interviews (provided in Appendix D). This approach allowed additional questions and answers to emerge during the open-ended dialogue (DiCicco-Bloom & Crabtree, 2006). This objective provided valuable insights into challenges within honeybush cultivation, which would inform sustainability frameworks. The qualitative interviews were analysed using the same methods as Objective 2.

### 3.4) The development of a sustainable resource use framework considering environmental, economic, and social aspects, which might be useful for future honeybush cultivation enterprises

The findings from the research's three objectives were integrated to create a sustainable resource use framework (considering environmental, economic, and social aspects of the cultivated honeybush industry). These findings were synthesised into a conceptual model. In addition to the above findings was the mapping of the four honeybush species.

In sustainability studies, the geographic distributions of species need to be modelled to address spatial patterns of species diversity and climate change-related changes to species distributions (Pearson & Dawson, 2003). This is worth noting for this research to identify areas where cultivation enterprises can be established (considering areas where the species naturally occurs). Secondary data for species distribution mapping were collected from the Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/species/search). Species datasets for the species *C. genistoides* (340 records from 1827–2022), *C. intermedia* (259 records from 1895–2022), *C. subternata* (302 records from 1895–2022) and *C. longifolia* (50 records from 1867–2022) were downloaded in 2022 (year of investigation). Additional acquired secondary data were global bioclimatic variables (derived from monthly temperature and rainfall values), entailing annual trends, seasonality and extreme or limiting environmental factors for which were downloaded (Fick & Hijmans, 2017).

Figure 14 is a cartographic model of the data collection (pale orange) and analysis (pale blue) processes used to conduct species distribution modelling using ArcGIS Pro. The data for the four species were converted from an Excel .xls table into XY points. These points were input into the Presence Only Prediction (Maxent) geoprocessing tool in ArcGIS Pro. A fynbos biome boundary was input into the Maxent tool to limit the extent of analysis. Explanatory training rasters, including 19 bioclimatic variables (which are variables derived from long-term climate data and widely used in environmental and ecological research) were input into the Maxent tool (Liu, 2022). The parameters, presented in Figure 14, were used in the tool as recommended by Liu (2022). This tool produced a set of results which may be used to assess the validity of the SDM and the probability of the distribution surface for each of the species.

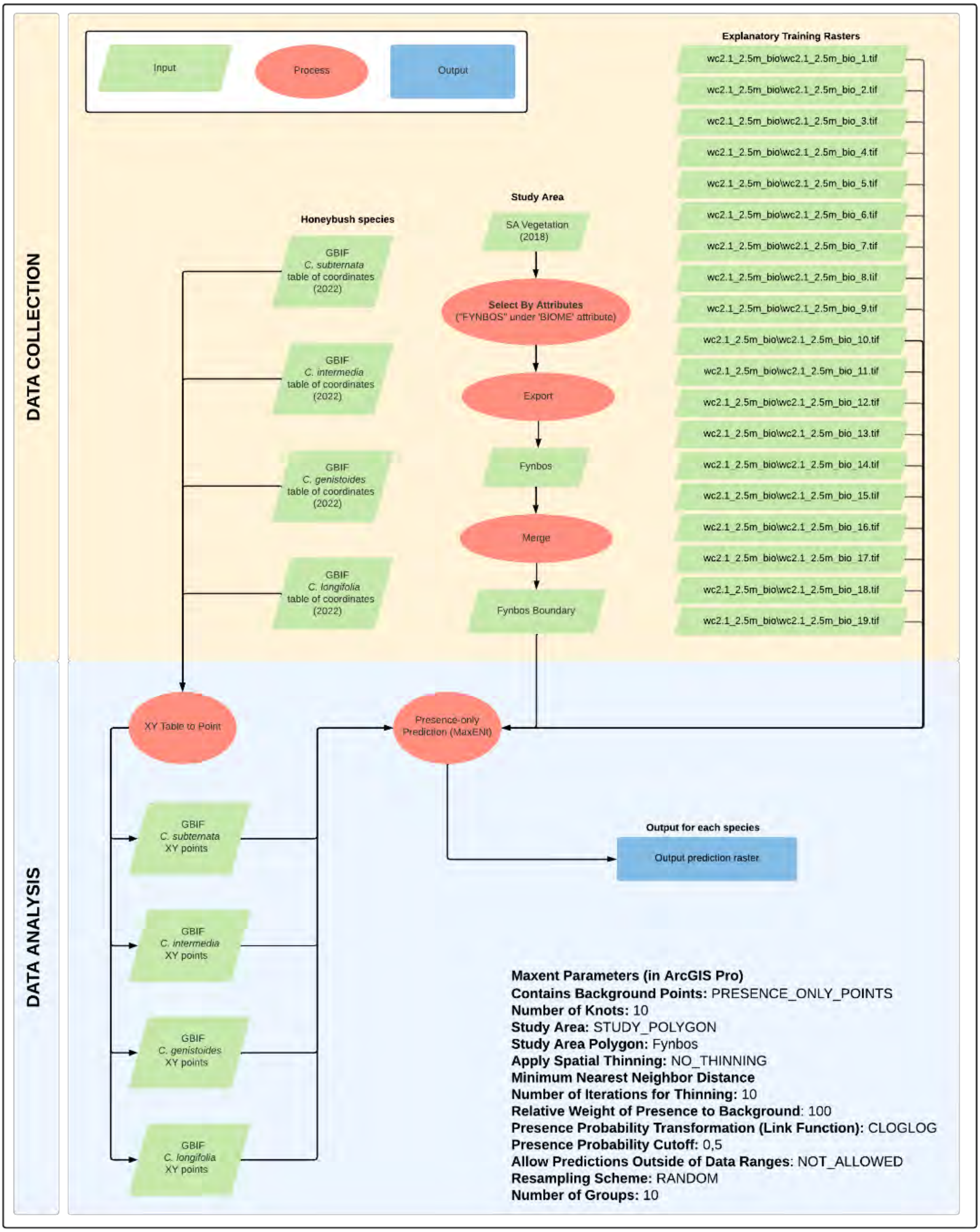


**Figure 14**: Cartographic model for species distribution modelling using ArcGIS Pro (data collection highlighted in pale orange block and data analysis highlighted in pale blue).

### 3.5) Ethical clearance

Since this research entailed in-depth interviews and questionnaire surveys, Ethics Approval from the Science Faculty Ethics Committee at Rhodes University was granted to commence this study. The Ethics Approval number for this research is 2022–5734–7238 (approval letter attached in Appendix F).

**KEY FINDINGS**

**CHAPTER 3**

The research proposal and methodologies were developed and refined with input from a botanist, industry experts, consultants, and farmers (small- and large-scale).

A multi-phased, exploratory design approach was used which allowed a thorough investigation of the cultivated honeybush tea industry from multiple angles and provided insights into the cultivated industry's current state, successes, and challenges. This would help inform the aspects of the industry's sustainability. The data collected would inform an assessment of the various aspects of the sustainability of the cultivated honeybush tea industry.

The following table is the summary of the qualitative (red) and quantitative (blue) methods conducted in the research.

REALISM UNDER 'CRITICAL SCIENCE'

MIXED METHODS APPROACH

| OBJECTIVES | DATA COLLECTION | DATA ANALYSIS |
|---|---|---|
| 1 | • Cultivated honeybush industry stakeholders consulted (via email and personal communication) to update the cultivated sector inventory. | Cultivated sector inventory map was updated for 2023 between 2019 and 2023 in ArcGIS Pro |
| 2 | A case study was conducted on five successful enterprises:<br>• Semi-structured interviews (5 participants)<br>• Mapping (landcover) for 1990, 2013-14 and 2022<br>• Plant surveys in cultivated sites<br>• Biodiversity surveys (in cultivated and non-cultivated sites)<br>• Soil sample collections (in cultivated and non-cultivated sites)<br>• Estimating costs and yields per hectare for different species | • Thematic & interpretational analysis<br>• LULC analysis in ArcGIS Pro<br>• Descriptive statistics & ANOVA<br>• Descriptive statistics & ANOVA<br>• Descriptive statistics<br>• Descriptive statistics |
| 3 | Discussion of industry challenges<br>• Semi-structured interviews (7 participants)<br>(3 left the industry, 1 changing cultivated honeybush species, 1 community nursery owner, 1 community enterprise owner and 1 an industry community entrepreneur) | • Thematic & interpretational analysis |
| 4 | • Synthesis of all objectives<br>• Mapping (honeybush species) | • Thematic & interpretational analysis<br>• Maxent modelling in ArcGIS Pro |

## CHAPTER 4

The research results per objective are presented as follows:

1. Updated cultivated honeybush tea inventory for 2023 (mapped)
2. Five case studies: interviews, mapping, plant survey, biodiversity survey, soil survey, cost estimations per hectare
3. Challenges in the cultivated honeybush tea industry: interviews

### 4.1) Updated inventory of the cultivated industry

In 2020, there were 37 cultivated honeybush enterprises, of which 19 were in the Western Cape and 18 were in the Eastern Cape (Figure 15). The majority (26) were private enterprises and 11 were community enterprises. In terms of the extent of cultivation, 24 were between 0–5 ha (small-scale), seven were between 5–10 ha (medium-scale), four were between 10–40 ha (large-scale) and two were between 40–70 ha (large-scale). Of the 37 enterprises, 26 were producing, nine were not in production, six were nurseries and one had deteriorated. There were six nurseries and seven processors (two processors and four nurseries in the Western Cape; five processors and two nurseries in the Eastern Cape). In 2020, there were 239.63 ha of cultivated honeybush of which 254.35 ha were from private enterprises and 39.3 ha were from community enterprises.

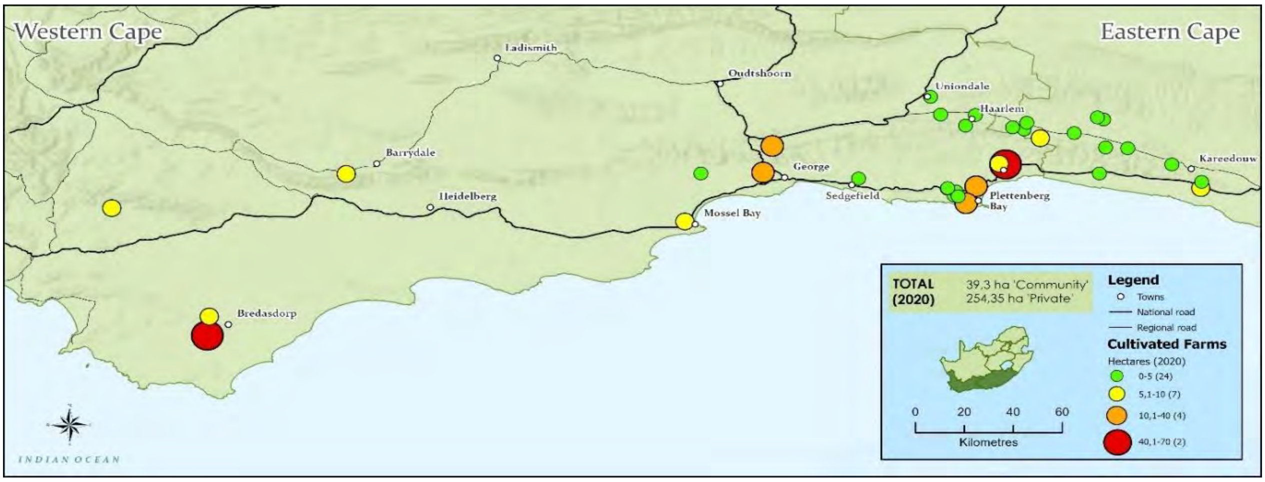


**Figure 15:** The inventory (sizes in hectares) of cultivated honeybush tea industry cultivation enterprises in 2020.

Figure 16 illustrates the updated inventory map of the cultivated honeybush tea industry for 2023. Of the 40 enterprises, 13 were producing, and 10 had exited the industry (seven from the Eastern Cape and three from the Western Cape). Of the 40 enterprises, four were not producing, and the status of 12 enterprises was unknown. Since 2020, three new enterprises have started producing honeybush tea. Based on the figures for 18 known enterprises, 325.9 ha of honeybush were in production in 2023. Of the enterprises with an unknown status, 12 had 75 ha in production in 2020. Ten enterprises exited the industry, which had formerly contributed to 25.55 ha. The community enterprises produced 12.3 ha in 2023. Of the unknown enterprises, six jointly contributed to 12.3 ha in 2020. There is one known nursery producing (5.2 ha). The status of two is unknown and an additional three have exited the industry.


**Figure 16:** The inventory of the cultivated honeybush tea industry in 2023 showing a combination of edited data from McGregor 2020 and new expert mapping input.

Table 12 summarises the key aspects of the cultivated honeybush tea industry's 2023 inventory. In 2023, 15 enterprises actively cultivated honeybush tea (7 in the Eastern Cape and 8 in the Western Cape). Processors were present at 4 enterprises (1 in the Eastern Cape and 4 in the Western Cape). The Eastern Cape had two large enterprises (80 and 38 ha respectively near Joubertina, cultivating 3 species). The Western Cape had more scattered but smaller sites, with the largest being a 67.2 ha farm near Plettenberg Bay.

**Table 12:** The cultivated honeybush tea industry inventory for 2023 indicating the enterprises currently in production and those that have exited the industry. (Abbreviations used: EC = Eastern Cape; WC = Western Cape; Y = Yes; N = No).

| Enterprise | Province (EC/WC) | Status | Processor (Y/N) | Nearest town | Species | Total ha |
|---|---|---|---|---|---|---|
| 1 | EC | Producing | Y | Misgund | 2 | 4.5 |
| 2 | EC | Producing | N | Joubertina | 1 | 1.7 |
| 3 | EC | Producing | N | Joubertina | 3 | 38 |
| 4 | EC | Producing | N | Joubertina | 3 | 80 |
| 5 | EC | Producing | N | Joubertina | 3 | 15 |
| 6 | EC | Not in production | N | Kareedouw | 1 | 0.2 |
| 7 | EC | Out | Out | Out | Out | Out |
| 8 | EC | Out | Out | Out | Out | Out |
| 9 | EC | Out | Out | Out | Out | Out |
| 10 | EC | Out | Out | Out | Out | Out |
| 11 | EC | Out | Out | Out | Out | Out |
| 12 | EC | Out | Out | Out | Out | Out |
| 13 | EC | Unknown | N/A | N/A | N/A | N/A |
| 14 | EC | Unknown | N/A | N/A | N/A | N/A |
| 15 | EC | Unknown | N/A | N/A | N/A | N/A |
| 16 | WC | Producing | N | Plettenberg Bay | 2 | 67.2 |
| 17 | WC | Producing | Y | Sedgefield | 1 | 1 |
| 18 | WC | Producing | N | Barrydale | 2 | 8 |
| 19 | WC | Producing | N | Herold | 1 | 12 |
| 20 | WC | Producing | Y | Plettenberg Bay | 2 | 31 |
| 21 | WC | Producing | N | Plettenberg Bay | 1 | 0.3 |
| 22 | WC | Producing | N | Plettenberg Bay | 1 | 12 |
| 23 | WC | Producing | Y | Bredasdorp | 4 | 50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 24 | WC | Not in production | N | Plettenberg Bay | Unknown | 0 |
| 25 | WC | Not in production | N | Plettenberg Bay | 1 | 0 |
| 26 | WC | Not in production | N | Plettenberg Bay | 1 | 0 |
| 27 | WC | Out | Out | Out | Out | Out |
| 28 | WC | Out | Out | Out | Out | Out |
| 29 | WC | Out | Out | Out | Out | Out |
| 30 | WC | Out | Out | Out | Out | Out |
| 31 | WC | Unknown | N/A | N/A | N/A | N/A |
| 32 | WC | Unknown | N/A | N/A | N/A | N/A |
| 33 | WC | Unknown | N/A | N/A | N/A | N/A |
| 34 | WC | Unknown | N/A | N/A | N/A | N/A |
| 35 | WC | Unknown | N/A | N/A | N/A | N/A |
| 36 | WC | Unknown | N/A | N/A | N/A | N/A |
| 37 | WC | Unknown | N/A | N/A | N/A | N/A |
| 38 | WC | Unknown | N/A | N/A | N/A | N/A |
| 39 | WC | Unknown | N/A | N/A | N/A | N/A |

The commonly cultivated species in 2020 was *Cyclopia subternata* (at 34 enterprises) (Table 13). In 2023, the number of enterprises producing *C. subternata* dropped to 15 enterprises. In 2023, there was also a substantial decline in enterprises producing *C. longifolia* (7 to 3 enterprises).

**Table 13:** Total number of enterprises cultivating one honeybush tea species in 2020 versus 2023.

| Honeybush species | 2020 | 2023 |
|---|---|---|
| *C. subternata* | 34 | 15 |
| *C. longifolia* | 10 | 3 |
| *C. intermedia* | 4 | 3 |
| *C. maculata* | 4 | 3 |
| Unknown | 2 | 1 |

In 2020, 21 enterprises produced one species, 10 produced two different species, 3 produced three species, and 1 produced 4 species (Table 14). The most abundant species across the distribution was *Cyclopia subternata*, seen at 34 enterprises. In 2023, 8 enterprises produced one species, 5 produced two different species, 3 produced three species, and 1 produced 4 species. There was a significant decline in enterprises with *C. subternata*. Half of the enterprises producing two species exited the industry in 2023. The ones producing more than three species all remained in 2023.

**Table 14**: Total number of enterprises cultivating either one species or a combination of honeybush tea species in 2020 versus 2023.

| Honeybush species | 2020 | 2023 |
|---|---|---|
| *C. subternata* | 20 | 7 |
| *C. subternata* and *C. longifolia* | 6 | 3 |
| *C. subternata* and *C. intermedia* | 4 | 2 |
| *C. subternata, C. longifolia* and *C. maculata* | 3 | 3 |
| *C. subternata, C. longifolia, C. genistoides* and *C. sessilifolia* | 1 | 1 |
| *C. maculata* | 1 | 1 |
| Unknown | 2 | 2 |

## 4.2) An investigation into the environmental, economic, and social practices in successful cultivation enterprises

The following principles from the UEBT Standard Checklist were used to frame the interviews (to get a better understanding of the sustainability of the enterprises): (i) Conservation of biodiversity, (ii) Sustainable use of biodiversity, (iii) Fair and equitable sharing of benefits derived from the use of biodiversity, (iv) Socio-economic sustainability (productive, financial and market management), (vi) Respect for the rights of actors involved in BioTrade activities. Since this research's overarching theme is sustainability, this section was divided into the major themes: (a) environmental sustainability, (b) social sustainability and (c) economic sustainability. According to thematic analysis conducted on the interview notes, the following themes were identified: (i) The problem of invasive species, (ii) Choosing which honeybush species to cultivate, (iii) Ensuring quality in the industry, (iv) Biophysical conditions associated with the industry and (v) Enterprise operations. Table 15 highlights the connection between the thematic analysis themes, their associated UEBT Standard Principle, and where they fit in sustainability.

**Table 15:** Connection between the thematic analysis themes, its associated UEBT Standard Principle, and major sustainability themes.

| Thematic analysis themes | UEBT Standard Principle | | Sustainability themes |
|---|---|---|---|
| The problem of invasive species | 1 | Conservation of biodiversity | Environmental |
| Choosing which honeybush species to cultivate | 2<br>4 | Sustainable use of biodiversity<br>Socio-economic sustainability (productive, financial and market management) | Environmental |
| Biophysical conditions associated with the industry | 2<br>3 | Sustainable use of biodiversity<br>Fair and equitable sharing of benefits derived from the use of biodiversity | Social and economic |
| Ensuring quality in the industry | 3<br>4 | Fair and equitable sharing of benefits derived from the use of biodiversity<br>Socio-economic sustainability (productive, financial and market management) | Social and economic |
| Enterprise operations | 6 | Respect for the rights of actors involved in BioTrade activities | Social and economic |

The environmental, economic, and social practices in five successful cultivation enterprises (where five owners served as participants) were investigated using the UEBT framework to guide questions. Four of the participants ran large-scale, commercial enterprises for the species of interest: *C. genistoides* (Participant 1), *C. intermedia* (Participant 2), *C. subternata* (Participant 5) and *C. longifolia* (Participant 4). The fifth participant owned a small-scale enterprise (*C. subternata*) (Participant 3).

**A) Environmental sustainability**

### 4.2.1) The problem of invasive species

*Conserving biodiversity*: All five participants mentioned that the main threat to biodiversity in their cultivated sites was IAPs (illustrated in Figures 17, 18 and 19). Three participants had *Acacia mearnsii* (Australian black wattle) in and around their cultivated sites. One had to clear IAPs, namely Australian black wattle and *Acacia melanoxylon* (black wood) before they could plant *C. subternata*. Figures 17c and d illustrate an IAP infestation in their enterprise (highlighting the reduced biodiversity at the base of the trees). This participant further stressed the difficulties with producing honeybush in the presence of invasive species:

*"... wherever the acacia species have grown, honeybush has struggled to grow. I have virtually had zero success rate in those areas."* – Participant 3

Participant 2 had Australian black wattle and *Hakea sericea* (silky hakea) in their cultivation sites and *Pinus L* (pine) in the surrounding mountains. Participant 4 notes that there used to be *Graphocephala coccinea* (blue leafhopper) on their farm and that *Solanum mauritianum* (bugweed) has become highly prolific in the past 5 years. Participant 3 had to clear pine and native fynbos to plant *C. subternata*. They further mentioned that although fynbos was cleared, honeybush (endemic to the fynbos biome) was planted. Participant 1 noted that they cannot clear around the cultivated sites yet as IAP clearing is expensive. They therefore keep their rivers, wetlands and cultivated sites clear. All five participants mentioned that IAPs were not introduced through cultivation. This is emphasised by Participant 1 who mentioned that:

*"... the invasive species* (wattles and pine) *were already present on the farm* (before honeybush cultivation occurred) *and subsequently spread due to not being controlled and managed."* – Participant 1


**Figure 17:** Photos taken within IAP infestations primarily adjacent to cultivation collection sites at Enterprise 5; (a) the shade from the canopy of IAPs illustrated; (b) density of infestation illustrated with *Acacia mearnsii* at the forefront; (c) lack of plant species diversity illustrated at the base; (d) size of IAP's basal circumference illustrated compared to a pen).

Participant 1 mentions that the IAPs, namely black wattle, *Acacia saligna* (Port Jackson willow) and *Myrtus communis* (myrtle), were on the enterprise before cultivation. They occurred naturally due to the rigorous seedbed within the soil. The participant described the difficulty of soil preparation with the present IAPs:

*"The minute you do the initial soil preparation, they tend to grow faster (i.e., the minute you stir the ground, they will grow). Initially, it is important to take them out manually because you don't want to stir the soil too much."* – Participant 1

**Figure 18:** IAPs (highlighted in yellow dashes) (a) adjacent to cultivated sites at Enterprise 1; (b) in the background at Enterprise 4; (c) adjacent to cultivated sites at Enterprise 3; and (d) directly adjacent to a honeybush tea field at Enterprise 1.

*Risk assessment tools to analyse biodiversity*: None of the participants had formal risk assessments. Three participants would clear IAPs at least once a year when time allowed. Participant 3 highlighted the risk of disturbing soil by cultivating honeybush (i.e., the soil getting flattened by equipment and tractors). They therefore aimed to do minimal groundwork to reduce soil movement.

*Sourcing information about biodiversity*: Three participants mentioned that they consult the ARC regarding major problems. Participant 3 made use of research and theses. Participant 3 noted that problems cannot simply be solved with Google (because they are too specific or niche questions). Two participants mentioned that there were no formal guidelines which might inform farmers of how to actively improve or retain biodiversity. They deal with problems as they arise. Participant 1 emphasised how they deal with problems as they arise below:

*You have to do what you have to do. If there is an invasive tree, you deal with it.* – Participant 1

**Figure 19**: *Acacia saligna* (IAP) (highlighted in yellow dashes) in one of the honeybush tea fields at Enterprise 1, which are typically removed periodically in their infancy.

*Enhancing biodiversity*: Four participants produced organically (i.e., without the use of pesticides and herbicides). Participant 5, who abides by ECOCERT Standards, only slashed the farm once or twice a year with a tractor. All the clearing done around the plants was done by hand, and the slashed plants were placed in the middle of the row to compost. Participant 3, who is not fully organic, encouraged natural germination to make the enterprise sustainable and self-sufficient, and further only irrigated when necessary. Participant 4 used manual weeding when the tea was young, followed by mowing the rows. It was also not intensive farming and existed in a "semi-natural state" (Participant 4). Participant 1 emphasised the importance of keeping their enterprise as natural as described below:

> *"The moment you take the* (alien) *vegetation out, the fynbos will flourish again. We really had to go resow the fynbos again. We farm with the honeybush between the fynbos. We don't clear fynbos species; we want it to grow in between."* – Participant 1

### 4.2.2) Selecting honeybush species to cultivate

*Selecting which honeybush species to cultivate*: All participants started honeybush cultivation on their enterprises with planted seedlings. Two participants mentioned that the choice was based on general recommendations. Participant 3 mentioned that it was trial and error. The advice they received was generally vague (i.e., they inquired where they could plant honeybush, and they were told "anywhere" and no one could tell them if they were in the right area or not. They further expressed their frustration with species selection:

> *"There are no hard and fast rules saying that this is what you should pick or this is what you should grow. You cannot farm with general recommendations anymore."* – Participant 3

Participant 4 was advised to plant *C. longifolia* because it was suitable for the area and fast-growing. The participant also had *C. maculata,* which they will not plant again because *C. longifolia* was more desirable and germinated successfully in the farm nursery (illustrated in Figure 20b)


**Figure 20:** (a) Honeybush tea seedling nursery at Enterprise 4 with (b) workers planting seeds and tending to seedlings.

Participant 2 mentioned that *C. intermedia* occurred naturally in the veld, prompting their decision to cultivate it. Their establishment is displayed in Figure 21. They also have *C. subternata* because it could be harvested annually, making it an economically better option than *C. intermedia* (which is harvested every third year). However, they plan to keep cultivating *C. intermedia* (because they have enough land). They also believed that the market would one day desire cultivated *C. intermedia* as expressed below:

> "… *because maybe in the future, they will poach all the* C. intermedia *in the Eastern Cape and perhaps the populations will be so small that they force people to stop harvesting in the wild."* – Participant 2

**Figure 21:** Cultivated *Cyclopia intermedia* field at Enterprise 2.

Participant 5 mentioned that *C. subternata* is a difficult plant to propagate, and they battled to reach their 7-year growth life cycle. The participant stated that:

> *"If you take germination from* (C. subternata) *seedlings, on a good day, you get an 80% growth rate and 20% mortality rate. Transplanting out, you will lose another 10%. If you look after 3–4 years, you have probably lost another 30%. At the end of the day, you are under 50% success rate"* – Participant 3

The participant further believed that it would be beneficial if they had a resprouter, because if there was a fire on the enterprise, it would resprout as opposed to their *C. subternata* (a reseeder). They also expressed how poorly the plants responded to heat stress: "If it gets a hot day, it dies." (Participant 3). Participant 3 also cultivated *C. maculata,* which they found the easiest to grow. However, it was not a favourable species due to its high-water content (i.e., high loss of mass in processing) and an undesirable flavour, so it was not recommended to plant. The participant believed that a plant that could also be viable to plant in the area is *C. longifolia.*

**B) Social and economic sustainability**

### 4.2.3) Quality associated with cultivation

*Purchasing seeds and seedlings from reputable sources*: It was recognised by participants subscribed to ECOSERT Standards (Participants 4 and 5) that planting material needed to come from reputable sources. Both enterprises were organically certified and thus harvested and used seeds from their certified cultivated sites. Participant 1 was also organically certified and produced and provided quality seeds. Participant 2, who used a trial-and-error method for their enterprise, collected and used their seeds for cultivation. Participant 3 mentioned that they bought seeds from the ARC (who provide seed from improved plants). The ARC also had guidelines for germinating and creating seedlings, training courses and general information which they found helpful.

*Challenges in disease and pest control*: Due to limited information about pests and organic restrictions, and constraints in terms of suitable control products. The greatest challenge for Participant 3 was combating fungi, root-knot nematodes, pest control, and weed control with limited information. Some preventative methods included: physically extracting diseased plants (Participant 5), having hands-on staff who monitored any infestations in nurseries (Participant 4 once had an *Agrotis ipsilon* (cutworm infestation)), using treatment actions for seeds (i.e., Participant 1 placed seeds in hot water for a few seconds to destroy contaminants and then stored them in air-tight containers) and merely leaving the plants as they are (Participant 2 maintained a natural state).

*Ensuring that plants were in a well-established cropping system*: Participant 3 suggested cutting only 40% of the plant (*C. subternata*), watering them if one had water, harvesting selectively and ensuring your staff had adequate training. Participant 3 did weed control by hand between the plants (*C. subternata*), did a cut and drop (with a brush cutter, cut the weeds and dropped them where they are; also done by Participant 2), only irrigated when necessary, and encouraged natural germination. Participant 4 mentioned that intensive weeding needs to be done for the first year of planting (*C. longifolia*). Participant 1 learned, through trial and error, that it was ideal to have a crop rotation system and careful monitoring of each block. Participant 2 uses pruning shears to make a clean cut, close to the ground (*C. intermedia*) and uses the normal guidelines for the species.

Participants 1–2 and 4–5 were confident that their *staff had the skills to implement necessary cultivation practices.* Participant 5, for instance, had monthly training with their staff. Participant 1 taught all their staff how to cultivate honeybush. However, Participant 3, who was an engineer by trade, did not initially have the needed skills and expressed how this affected them while trying to cultivate their honeybush:

> *"If I notice a problem, I don't have the skills to immediately correct the problem. I have to research and contact others on how to solve the problem."* – Participant 3

*Quality*: Four participants did not use agrochemicals. Participant 3 mentioned that the biggest challenge was controlling IAPs, without pesticides and herbicides. They did physical IAP removals, including roots. They mentioned that herbicides and pesticides were not encouraged, however, this results in mechanical costs to physically remove the IAPs. The participant mentioned that they were able to remove IAPs, but when it comes to *Cenchrus clandestinus* (Kikuyu grass) found on the enterprise, it was physically taxing to mechanically remove the IAPs. Therefore, it was a challenge not to use herbicides. Therefore, the pesticides and fungicides they used is neem oil and Trichoderma (which was not harmful). Participant 3, therefore, grows honeybush organically, but they are not certified and mentioned that:

> *"It is not financially viable for small-scale farmers to get certified organically."* – Participant 3

### 4.2.4) Biophysical aspects associated with cultivation

*Adopting cultivation practices to climate influences:* Cultivation practices needed to be adapted to the geographic conditions of the area, due to the honeybush species being resprouters or reseeders. Participant 3 only irrigated when necessary, especially in 2020 due to a lack of rainfall. However, in 2022, rainfall improved, but it was still low. Participant 4 had access to rainwater from a dam on the enterprise, and because honeybush naturally grew in the area, they did not have to adapt much. Participant 1 also did not have to worry about adapting too much. When there wasn't rain, their honeybush plants (*C. genistoides*) grew more slowly and lost their leaves, but did not die. They attribute their plant's success to their nature-like cultivation style:

> *"Because we farm so close with nature, we don't find that climate change has a dramatic effect on our plants… When there isn't rain, the plants pull back their resources again but then when there is rain again, they flourish again."* – Participant 3

The incidence and severity of fires were also considered a risk by participants, which could be managed in various ways. Participant 5 had fire barriers around the crops, so their plants were not damaged in the June 2017 fires. Participant 3 was also affected by the same fire, which burnt black wattle, blue gum and pine around the farm to the ground but has since regrown (Figure 21). The IAPs grew back, due to their substantial seedbanks. They noted that after the fire, actions should have been to control the IAPs.

**Figure 22:** Invasive species (highlighted in yellow dashes) adjacent to the honeybush tea fields (in the foreground), that grew after the 2017 fire.

Participant 2 acknowledged that if a fire occurred, all they could do was try their best to keep fires out of the cultivated fields. The participant considered fire a normal feature of the fynbos community and the *C. intermedia* would naturally resprout. However, the participant acknowledges that if a fire were to burn their *C. subternata*, it would be financially disastrous. This participant was also affected by the 2017 fire and another fire in the area about three or four years prior. However, since the participant maintains a nature-like cultivation system, they do not worry about climatic conditions as expressed below:

> *"Climate is organic, so I try to interfere as little as possible."* – Participant 3

*Access to good-quality water*: Participant 5 faced problems with water access. They did not have sufficient surface water and groundwater, since they were located on a hill. They invested in a borehole, but the water was salty due to being drawn from a low level. They also have a dam on the enterprise to irrigate when necessary. Participant 3 used drip irrigation when necessary (considered costly but less compared to flood irrigation). Participant 2 practised dryland farming, relying on seasonal rainfall. Participant 4 had three natural springs, next to the Salt River, known to have never run dry in recent memory. There were no immediate establishments upstream of the enterprise, which prevented water quality and shortage problems. The enterprise also had a deep borehole with high-quality water.

*Assessing soil quality*: Knowledge of soil properties was recognised as important by all participants who had conducted soil analyses (through professional laboratories) on their cultivated sites, particularly during the land preparation phase. Participant 1 mentioned that they did soil analysis once on their oldest cultivated sites (planted 15 years ago), and it is still flourishing. Participant 4 mentioned that in the early planting stages, they had minor reports of nematodes in the soil in nine of their cultivated sites, which used to have Australian black wattle (known to attract nematodes).

### 4.2.5) Enterprise operations

Participant 1 is a producer (namely, *C. genistoides*) and processor (who processes their tea species and the wet material of other partnered producers). Figure 23 illustrates their processing facility where staff are photographed feeding bundles of wet material into the tea cutter (Figure 23a). The freshly cut tea is then spread on the drying racks (Figure 23 b and d), which are later fermented in their furnaces. They package their tea into clean bags for sale, labelling them with the lot number and production date for traceability purposes. This whole operation is run on solar power. The owner also emphasises keeping the processing facility and its machinery well-maintained, clean and compliant.


**Figure 23:** Honeybush tea processing facility at Enterprise 1. (a) Staff are feeding bundles of wet honeybush tea material into the tea cutter to be cut into different sizes; (b) Student (Tafadzwa Makhuza) is seen spreading freshly cut honeybush tea on the drying racks; (c) Well-maintained equipment and processing compliant; (d) Honeybush tea that is drying on drying.

Participant 3 is a producer (namely, *Cyclopia subternata*) and processor (who processes their tea species and *Sceletium tortuosum* (sceletium) from sceletium producers). As an engineer by trade, they built their processing facility, including their furnace, tea cutter, and tea storage mats (Figures 24 a, b and c, respectively). They also had a storage facility for their tea in which they further packaged and sold their tea. Regarding energy use, they ensured that equipment that used petrol was used carefully and maintained. They only used a brush cutter once the honeybush was fully grown. They used ESKOM-supplied electrical power for the processing facility and pumping water. however, to reduce waste, they use less water and thus pump less.


**Figure 24:** Honeybush tea processing facility at Enterprise 3, which was built by the owner. It includes a (a) furnace; (b) tea cutter; (c) tea drying racks; and (d) a storage facility housing all the processed products in bags in the storage facility.

Participant 2 had a low-energy-consuming enterprise. They only cultivated honeybush tea (namely, *C. intermedia).* They delivered this tea to a processor, so they employed protocols to maintain a clean crop delivery such as cleaning their vehicles and tools before and during harvest. They also regularly took tea samples for chemical residue analyses. Participant 5 is a producer and a processor (namely, *C. subternata* and *C. longifolia)*. They have a modern processing facility which processes their tea. ECOSERT compliance, which they are under, requires that they keep detailed records of a clean, well-maintained processing facility which prevents foreign matter from encountering the tea. For this, their tea is hand-sorted, cut and dried. They also conduct moisture tests. Participant 4 is a producer (namely *C. longifolia*) and a nursery (which grows seedlings for supply) (Figure 20). Since they were also under ECOSERT compliance, they had to ensure that rigorous records for their tea production and nursery activities (i.e., ensuring that seedlings were pest-free and of good quality) were kept.

All participants made sure that quality controls were applied before harvesting and during harvesting (i.e., ensuring no foreign material was found with the raw material, cutting tea (with clean, well-maintained equipment) at the right ages, cutting the right amount of tea off the plants, transport the tea immediately from the collection site to the factory (which is the bonus of having an on-site factory). Quality control was even required post-harvest. Overall, extensive cleaning practices, training and record-keeping were required.

For enterprise operations to function well, trained operation staff are required. It is different for every enterprise depending on the operations and scale. Participant 2 has permanent staff workers who harvest their tea. Participant 5 has 10 workers from the local community. Participant 4 has local workers who are employed through a management service level agreement. Participant 3 has one labourer who is involved in all operations. Regarding *fair treatment and training for workers on health and safety,* Participant 1 found that the women on neighbouring farms often did not have employment, while their husbands had full-time jobs. For quite a while, they employed the women on the neighbouring farms through a "fixed term contract" (6 months). They found that employing the women for only 6 months would therefore not have a detrimental effect on the household because the husband would still have full-time work.

All participants had *standard operating procedures (mostly in the factories).* On the factory side, standards such as ECOSERT, SA-GAP, GlobalGAP, Personal Protective Equipment (PPE), and HAZOP (risk assessment for processing). Participants who did not have processing facilities needed to interact with their processors for instruction on what type of wet material to cultivate and send to them. This could be done through samples. Processors could then conduct taste tests on processed tea, which partly dictated how long the tea should be fermented and how long it is dried (i.e., moisture content must be between 5 – 7%, and that gets measured by the processor). All participants recognised that from the start of cultivation, they needed to understand what inputs are allowed for European, Chinese, American and Canadian countries (international markets); therefore, quality regulations need to be placed from the start. However, Participant 2 (who is a small-scale processor) noted how complex it is to achieve a quality product, as expressed below:

> *"There are no quality requirements from the industry. It needs to get built up from the industry so that we supply a quality product. The different areas that the honeybush grows provide different flavours and tastes. We need to know how is honeybush going to be graded as quality. We know how the wild honeybush must taste and its quality. Cultivated tea is going to be different. In every soil that it is grown, you will get a different flavour and quality. You will get a different quality from every factory in which it is processed. The factory is very much the manipulative point from the outcome of the quality of the tea."* – Participant 3

All participants provided *health and safety training and had first aid equipment*. Workers received one-on-one training for farming tasks, and specialists handled equipment operations. Additionally, all participants *paid their workers in line with official minimum wage regulations,* with two paying above the minimum wage. All participants expressed that their *workers were informed in writing and local language of the job conditions related to their work* (i.e., job position, working hours, level of wages, payment of wages, legal rights and duties, sick leave, and permitted vacations). Participant 1 even provided workers with a 2–4 week trial to ensure that they could work, and further stated that:

> *"We make them understand that they may work in hot greenhouses. If they have a heart problem, they cannot work for us (not out of discrimination but just that it's safer that they do not)."* – Participant 1

### 4.2.1) Enterprise 1: A case study of *C. genistoides*

#### 4.2.1.1) Mapping

Figure 25 is a land cover map for Enterprise 1 for 1990, 2014 and 2022. In 1990, the largest land cover classes by area were 1 135.20 ha of 'shrubland fynbos' surrounding the enterprise, of which 212.16 ha lay in the enterprise. There were 933.36 ha of 'cultivated commercial fields (high)' and 392.65 ha of 'cultivated commercial fields (medium)' of which 261.89 ha and 180.20 ha lay in the enterprise, respectively. Over the years, 'shrubland fynbos' decreased in surrounding areas (1097.33 ha in 2014) and increased in the enterprise (225.64 ha in 2014). In 2014, high and medium-cultivated commercial fields decreased in surrounding areas (612 ha and 563.86 ha, respectively) and within the enterprise (207.62 ha and 201.30 ha, respectively). In 2022, cultivation around and within the enterprise increased. In surrounding areas, ‘commercial annual crops rain-fed/ dryland’ covered 1 288.09 ha of which 451.12 ha occurred in the enterprise. ‘Low shrubland (fynbos)’ occupied 612 ha around the area with 166 ha occurring within the enterprise. “Fallow land and old fields (trees) were the third largest class in the area (311.16 ha). It is the fourth-highest land cover in the surrounding area at 223.48 ha. In 2022, fallow lands surrounding the enterprise replaced a substantial amount of fynbos shrubland. The third largest class in the enterprise is ‘dense forest and woodland’ occupying 88.14 ha. Additionally, ‘contiguous low forest and thicket’ have increased in the enterprise area to 69.42 ha. The trees have particularly increased within the centre of the enterprise, running towards the north. The forested/ tree areas show a notable increase at the centre of the farm, extending northwards.

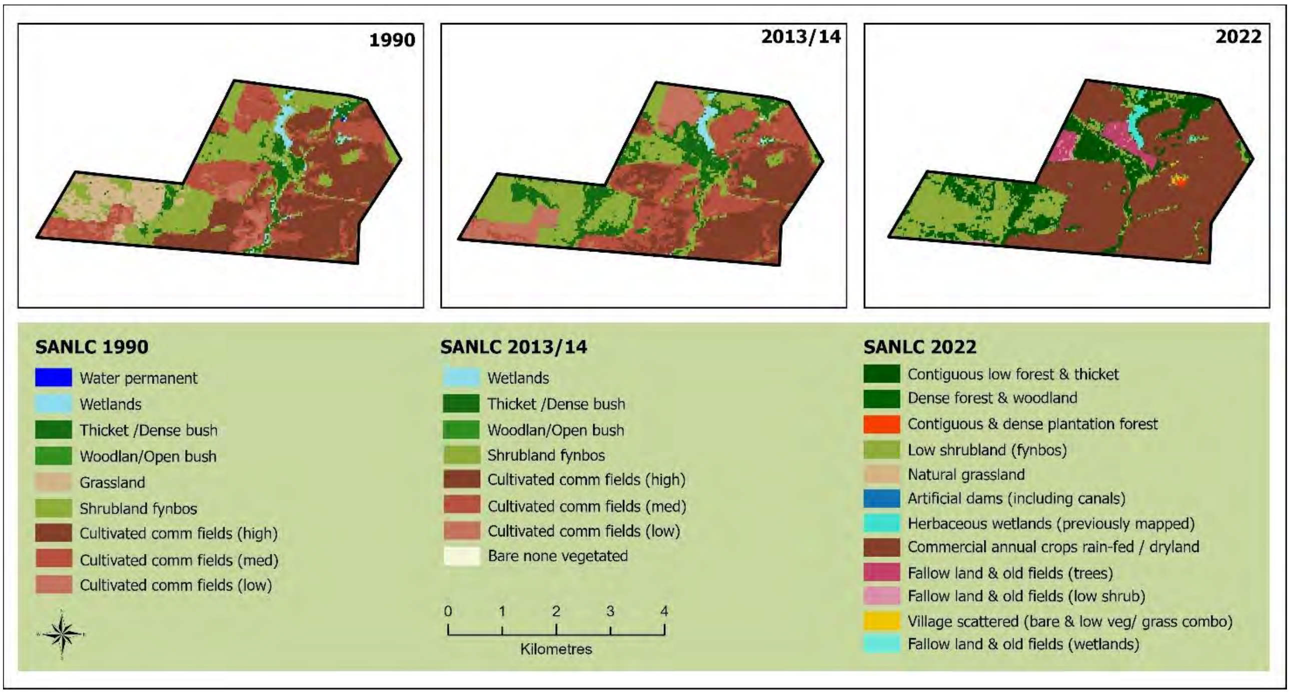


**Figure 25:** South African National Land Cover (SANLC) map of Enterprise 1 for 1990, 2013-2014, and 2022; ‘woodlan’ = woodland; = commercial; ‘med’ = medium; ‘veg’ = vegetation.

Figure 26 is a species distribution map highlighting the probability of occurrence of *C. genistoides* throughout the Fynbos extent in South Africa. The species is largely found along the western coast and interior of the Fynbos extent. Enterprise 1, which grows *C. genistoides*, occurs within the 0.25–0.50 distribution range.

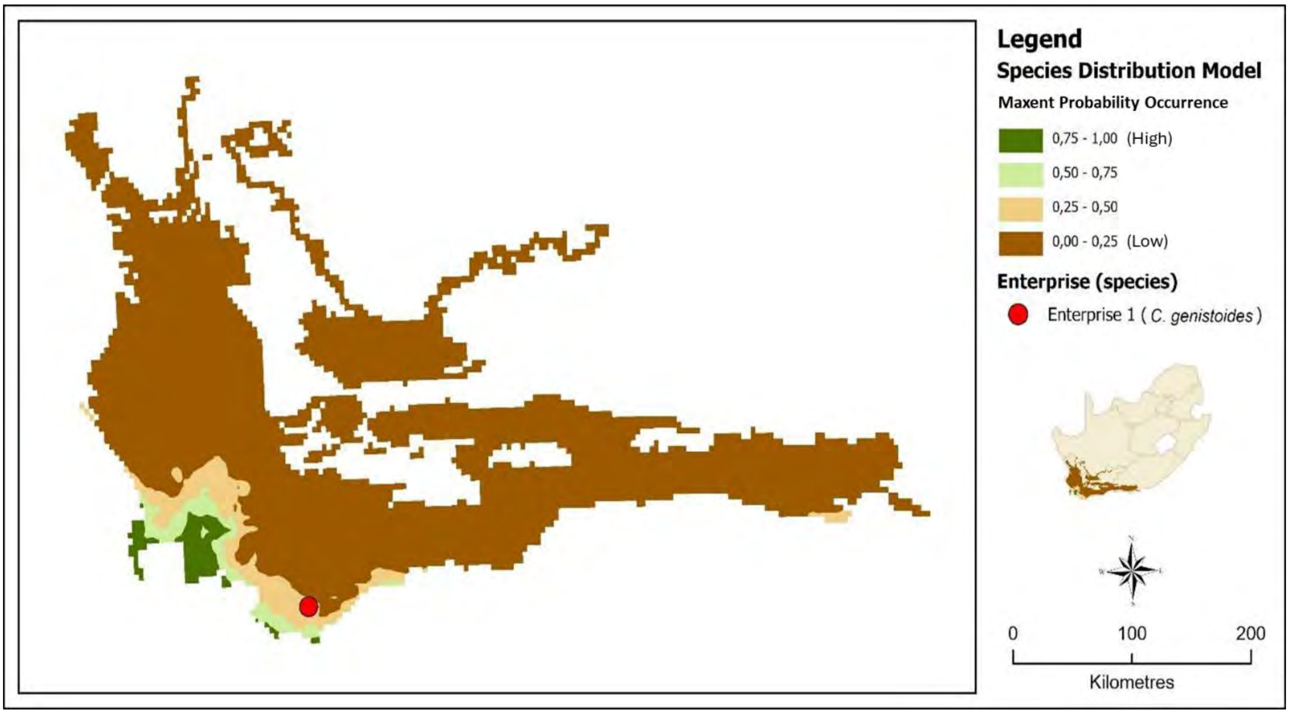


**Figure 26:** Species distribution map (Maxent), highlighting the probability of occurrence of *Cyclopia genistoides* throughout the Fynbos extent, including Enterprise 1 (which plants *C. genistoides*).

### 4.2.1.2) Plant survey

Figure 27 illustrates the plant allometry measurements of the average (a and b) length (height and crown), (c) yield (kg), (d) basal circumference (cm), (e) stem count (no.) and (e) average stem diameter (mm) for *C. genistoides* for cultivated sites that were 3-, 7- and 14-years-old. The average measurements of the plants' physical size increase with age (particularly at age 7) (with notable variability occurring in older plants). Although the physical size increases with age, there were no significant differences between the following measurements: height ($p = 0.817$), crown ($p = 0.653$), yield ($p = 0.564$), basil circumference ($p = 0.944$), stem count ($p = 0.214$) and average stem diameter ($p = 0.614$). The plants are at their greatest sizes at age 7 with average measurements of 86.05 cm (height), 109.9 cm (crown), 71.25 cm (basal circumference), and 4.27 in stem count. The yield increases from an average of 0.71 kg at age 3 to 2.85 kg at age 7. All the measurements, except for stem count (which dramatically increases at age 14), decrease by age 14. However, all measurements are greater than age 3. Overall, the are higher incidences of variability as the plants age.

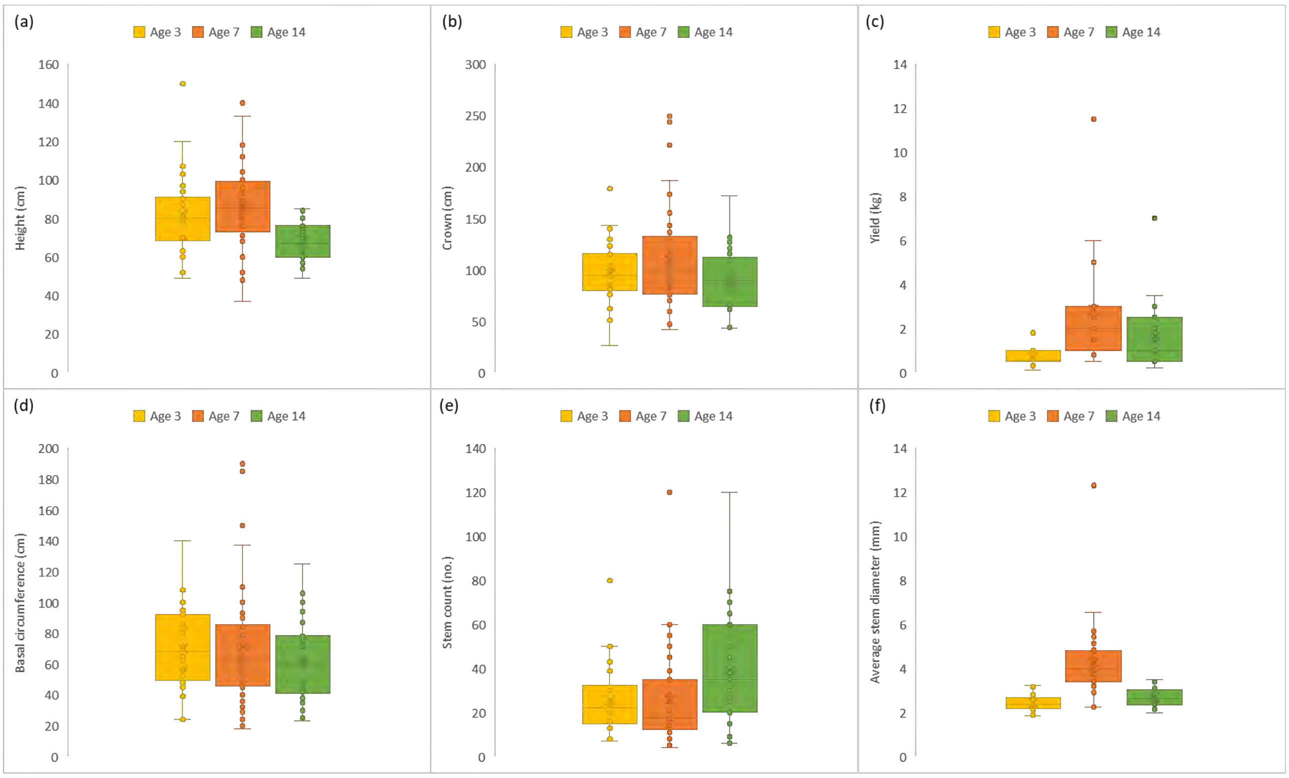


**Figure 27:** Plant allometry measurements of the (a) length (height and crown), basal circumference (cm), (b) yield (kg), stem count (no.) and stem diameter (mm) for *Cyclopia genistoides* for cultivated sites that were 3-, 7- and 14-year-old.

### 4.2.1.3) Biodiversity survey

Figure 28 is a tree map illustrating the species in the cultivated site according to those that had the most aerial cover (above 9 m$^2$), moderate aerial cover (between 0.9 to 9 m$^2$) and had a low aerial cover (between 0 and 0.9 m$^2$). These are written in green, yellow and red, respectively. There were 28 species in this site from 10 families. The largest plant family in this site was Asteraceae (11 species) and Restionaceae (6 species). The species that covered the largest area were *Metalasia muricata, Helichrysum patulum, Chrysocoma ciliata* (Asteraceae), *Pennisetum clandestinum* (Restionaceae) and *Pennisetum clandestinum* (Poaceae).


**Figure 28:** Tree map illustrating the species in the cultivated honeybush tea site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

Figure 29a illustrates a honeybush tea cultivated site at the enterprise in which two other plant families are growing amongst *C. genistoides*. Other species depicted include *Protea repens, Leucadendron; and Erica canaliculate* (Figures 29 b to d, respectively).

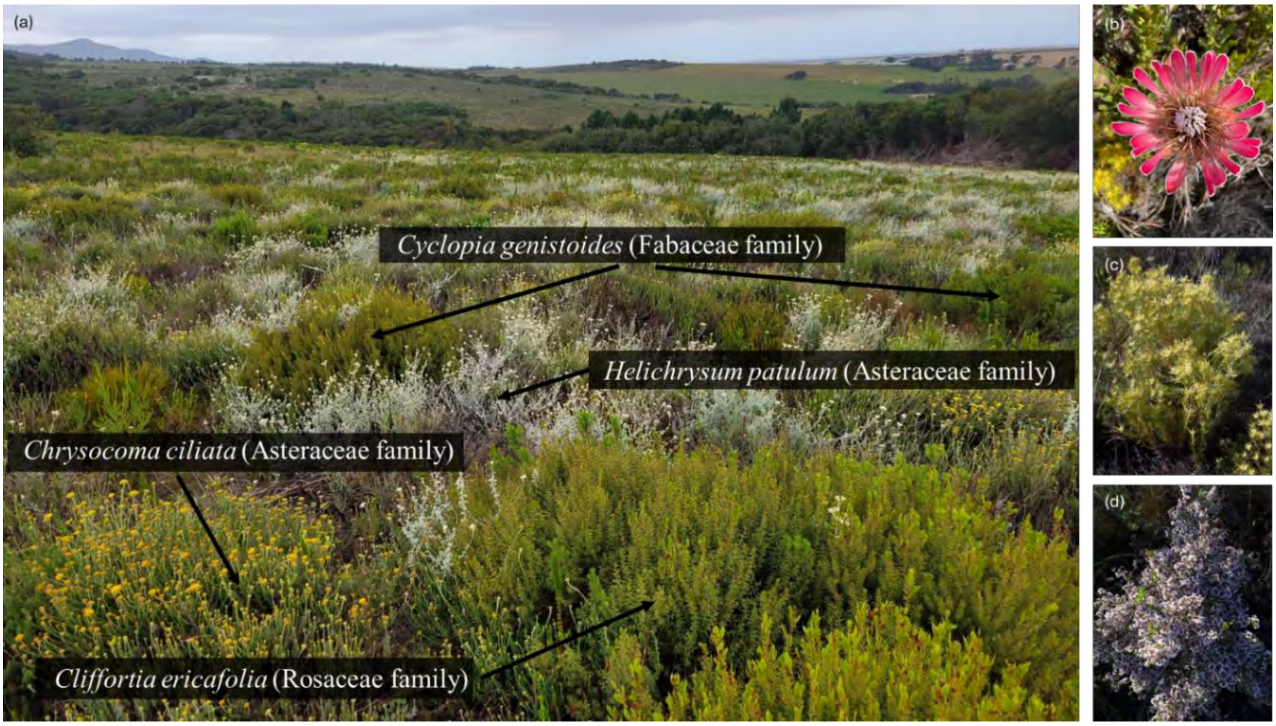


**Figure 29**: Cultivated site at Enterprise 2 with three visible plant families; (b) *Protea repens*; (c) *Leucadendron*; (d) *Erica canaliculate.*

There were 19 species in this non-cultivated site from 10 families (Figure 30). The largest plant family on this site was Restionaceae (7 species). The species that covered the largest area were *Restio tetragonus, Restio egregious*, *and Elegia ebracteate* (Restionaceae), *Erica canaliculata* (Ericaceae) and *Myrtus communis* (Myrtaceae).


**Figure 30**: Tree map illustrating the species in the non-cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

There were three species from three different families found within an IAP-inverted site (Figure 31). The species that covered the largest area was *Acacia longifolia* (Fabaceae).


**Figure 31**: Tree map illustrating the species in the invaded non-cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

### 4.2.1.4) Soil survey

Table 16 illustrates the soil survey results of soil extracted from a cultivated site and a non-cultivated site at Enterprise 1. Both soil textures were sand. The following elements were higher at the cultivated site: pH (pH 4.8), resistance (2 370 ohms), phosphorus (Bray II) (6.3 mg/kg) and calcium (2.4 cmol/kg). The remaining elements were slightly higher in the non-cultivated site; magnesium (0.86 cmol/kg), potassium (85.5 mg/kg which was substantially higher than the 37.7 mg/kg at the cultivated site), sodium (2.1 cmol/kg), zinc (0.97 mg/kg which was substantially higher than the 0.49 mg/kg at the cultivated site), baron (2.5 mg/kg) and Iron (49.4mg/kg). Copper remained the same at both sites at <0.33 cmol/kg.

**Table 16:** Soil analysis results of macro- and micronutrients of soil extracted from a honeybush tea cultivated site and a non-cultivated site at Enterprise 1.

| Site | Texture | pH KCl | Resist. (ohm) | H+ cmol/kg | P (Bray II) mg/kg | K mg/kg | Ca cmol/kg | Mg cmol/kg | Na cmol/kg | Cu mg/kg | Zn mg/kg | Mn mg/kg | B mg/kg | Fe mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cultivated | Sand | 4.8 | 2,370 | 1.23 | 6.3 | 37.7 | 2.4 | 0.78 | 0.11 | <0.33 | 0.49 | 1.6 | 2.1 | 35.5 |
| Non-cultivated | Sand | 4.3 | 1,150 | 2.24 | 5.3 | 85.5 | 1.9 | 0.86 | 0.21 | <0.33 | 0.97 | 2.3 | 2.5 | 49.4 |

***Resit. = resistance**

### 4.2.2) Enterprise 2: A case study of *C. intermedia*

### 4.2.2.1) Mapping

Figure 32 is a land cover map for Enterprise 2 for 1990, 2014 and 2022. In 1990, the largest land cover classes by area were 754 ha of 'shrubland fynbos' surrounding the enterprise of which 66.63 ha lay in the enterprise. There were 199.97 ha of 'grassland' and 112.78 ha of 'cultivated commercial fields (low)' in the surrounding areas of which 16.15 ha and 26.43 ha lay in the enterprise, respectively. Over the years, 'shrubland fynbos' decreased in surrounding areas (443.34 ha in 2014) and increased in the enterprise (31.08 ha in 2014). In 2014, medium- and low 'cultivated commercial fields' were the largest land cover classes within the enterprise at 60.47 and 36.58 ha, respectively. In the surrounding areas, 'thicket/ dense bush' increased to 303.46 ha of which 18.02 ha lay in the enterprise. Grassland was the third largest land cover in the surrounding areas (250.20 ha) of which 23.30 lay within the enterprise. In 2022, the largest land cover classes were 'low shrubland (fynbos)' (1 033.16 ha of which 99.25 ha lay in the enterprise), 'commercial annual crops rainfed/ dryland' (228.72 ha of which 82.44 ha lay in the enterprise) and 'cultivated commercial permanent orchards' (105.58 ha of which 11.74 ha lay in the enterprise). It is worth noting that in 2022, 'fallow lands and old fields (low shrub)' covered an area of 72.54 ha, to the north-west of the enterprise, replacing low and medium cultivated commercial fields that were present in 2024.

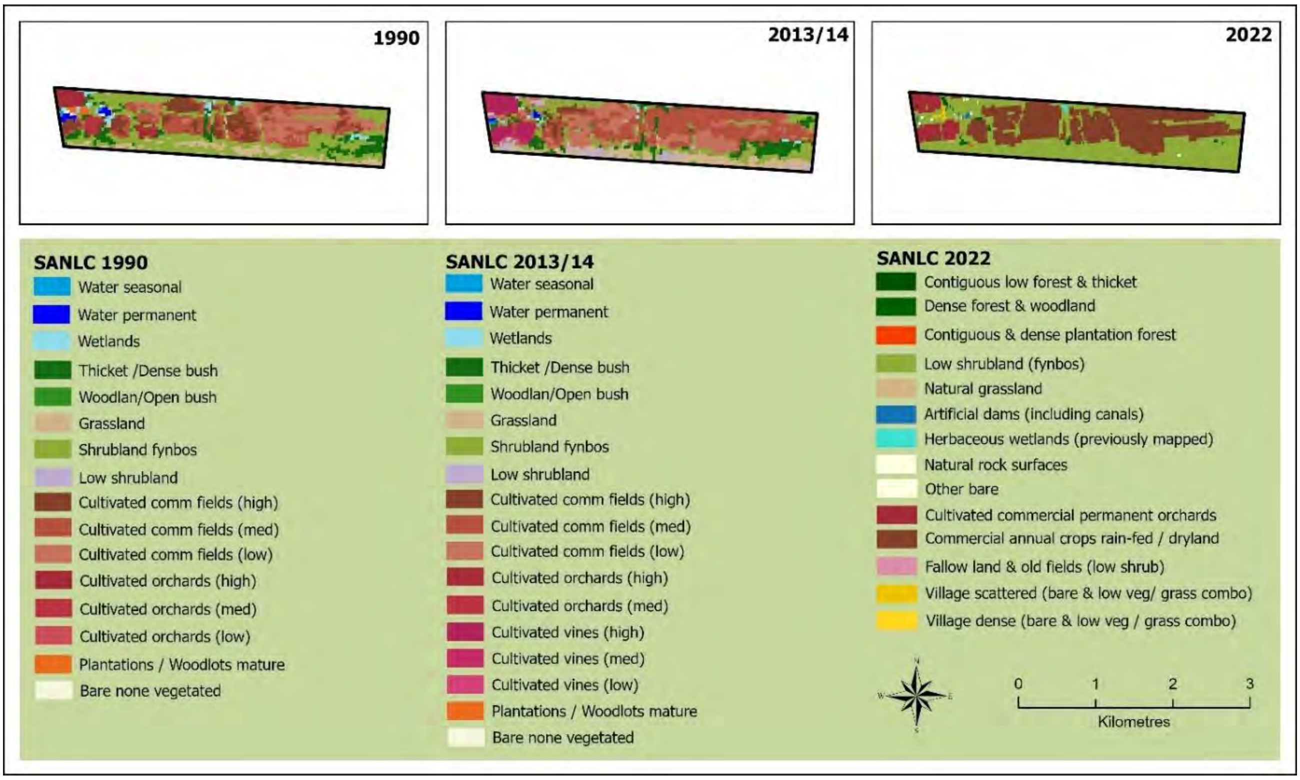


**Figure 32**: South African National Land Cover (SANLC) map of Enterprise 2 for 1990, 2013-2014, and 2022; 'woodlan' = woodland; = commercial; 'med' = medium; 'veg' = vegetation.

Figure 33 is a species distribution map highlighting the probability of occurrence of *C. intermedia* throughout the Fynbos extent in South Africa. The species is largely found along the eastern coast and interior of the Fynbos extent. It is the widest-distributed species in the genus. Enterprise 2, which grows *C. intermedia*, occurs within the 0.25–0.50 distribution range.

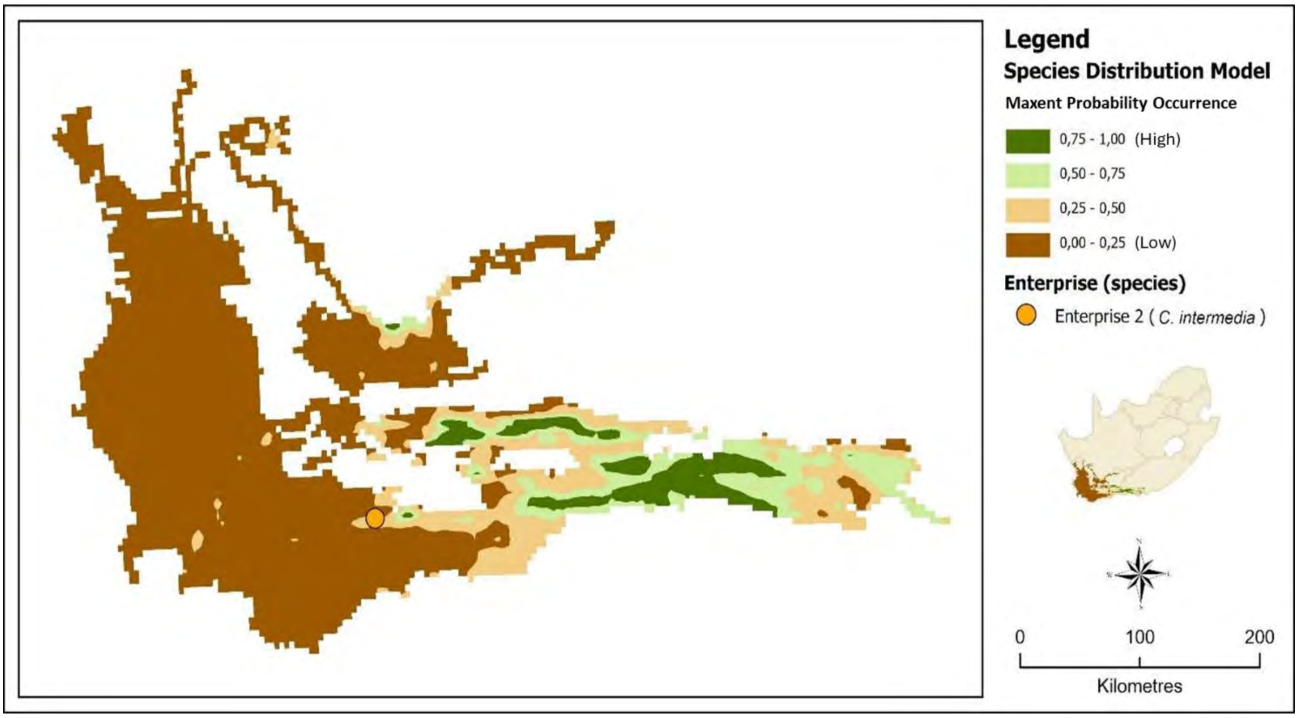


**Figure 33**: Species distribution map (Maxent), highlighting the probability of occurrence of *Cyclopia intermedia* throughout the Fynbos extent, including Enterprise 2 (which plants *C. intermedia*).

### 4.2.2.2) Plant survey

Figure 34 illustrates the allometry measurements of the average (a and b) length (height and crown), (c) yield (kg), (d) basal circumference (cm), (e) stem count (no.) and (e) average stem diameter (mm) for *C. intermedia* for cultivated sites that were 7-, 12- and 17-years-old. There were no significant differences between the following measurements: height ($p = 0.308$), crown ($p = 0.126$), yield ($p = 0.292$), basil circumference ($p = 0.215$), stem count ($p = 0.223$) and average stem diameter ($p = 0.294$). The average measurements of the plants' physical length and crown slightly increase between ages 7 and 12. The basal circumference shows substantial growth from an average of 31.10 cm by age 7 to 57.53 cm at age 17. The yield and stem count also dramatically increase from ages 7 to 12, averaging 0.58 to 0.7 kg and 12 to 29 stems. Stem diameter stays constant from years 7 to 17.

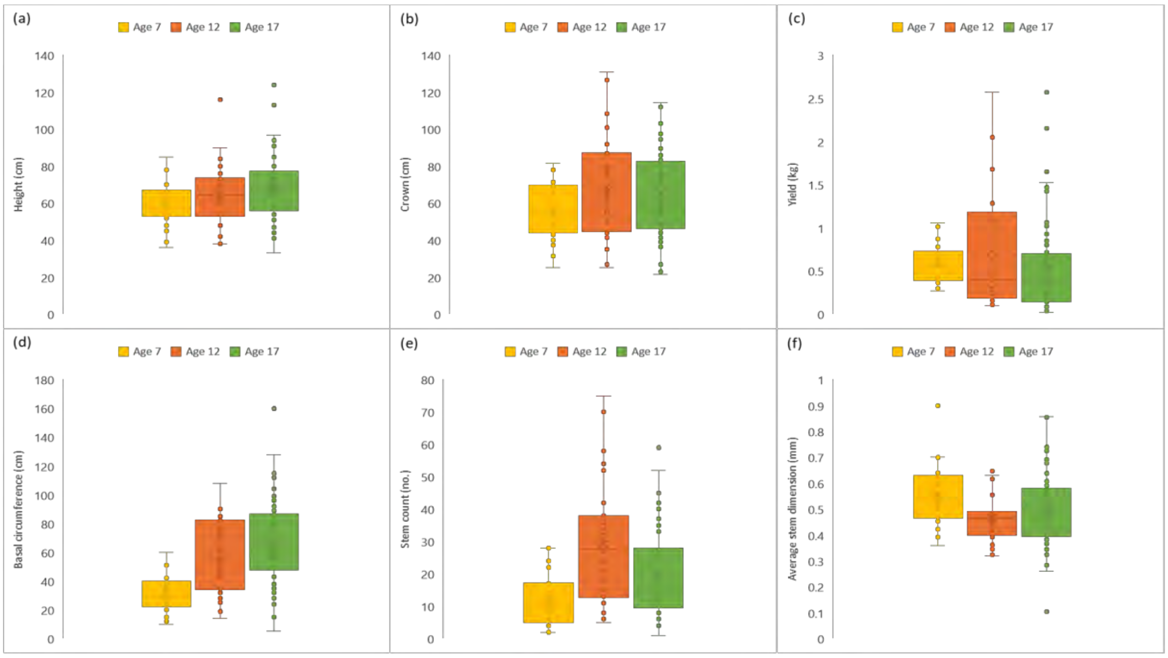


**Figure 34**: Allometry measurements of the (a) length (height and crown), basal circumference (cm), (b) yield (kg), stem count (no.) and stem diameter (mm) for *Cyclopia intermedia* for cultivated sites that were 7-, 12- and 17-years-old.

### 4.2.2.3) Biodiversity survey

Figure 35 is a tree map illustrating the species in the cultivated site according to those that had the most aerial cover (above 9 $m^2$), moderate aerial cover (between 0.9 to 9 $m^2$) and had a low aerial cover (between 0 and 0.9 $m^2$). These are written in green, yellow and red, respectively. There were 15 species in this site from 7 families. The largest plant family in this site was Asteraceae (5 species) and Restionaceae (4 species). The species that covered the largest area were *Merxmuellera stricta* (Poaceae), *Helichrysum patulum, Baccharis*, and *Taraxacum officinale* (Asteraceae) and *Anthospermum aethiopicum* (Rubiaceae).


**Figure 35**: Tree map illustrating the species in the cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

Figure 36a illustrates a cultivated site at the enterprise in which two other plant families are growing amongst *C. genistoides*. Other species depicted include *Protea neriifolia; Erica vestita, Tritoniopsis antholyza, Elegia cuspidate, Anthospermum aethiopicum* and *Aspalathus* (Figures 36a to g, respectively).

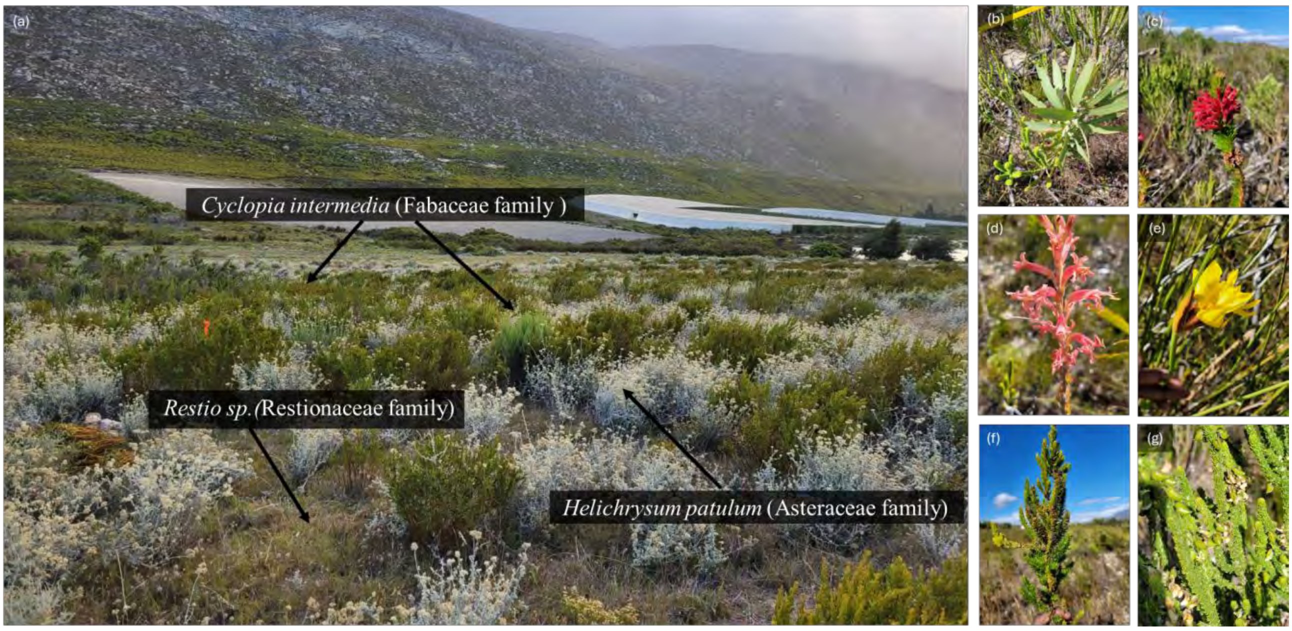


**Figure 36**: Cultivated site at Enterprise 2 with three visible plant families; (b) *Protea neriifolia;* (c) *Erica vestita;* (d) *Tritoniopsis antholyza;* (e) *Elegia cuspidate;* (f) *Anthospermum aethiopicum* and (g) *Aspalathus sp.*

There were 25 species in this non-cultivated site from 8 families (Figure 37). The largest plant family in this site was Restionaceae (8 species) and Asteraceae (6 species). The species that covered the largest area were *Hypodiscus willdenowia* (Asteraceae), *Protea neriifolia* (Proteaceae) and *Aspalathus* (Fabaceae).

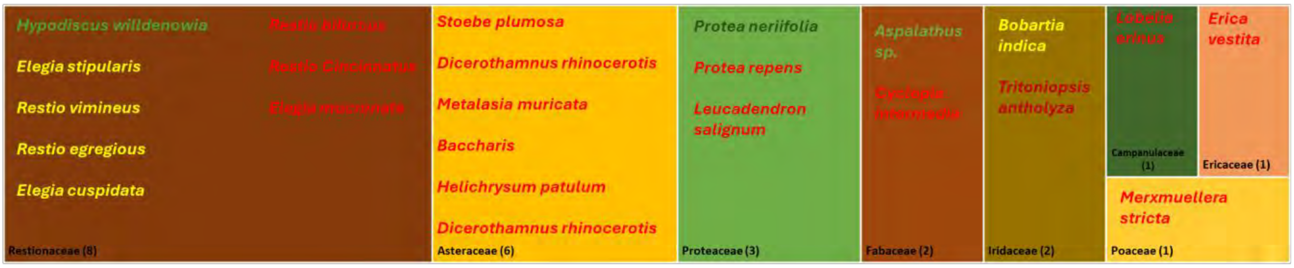


**Figure 37**: Tree map illustrating the species in the non-cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

### 4.2.2.4) Soil survey

Table 17 illustrates the soil survey results of soil extracted from a cultivated site and a non-cultivated site at Enterprise 2. Both soil textures were sand. The following constituents were slightly higher at the cultivated site: calcium (2.6 cmol/kg), zinc (0.39 mg/kg) and baron (1.5 mg/kg). The remaining constituents were slightly higher in the non-cultivated site: resistance (2 240 ohms; more than double the resistance found at the cultivated site) and hydrogen (0.85 cmol/kg). The pH, phosphorus (Bray II) and magnesium content were similar at both sites. Copper was the same at both sites.

**Table 17:** Soil analysis results of macro- and micronutrients of soil extracted from a honeybush tea cultivated site and a non-cultivated site at Enterprise 2.

| Site | Texture | pH KCl | Resist. (ohm) | H+ cmol/kg | P (Bray II) mg/kg | K mg/kg | Ca cmol/kg | Mg cmol/kg | Na cmol/kg | Cu mg/kg | Zn mg/kg | Mn mg/kg | B mg/kg | Fe mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cultivated | Sand | 5.1 | 1210 | 0.7 | 21.3 | 54.8 | 2.6 | 0.78 | 0.19 | <0.33 | 0.39 | 1.3 | 1.5 | 46.2 |
| Non-cultivated | Sand | 5 | 2240 | 0.85 | 21.8 | 49.1 | 2.4 | 0.77 | 0.12 | <0.33 | <0.36 | 1.7 | 1.1 | 54.4 |

***Resit. = resistance**

### 4.2.3) Enterprise 3: A case study of *C. subternata* (small-scale)

#### 4.2.3.1) Mapping

Figure 38 is a land cover map for Enterprise 3 for 1990, 2014 and 2022. In 1990, the largest land cover classes by area, largely occurring in the south of the enterprise, were ‘plantations/ woodlots mature’ (212.95 ha), ‘indigenous forest’ (97.09 ha, in which 6.37 ha lay and made up the largest land cover in the enterprise) and ‘thicket/ dense bush’ to north of the enterprise (65.13 ha in which 0.9 ha lay and made up the second largest land cover in the enterprise) and ‘cultivated commercial fields (medium)’ (43.16 ha). ‘Shrubland fynbos’ was 34.04 ha, of which 0.79 ha lay within the enterprise. In 2014, ‘plantations/ woodlots mature’ decreased to 184.11 ha, ‘indigenous forest’ decreased to 89.97 ha, ‘thicket/ dense bush’ increased to 125.1 ha and ‘cultivated commercial fields (medium)’ decreased to 38.99 ha. ‘Shrubland fynbos’ decreased to 15.15 ha. Within the enterprise, the largest land cover was thicket/ dense bush (5.33 ha), ‘indigenous forest’ (2.79 ha) and ‘shrubland fynbos’ (0.42 ha). In 2022, the largest land cover in the area was ‘contiguous (indigenous) forest’ (171.87 ha), ‘contiguous and dense plantation forest’ (92.56 ha), and ‘contiguous low forest and thicket’ (67.25 ha of which 3 ha lay in the enterprise). The fourth largest land cover was ‘commercial annual crops rainfed/ dryland’ (52.85 ha). The largest land cover within the enterprise was ‘dense forest and woodland’ (4 ha out of 46.86 ha in the surrounding area). ‘Contiguous and dense plantation forest’ and ‘low shrubland (fynbos) were less than 1 ha.

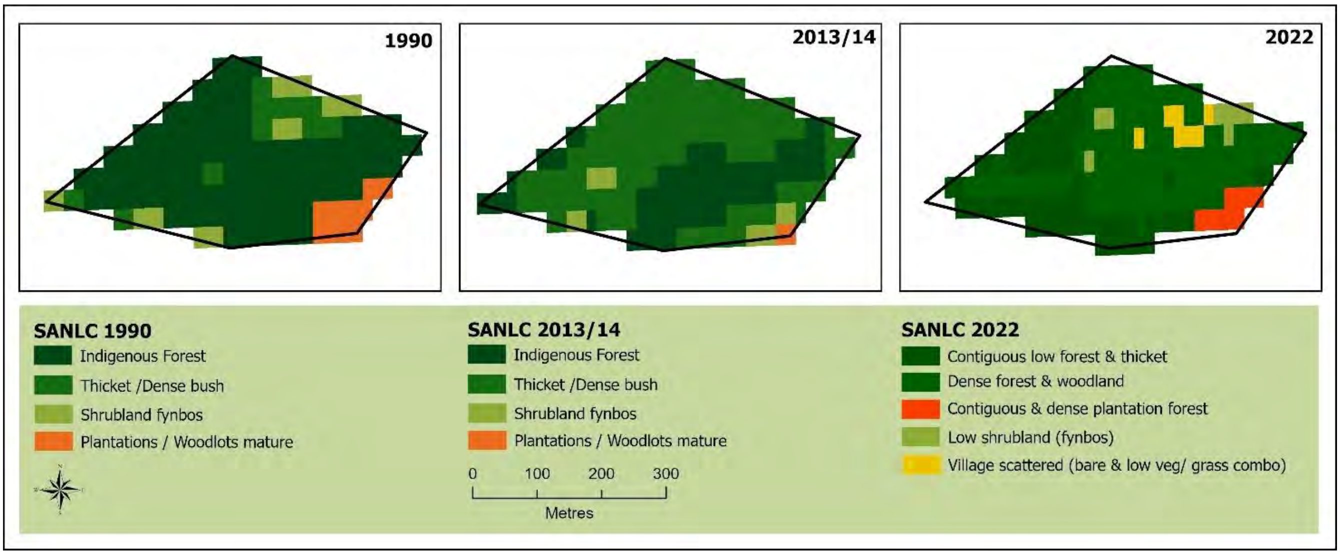


**Figure 38**: South African National Land Cover (SANLC) map of Enterprise 3 for 1990, 2013-2014, and 2022.

Figure 39 is a species distribution map highlighting the probability of occurrence of *C. subternata* throughout the Fynbos extent in South Africa. The species is largely found in a thin band along the eastern coast and interior of the Fynbos extent. Enterprise 3, which grows *C. subternata*, occurred just below the 0.75–1.00 distribution range.

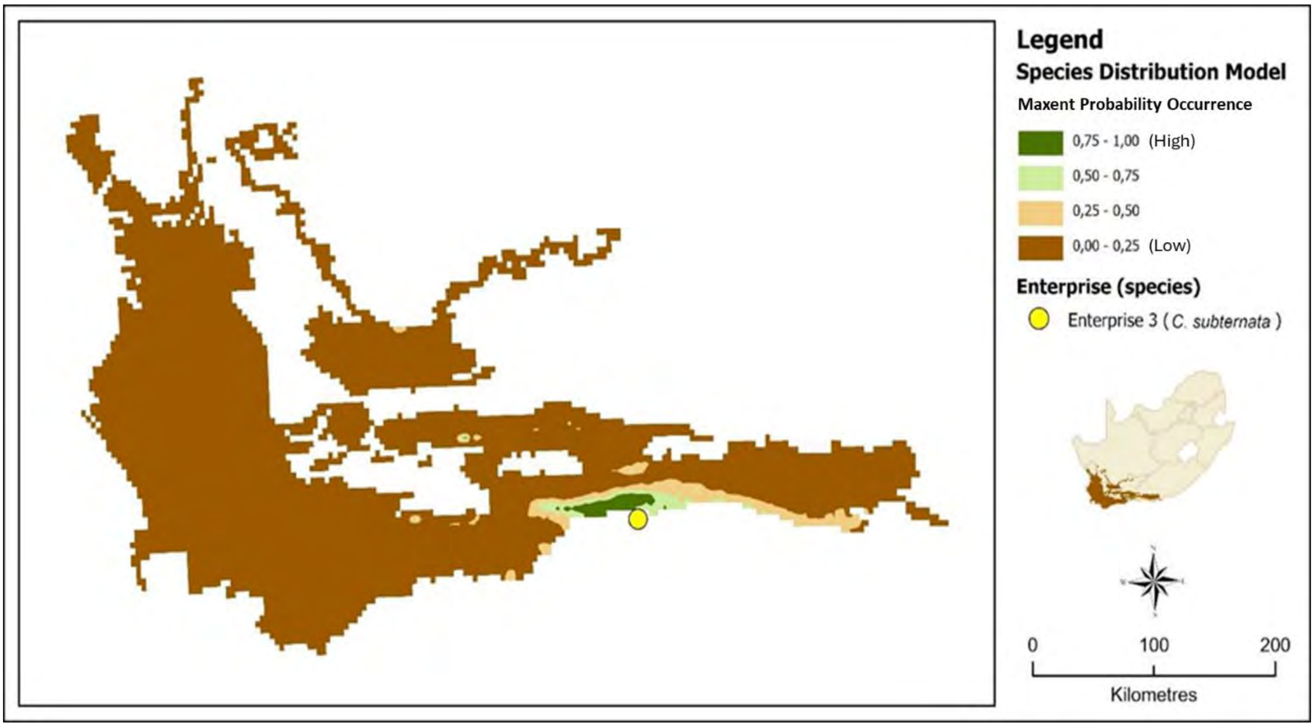


**Figure 39:** Species distribution map (Maxent), highlighting the probability of occurrence of *Cyclopia subternata* throughout the Fynbos extent, including Enterprise 3 (which plants *C. subternata*).

### 4.2.3.2) Plant survey

Figure 40 illustrates the allometry measurements of the average (a and b) length (height and crown), (c) basal circumference (cm), (d) stem count (no.) and (e) average stem diameter (mm) for *C. subternata* for cultivated sites that were 4- and 7-years-old. There were no significant differences between the following measurements: height ($p = 0.358$), crown ($p = 0.861$), basil circumference ($p = 0.231$), stem count ($p = 0.685$) and average stem diameter ($p = 0.290$). The average measurements of the plants' average height decrease from ages 4 to 7. The crown stays constant between the two years. Stem count from the base of the plant starts from an average of 1 main stem and then branches off into 15 stems at age 4, to 24.43 stems at age 7. Stem diameter stays constant from age 4 to 7. The stem diameter also increases from 0.7 mm to 0.81 mm. The plants that were aged 7 exhibited greater overall variability than those that were aged 4. The yield was not taken at this enterprise as the farmer was not harvesting that year.

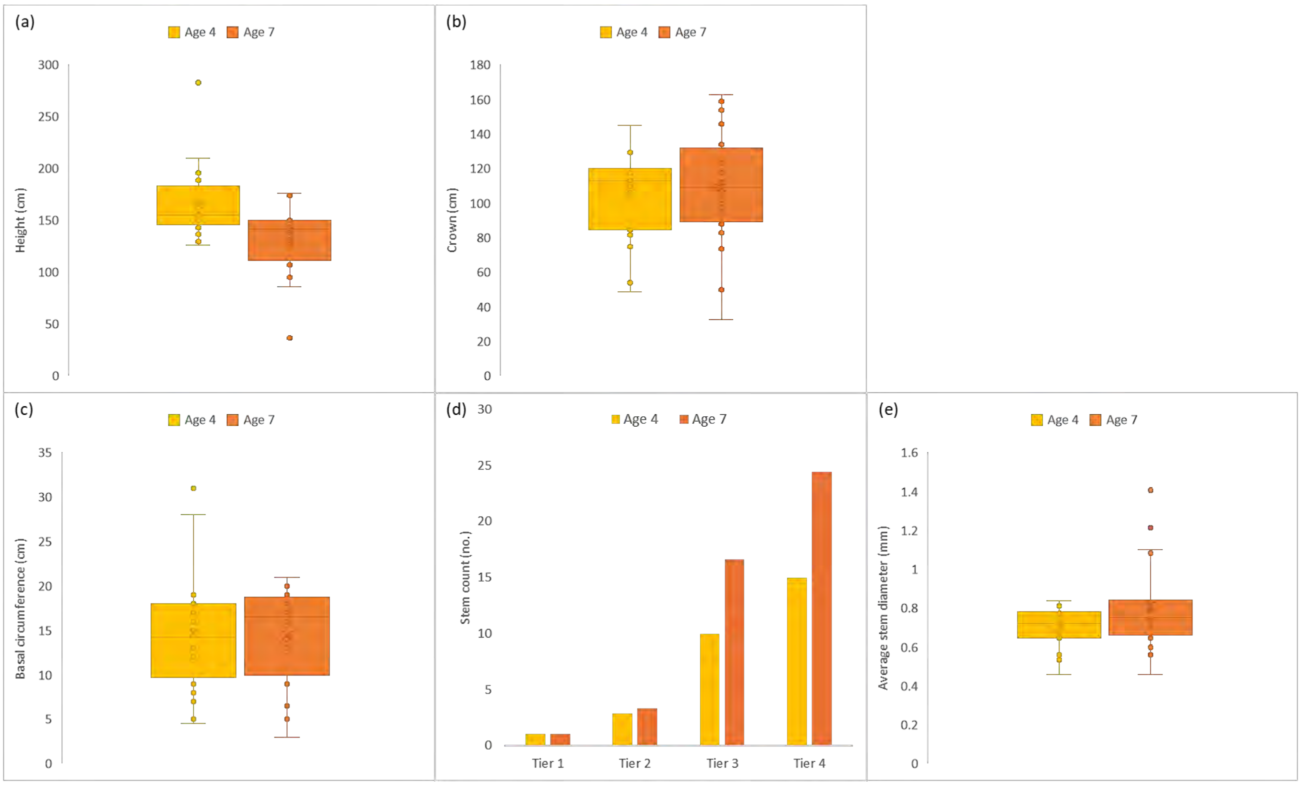


**Figure 40**: Allometry measurements of the (a) length (height and crown), basal circumference (cm), (b) yield (kg), stem count (no.) and stem diameter (mm) for *Cyclopia subternata* for cultivated sites that were 4- and 7-year-old.

### 4.2.3.3) Biodiversity survey

Figure 41 is a tree map illustrating the species in the cultivated site according to those that had the most aerial cover (above 9 m$^2$), moderate aerial cover (between 0.9 to 9 m$^2$) and had a low aerial cover (between 0 and 0.9 m$^2$). These are written in green, yellow and red, respectively. There were 19 species in this site from 12 families. The largest plant family in this site was Asteraceae (3 species), Restionaceae (3 species) and Poaceae (3 species). The species that covered the largest area were *Arctotheca calendula* (Asteraceae), *Sporobolus sp*. (Poaceae) and *Galium capense* (Rubiaceae).

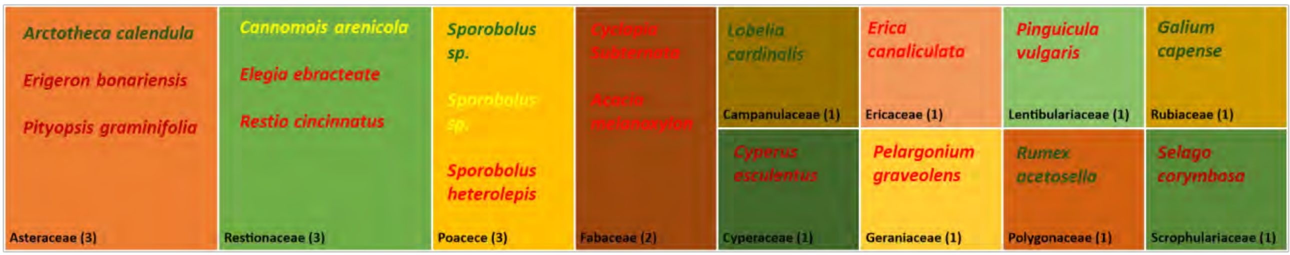


**Figure 41**: Tree map illustrating the species in the cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

Figure 42 depicts some of the diverse species found in the cultivated site. Additionally, a *C. subternata* plant in bloom is illustrated (Figure 41a). The species include *Erica canaliculate* (Ericaceae), *Arctotheca calendula* (Asteraceae), *Helichrysum patulum* (Asteraceae), *Selago corymbose* (Scrophulariaceae) and *Sporobolus heterolepis* (Poaceae).


**Figure 42**: (a) Cultivated site at Enterprise 3; (b) *Cyclopia subternata*; (c) *Erica canaliculate*; (d) *Arctotheca calendula*; (e) *Helichrysum patulum*; (f) *Selago corymbose*; and (g) *Sporobolus heterolepis* from the cultivated site.

There were 6 species in this non-cultivated site from 3 families (Figure 43). The largest plant family on this site was Fabaceae (3 species). The species that covered the largest area were *Virgilia oroboides* (Fabaceae) and *Acacia mearnsii* (Fabaceae).


**Figure 43**: Tree map illustrating the species in the non-cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

### 4.2.3.4) Soil survey

Table 18 illustrates the soil survey results of soil extracted from a cultivated site and a non-cultivated site at Enterprise 3. The soil texture at the cultivated site was loam, and the soil texture at the non-cultivated site was sand. The following constituents were substantially higher at the cultivated site: resistance (680 ohms compared to the non-cultivated site, which had a resistance of 230 ohms). The remaining constituents were higher in the non-cultivated site; pH (pH 4.1), phosphorus (Bray II) (14.7 mg/kg compared to the cultivated site which had 5.3 mg/kg), potassium (262 mg/kg which was substantially higher than the 47.1 mg/kg at the cultivated site) and calcium (15.6 cmol/kg which was higher than the

0.77 cmol/kg at the cultivated site), sodium (0.64 cmol/kg which was higher than the 0.19 mg/kg at the cultivated site), magnesium (6.3 cmol/kg which was higher than the 0.19 cmol/kg at the cultivated site), manganese (131 mg/kg which was higher than the 2.6 mg/kg at the cultivated site) and baron (2.4 mg/kg which was higher than the 0.92 mg/kg at the cultivated site).

**Table 18:** Soil analysis results of macro- and micronutrients of soil extracted from a honeybush tea cultivated site and a non-cultivated site at Enterprise 3.

| Site | Texture | pH KCl | Resist. (ohm) | H+ cmol/kg | P (Bray II) mg/kg | K mg/kg | Ca cmol/kg | Mg cmol/kg | Na cmol/kg | Cu mg/kg | Zn mg/kg | Mn mg/kg | B mg/kg | Fe mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cultivated | Loam | 3.6 | 680 | 2.58 | 5.3 | 47.1 | 0.77 | 0.44 | 0.19 | <0.33 | 0.62 | 2.6 | 0.92 | 561 |
| Non-cultivated | Sand | 4.1 | 230 | 6.52 | 14.7 | 262 | 15.6 | 6.3 | 0.64 | 0.5 | 3.7 | 131 | 2.4 | 543 |

***Resit. = resistance**

### 4.2.4) Enterprise 4: A case study of *C. longifolia*

### 4.2.4.1) Mapping

Figure 44 is a land cover map for Enterprise 4 for 1990, 2014 and 2022. In 1990, the largest land cover classes by area were ‘thicket/ dense bush’ (815.5 ha in which 294.89 ha lay in the enterprise), ‘shrubland (fynbos)’ (488.61 ha of which 99.88 ha lay in the enterprise) and ‘cultivated commercial fields (medium)’ (157, 14 ha in which 51.85 ha lay within the enterprise). In 2014, ‘thicket/ dense bush’ increased to (1 109.77 ha) and increased in the enterprise (374.13 ha), ‘shrubland (fynbos)’ decreased to 356.98 ha and declined to 44.78 ha in the enterprise, and ‘cultivated commercial fields (medium)’ increased to 172.87 ha and decreased to 32 ha in the enterprise. The second-largest land cover within the enterprise was ‘cultivated commercial fields (high)’ (63.59 ha). In 2022, the largest land cover in the area was ‘dense forest and woodland’ (691.24 ha), ‘contiguous low forest and thicket’ (427.27 ha) and ‘low shrubland (fynbos)’ (165.13 ha). The fourth largest land cover was ‘commercial annual crops rainfed/ dryland’ (163 ha). Within the enterprise, the largest land cover classes were ‘dense forest and woodland’ (178.53 ha), ‘contiguous low forest and thicket’ (130.88 ha) and ‘fallow land and old fields’ (82.82 ha), largely occurring in the centre of the enterprise. Of the 165.13 ha of ‘low shrubland (fynbos)’, 29.04 ha lay in the enterprise. The fourth largest land cover in the enterprise was ‘commercial annual crops rainfed/ dryland’ (55.47 ha). Over the years, fynbos shrubland, mainly occurring to the north of the enterprise, has been replaced by thicket, dense bush and forests.

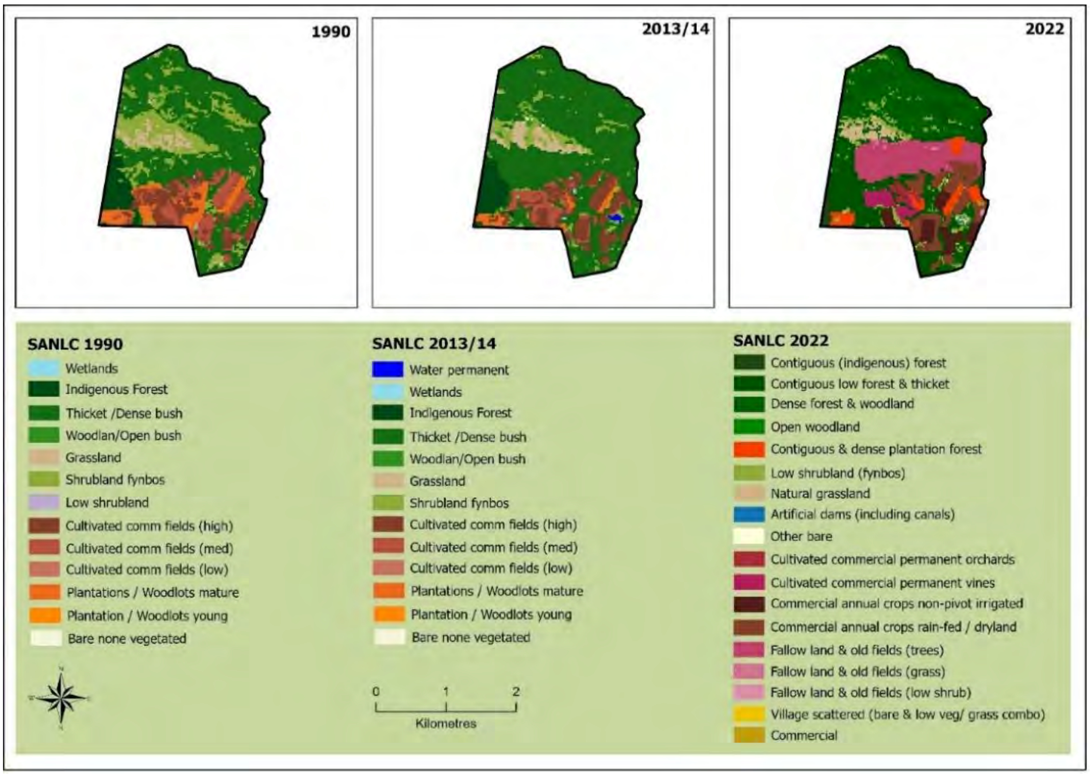


**Figure 44**: South African National Land Cover (SANLC) map of Enterprise 4 for 1990, 2013-2014, and 2022; ‘woodlan’ = woodland; = commercial; ‘med’ = medium; ‘veg’ = vegetation.

Figure 45 is a species distribution map highlighting the probability of occurrence of *C. longifolia* throughout the Fynbos extent in South Africa. The species is one of the smallest distributions of the genus and is largely found in isolated patches in the east and along the eastern coast of the Fynbos extent. Enterprise 4, which grows *C. longifolia*, occurred outside of the distribution range.

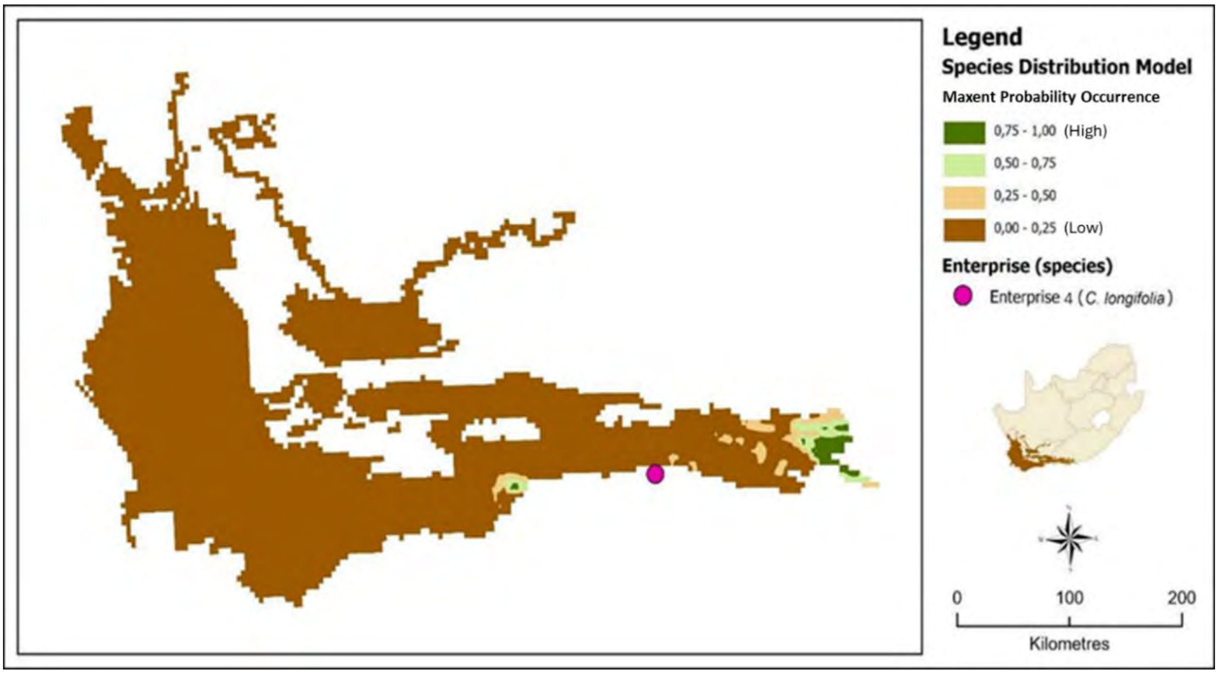


**Figure 45:** Species distribution map (Maxent), highlighting the probability of occurrence of *Cyclopia longifolia* throughout the Fynbos extent, including Enterprise 4 (which plants *C. longifolia*).

### 4.2.4.2) Plant survey

Figure 46 illustrates the allometry measurements of the average (a and b) length (height and crown), (c) yield (kg), (d) basal circumference (cm), (e) stem count (no.) and (e) average stem diameter (mm) for *C. longifolia* for cultivated sites for *C. longifolia* for cultivated sites that were 4-, 5- and 7-years-old. There were no significant differences between the following measurements: height (p = 0.999), crown (p = 0.999), basil circumference (p = 0.625), stem count (p = 0.639) and average stem diameter (p = 0.999). The average measurements of the plants' height decrease from an average of 201.6 cm to 162.2 cm from ages 5 to 7. The crown slightly increases at age 5 and then slightly decreases by age 7. Stem count from the base of the plant starts from an average of 1 main stem and then branches off into 9.60 stems at age 5 to 9.29 stems at age 7. Overall, with age, the stem counts decrease. Stem diameter is at its greatest at age 5 and then slightly decreases at age 7. Only one average yield measurement was taken at the enterprise. After four years, the crop was an average of 3.9 kg. Overall, the plants decrease in size at age 7.

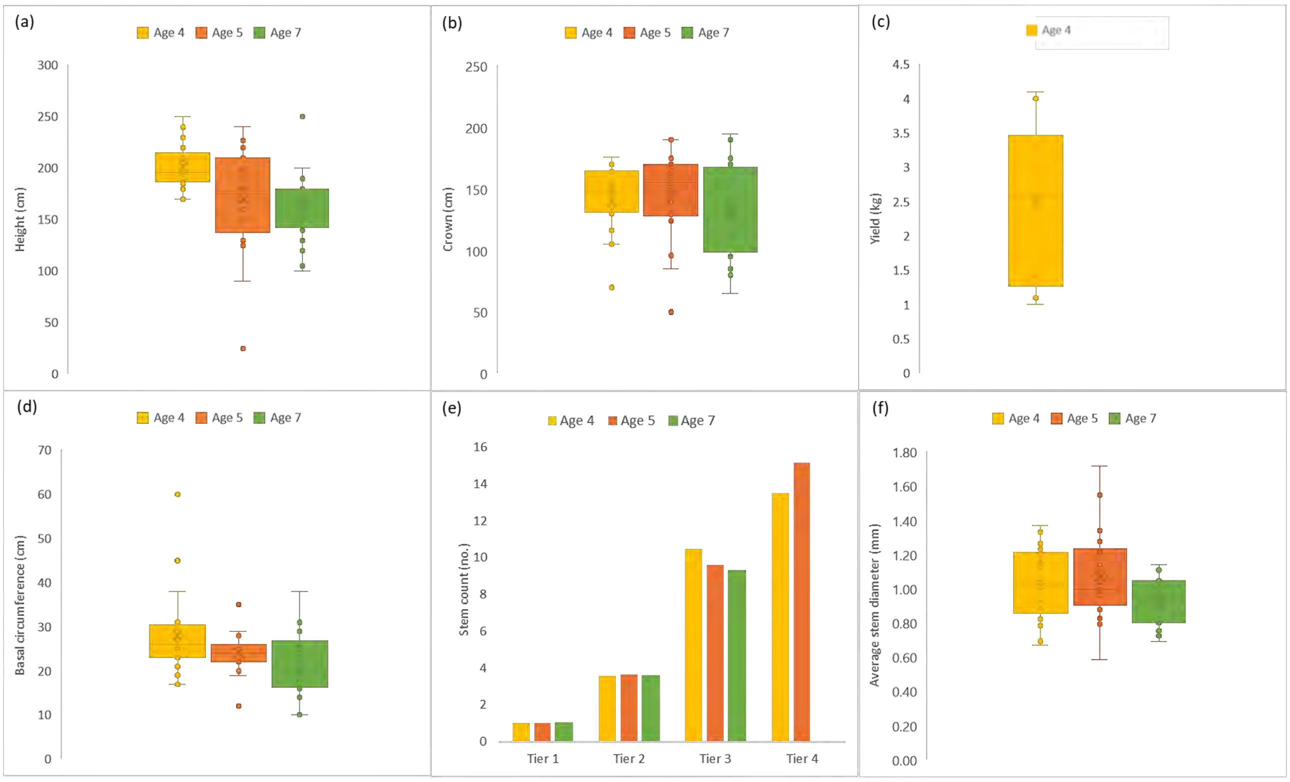


**Figure 46**: Allometry measurements of the (a) length (height and crown), basal circumference (cm), (b) yield (kg), stem count (no.) and stem diameter (mm) for *Cyclopia longifolia* for cultivated sites that were 4-, 5- and 7-years-old.

### 4.2.4.3) Biodiversity survey

Figure 47 is a tree map illustrating the species in the cultivated site according to those that had the most aerial cover (above 9 $m^2$), moderate aerial cover (between 0.9 to 9 $m^2$) and had a low aerial cover (between 0 and 0.9 $m^2$). These are written in green, yellow and red respectively. There were 20 species in this site from 8 families. The largest plant family in this site was Poaceae (7 species) and Fabaceae (4 species). The species that covered the largest area were *Pennisetum clandestinum. Paspalum dilatatum, Sporobolus sp., Sporobolus heterolepis,* and *Merxmuellera stricta* (Poaceae).

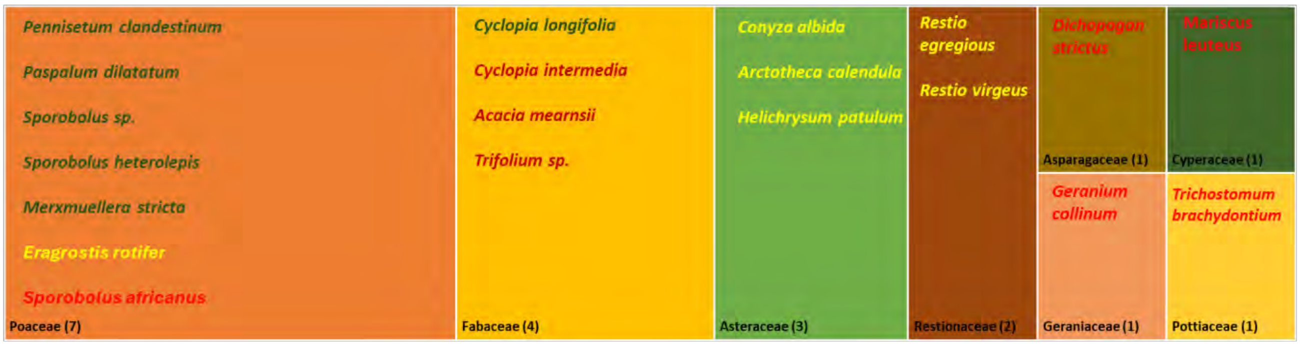


**Figure 47**: Tree map illustrating the species in the cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

Figure 48 depicts some of the diverse species found in the cultivated site. The species include Dichopogon strictus (Asparagaceae), *Paspalum dilatatum* (Poaceae), *Helichrysum patulum* (Asteraceae), *Mariscus leuteus* (Cyperaceae) and a *Resio sp*. (Resionaceae).


**Figure 48**: (a) Cultivated site at Enterprise 4. (b) *Dichopogon strictus*; (c) *Helichrysum patulum*; (d) *Mariscus leuteus*; (e) *Resio sp*. from the cultivated site.

There were 11 species in this non-cultivated site from 9 families (Figure 43). The largest plant family in this site was Apocynaceae (2 species) and Aspleniaceae (2 species). The species that covered the largest area were *Trichostomum brachydontium* (Pottiaceae)*, Elaeagnus pungens* (Elaeagnaceae*), Oplismenus hirtellus* (Poaceae) *and Olea capensis* (Oleaceae).

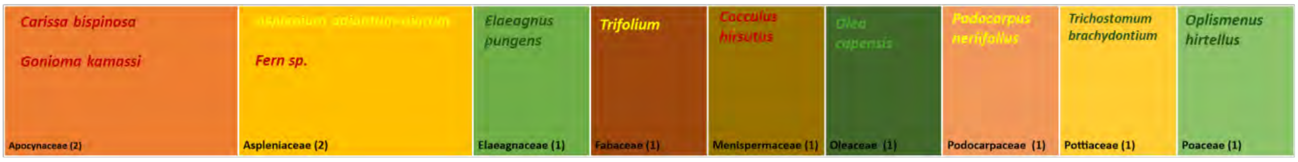


**Figure 49**: Tree map illustrating the species in the non-cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

### 4.2.4.4) Soil survey

Table 19 illustrates the soil survey results, of soil extracted from a cultivated site and a non-cultivated site at Enterprise 4. The soil texture at both sites was sand. The following constituents were substantially higher at the cultivated site; resistance (3 030 ohms compared to the non-cultivated site which had a resistance of 780 ohms). The remaining constituents were higher in the non-cultivated site; pH (pH 4.1), phosphorus (Bray II) (at, 4.48 mg/kg, which was over double the phosphorus found at the cultivated site), potassium (272 mg/kg was substantially higher than the 47.9 mg/kg at the cultivated site) and calcium (7.4 cmol/kg which was higher than the 0.62 cmol/kg at the cultivated site), sodium (0.66 mg/kg which was higher than the 0.13 mg/kg at the cultivated site), magnesium (2.9 cmol/kg which was higher than the 0.33 cmol/kg at the cultivated site), manganese (39.4 mg/kg which was substantially higher than the 0.58 mg/kg at the cultivated site) and iron (115 mg/kg which was higher than the 77.5 mg/kg at the cultivated site). Copper remained the same at both sites at <0.33 cmol/kg.

**Table 19**: Soil analysis results of macro- and micronutrients of soil extracted from a honeybush tea cultivated site and a non-cultivated site at Enterprise 4.

| Site | Texture | pH KCl | Resist. (ohm) | H+ cmol/kg | P (Bray II) mg/kg | K mg/kg | Ca cmol/kg | Mg cmol/kg | Na cmol/kg | Cu mg/kg | Zn mg/kg | Mn mg/kg | B mg/kg | Fe mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cultivated | Sand | 3.3 | 3,030 | 2.3 | 6.6 | 47.9 | 0.65 | 0.33 | 0.13 | <0.33 | 0.4 | 0.58 | 1.2 | 77.5 |
| Non-cultivated | Sand | 4.1 | 780 | 4.48 | 23.4 | 272 | 7.4 | 2.9 | 0.66 | <0.33 | 6.6 | 39.4 | 1.6 | 115 |

***Resit. = resistance**

### 4.2.5) Enterprise 5: A case study of *C. subternata* (large scale)

### 4.2.5.1) Mapping

Figure 36 is a land cover map for Enterprise 5 for 1990, 2014 and 2022. In 1990, the largest land cover classes by area were 'thicket/ dense bush' (518.45 ha in which 80,98 ha lay in the enterprise and made the second largest land cover class in the enterprise), 'shrubland (fynbos)' (440.59 ha of which 119.19 ha lay in the enterprise and made the largest cover class) and 'wetlands' (199.30 ha of which 56.22 lay in the enterprise). The enterprise's fourth-largest land cover class was 'cultivated commercial fields (medium)' (12.69 ha out of 107.49 ha in the surrounding area). In 2014, 'thicket/ dense bush' increased to 884.96 ha and decreased to 159.14 ha in the enterprise, 'shrubland (fynbos)' decreased to 214.11 ha and 58.42 ha in the enterprise, and 'wetlands' decreased to 206.37 ha and 55.77 ha in the enterprise. 'Cultivated commercial fields (medium)' decreased to 9.36 ha within the enterprise out of 80.48 in the surrounding areas. In 2022, the largest land cover classes were 'dense forest and woodland' (365.05 ha of which 78.53 ha lay within the enterprise), 'contiguous low forest and thicket' (275.08 of which 67.83 ha lay within the enterprise) and 'contiguous (indigenous) forest' (226.10 ha of which 0.87 ha lay within the enterprise). The enterprise's third-largest land cover was 'commercial annual crops rainfed/ dryland' (44.90 ha out of 202.13 ha in the surrounding areas). 'Low shrubland (fynbos)' made up 40.24 ha within the enterprise (out of the 165.50 ha in the surrounding area). Over the years, shrubland fynbos in the area was replaced by woodland, forest and commercial lands.

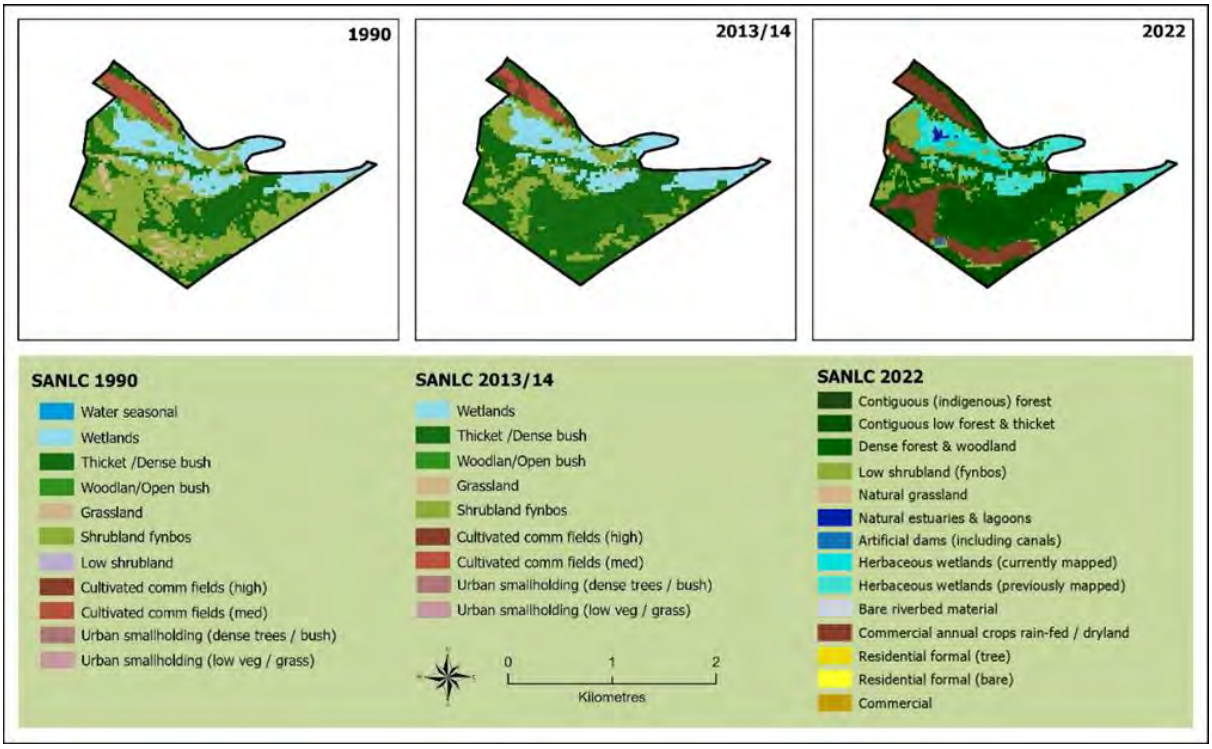


**Figure 50**: South African National Land Cover (SANLC) map of Enterprise 5 for 1990, 2013-2014, and 2022; 'woodlan' = woodland; = commercial; 'med' = medium; 'veg' = vegetation.

Figure 37 is a species distribution map highlighting the probability of occurrence of *C. subternata* throughout the Fynbos extent in South Africa. The species is largely found in a thin band along the eastern coast and interior of the Fynbos extent. Enterprise 5, which grows *C. subternata*, occurred just below the 0.50–0.75 distribution range.

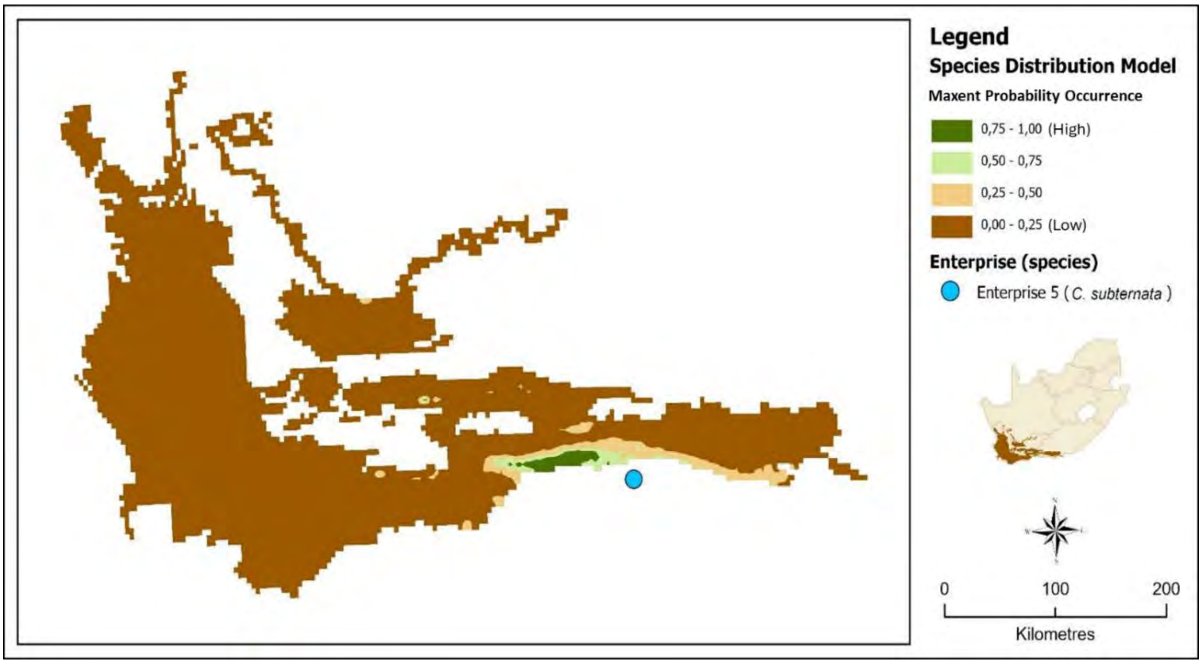


**Figure 51**: Species distribution map (Maxent), highlighting the probability of occurrence of *Cyclopia subternata* throughout the Fynbos extent, including Enterprise 5 (which plants *C. subternata*).

### 4.2.5.2) Plant survey

Figure 52 illustrates the allometry measurements of the average (a and b) length (height and crown), (c) yield (kg), (d) basal circumference (cm), (e) stem count (no.) and (e) average stem diameter (mm) for *C. subternata* for cultivated sites that were 4- and 7-years-old. There were no significant differences between the following measurements: height (p = 0.573), crown (p = 0.532), yield (p = 0.409), basil circumference (p = 0.555), stem count (p = 0.658) and average stem diameter (p = 0.331). The average measurements of the plants' height increase from 103.4 cm at age 4 to 119.5 cm at age 7. The crown increases at age 7. Stem count from the base of the plant starts from an average of 1 main stem and then branches off into 9.83 stems at age 7. Overall, with age, the stem count decreases. Stem diameter is thickest at age 7. The average yield is greater at age 7 (average of 1.2 kg).

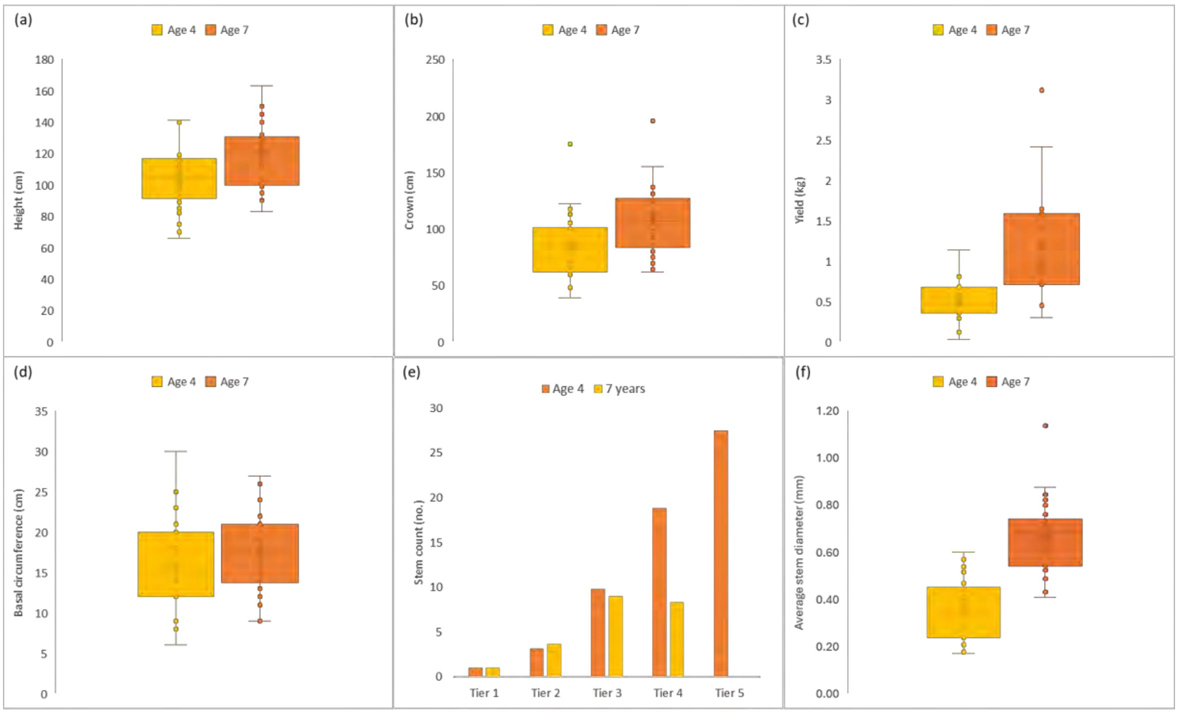


**Figure 52**: Allometry measurements of the (a) length (height and width), basal circumference (cm), (b) yield (kg), stem count (no.) and stem diameter (mm) for *Cyclopia subternata* for cultivated sites that were 4- and 7-year-old.

### 4.2.5.3) Biodiversity survey

Figure 53 is a tree map illustrating the species in the cultivated site according to those that had the most aerial cover (above 9 $m^2$), moderate aerial cover (between 0.9 to 9 $m^2$) and had a low aerial cover (between 0 and 0.9 $m^2$). These are written in green, yellow and red, respectively. There were 15 species in this site from 9 families. The largest plant family in this site was Asteraceae (4 species) and Fabaceae (3 species). The species that covered the largest area were *Miscanthus capensis* (Poaceae) and *Centella asiatica* (Apiaceae).


**Figure 53**: Tree map illustrating the species in the cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had low aerial cover (red).

Figure 54 depicts some of the diverse species found in the cultivated site. The species include *Erica canaliculate* (Ericaece), *Hermannia sp.* (Malvaceae), *Aspalathus* (Asteraceae), *Metalasia muricata* (Asteraceae) and *Helichrysum patulum* (Asteraceae).


**Figure 54**: (a) Cultivated site at Enterprise 4; (b)*Erica canaliculate*; (c) *Hermannia sp.*; (d) *Metalasia muricata*; and (e) *Helichrysum patulum* from the cultivated site.

There were 15 species in this non-cultivated site from 10 families (Figure 43). The largest plant family in this site was Asteraceae (4 species). The species that covered the largest area were *Euryops virginieus* and *Chrysocoma ciliata* (Asteraceae), and *Pennisetum clandestinum* and *Merxmuellera stricta* (Poaceae).


**Figure 55**: Tree map illustrating the species in the non-cultivated site according to those that had the most aerial cover (green), moderate aerial cover (yellow) and had a low aerial cover (red).

### 4.2.5.4) Soil survey

Table 20 illustrates the soil survey results of soil extracted from a cultivated site and a non-cultivated site at Enterprise 4. The soil texture at both sites was loam. The pH, resistance, sodium and copper content were constant at both sites. The rest of the constituents were higher in the non-cultivated site compared to the cultivated site including; phosphorus (Bray II) (6.8 mg/kg, which was double the phosphorus found at the cultivated site), potassium (251 mg/kg, higher than the 207 mg/kg at the cultivated site), calcium (4.8 cmol/kg, higher than the 3.6 cmol/kg at the cultivated site), copper (3.1 mg/kg, double the phosphorus found at the cultivated site), manganese (233 mg/kg which was substantially higher than the 147 mg/kg at the cultivated site) and iron (110 mg/kg, higher than the 71.5 mg/kg at the cultivated site).

**Table 20**: Soil analysis results of macro- and micronutrients of soil extracted from a honeybush tea cultivated site and a non-cultivated site at Enterprise 5.

| **Site** | **Texture** | **pH** KCl | **Resist.** (ohm) | **H+** cmol/kg | **P** (Bray II) mg/kg | **K** mg/kg | **Ca** cmol/kg | **Mg** cmol/kg | **Na** cmol/kg | **Cu** mg/kg | **Zn** mg/kg | **Mn** mg/kg | **B** mg/kg | **Fe** mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cultivated | Loam | 5.1 | 1660 | 1.19 | 3.3 | 207 | 3.6 | 2 | 0.28 | 0.61 | 1.7 | 147 | 1.5 | 71.4 |
| Non-cultivated | Loam | 5 | 1560 | 1.36 | 6.8 | 251 | 4.8 | 2.9 | 0.31 | 0.76 | 3.1 | 233 | 1.8 | 110 |

***Resit. = resistance**

**C) Economic sustainability**

### 4.2.6) Costs and yields per hectare for different species

The data collected for input to a calculation of profit from honeybush cultivation under different species is presented in Tables 21 and 22. In Table 21, all enterprises were assumed to bear the same set of land preparation costs in the establishment phase (Table 21, column 2), but the cost of high-density planting of seedlings (10,000/ha) made establishment costs higher for *C. longifolia* and *C. subternata*. The annual costs for *C. subternata* and *C. longifolia* were highest due to the high density of planting and subsequent greater effort in harvesting (Table 21, column 7). These two species also required regular weeding annually (Table 21, column 6), whereas *C. intermedia* and *C. subternata* did not.

**Table 21**: Costs of production for four honeybush species, per hectare of cultivated land (‘ZAR’ = South African rands).

| **Establishment costs** | | | | | **Annual variable costs** | | |
|---|---|---|---|---|---|---|---|
| **Species** | **Land prep. (ZAR/ha x 1)** | ***Seedling cost (ZAR/plant x 1)** | ****Labour: weeding (ZAR)** | **Total costs (ZAR)** | **Labour: weeding (ZAR)** | *****Labour: harvesting (ZAR)** | **Total costs (ZAR)** |
| C. *intermedia* | 120,000 | 6 x 6,000 = 36,000 | 10,590 | **166,590** | 0 | From yr 4: 588 | **588** |
| *C. genistoides* | 120,000 | 6 x 4,000 = 24,000 | 10,590 | **154,590** | 0 | From yr 3: 882 | **882** |
| *C. subternata* | 120,000 | 6 x 10,000 = 60,000 | 10,590 | **190,591** | 10,591 yr 1 & annually | From yr 2: 3,530 | **14,121** |
| *C. longifolia* | 120,000 | 6 x 10,000 = 60,000 | 10,590 | **190,591** | 10,5901 yr 1 & annually | From yr 2: 3,530 | **14,121** |

***Seedling cost: Planting density varies across the species. The figure does not account for mortality/replacement, which is highly variable, from 10% to 30%. **Labour days (3 sessions x 4 days x 4 staff = 48 labour days @ ZAR 220.64/day) estimated based on information from farmers, with the cost of labour based on ZAR 27.58/hr = ZAR 220.64 per labour day (Department of Employment & Labour, 2024). ***Harvesting day estimates: based on information from farmers. Harvesting labour days are doubled for high-density planting. Cost is averaged across year/s for all species, i.e. *C. intermedia* is harvested every 3rd year, but the cost is spread across 3 years.**

The revenue per annum per hectare was calculated for each species, based on harvest intervals, average yields per hectare and the price per kilogram, as detailed in Table 22. The resprouters have lower yields on average (1 800 kg for *C. intermedia* and 2 500 kg for *C. genistoides*) which is a function of the lower number of plants, the longer harvest interval and their resprouter form. The reseeder *C. subternata* and resprouter/reseeder *C. longifolia* which are harvested annually have the highest yields at about 5 000 kg per ha.

**Table 22**: Estimates of production and potential revenue per hectare of cultivated honeybush for four species.

| Species | No. of harvests across crop lifespan | *Harvest interval | **Ave. yield (kg) per ha, per yr | ***Wet price ZAR/kg | Annual revenue (ZAR) |
|---|---|---|---|---|---|
| *C. intermedia* | 7 harvests over 22 yrs | 1st harvest at 4 yrs then every 3 yrs | 1 800 | 14.00 | 25,200 |
| *C. genistoides* | 7 harvests over 15 yrs | 1st harvest at 3 yrs then every 2 yrs | 2 500 | 11.00 | 27,500 |
| *C. subternata* | 6 harvests over 7 yrs | 1st harvest at 2 yrs then annually | 5 000 | 11.00 | 55,000 |
| *C. longifolia* | 8 harvests over 9 yrs | 1st harvest at 2 yrs then annually | 5 000 | 11.00 | 55,000 |

***The plants need time to establish; thereafter, a fairly standard interval is applied. **Ave. yield (kg) per ha, per year is calculated based on no. of plants per ha, measured yield per plant (this research) plus the average yield estimate over time, from farmers. It is calculated as a yield per annum rather than per harvest to allow for comparison across species. ***Based on (McGregor, 2024b), commonly cultivated species fetch around ZAR 11.00/kg wet material. Wild-harvested species fetch ZAR 2-4.00 more per kilogram. A premium price of ZAR 16.00 or more is paid for wild *Cyclopia intermedia*, therefore, the price of cultivated *Cyclopia intermedia* is given as ZAR 14.00, while the other species are given a price of ZAR 11.00.**

The four graphs (Figure 56) illustrate the break-even point for the four species, which is year 9–10 for *C. intermedia* (Figure 56); year 9 for *C. genistoides* (Figure 56); year 5–6 for *C. subternata* (Figure 56) and year 5–6 for *C. longifolia* (Figure 56). The portion of the line to the right of the break-even point is significant as this represents profit: for the long-lived resprouter *C. intermedia*, there will be 10 to 11 years of profit before the land needs to be replanted, and for *C. genistoides*, around 5 years. *Cyclopia subternata* and *C. longifolia* have only 1 and 3 years of profit, respectively, before replanting must take place.

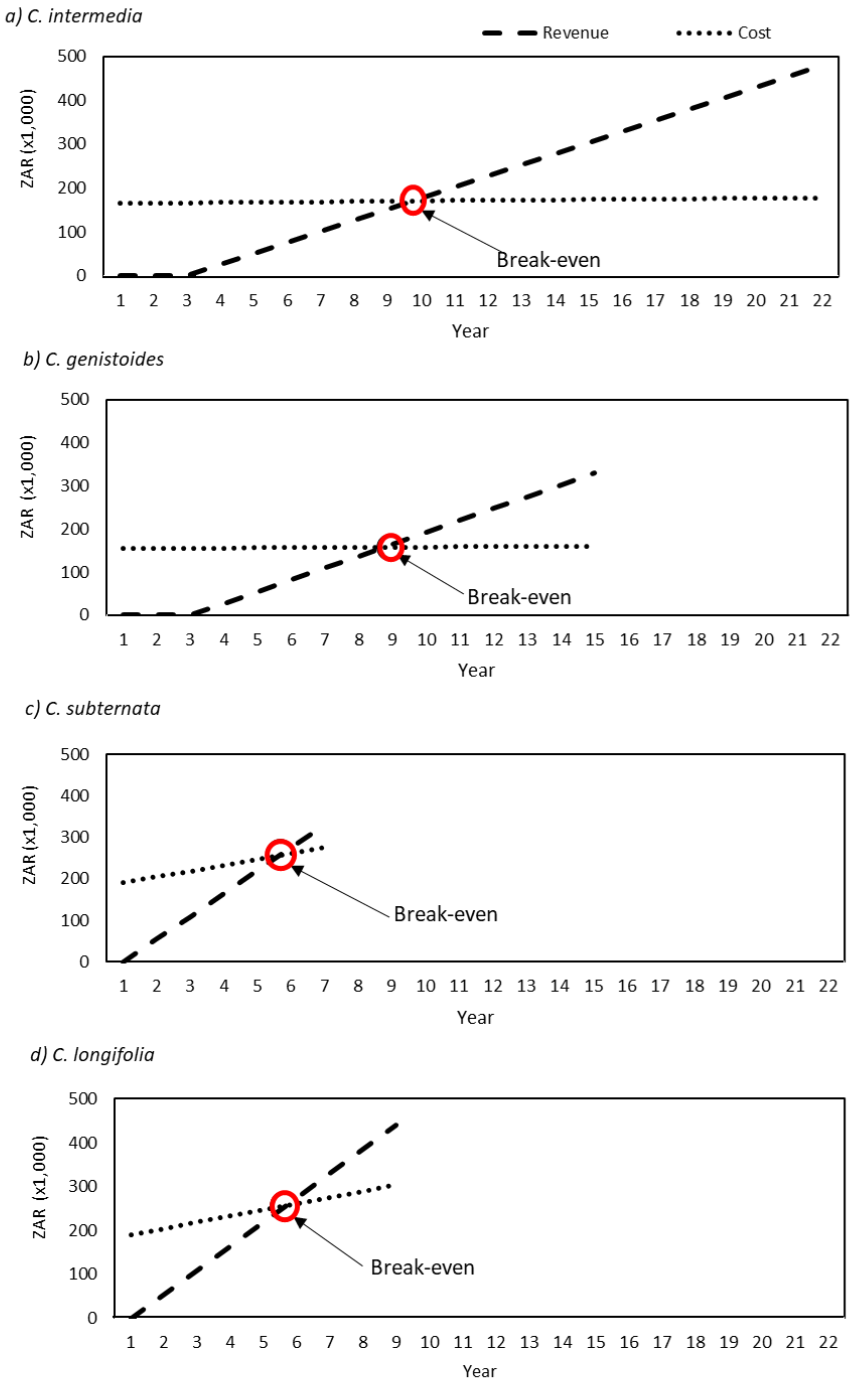


**Figure 56:** Estimated production costs versus revenue, to identify the break-even point (red) for *Cyclopia intermedia, C. genistoides, C. subternata,* and *C. longifolia*.

### 4.3) An investigation into the challenges experienced by exiting as well as community enterprises

#### 4.3.1) Exiting enterprises

Four cultivation honeybush tea enterprise producers served as participants for Objective 3, highlighted in Table 23. Participants 6–9 exited the industry due to challenges during their cultivation duration from 2020 to 2023, 2013 to 2021, and 2013 to 2023, respectively. Participant 9 had been in the industry since 2016 and was considering changing their cultivated species. According to thematic analysis conducted on the interview notes, the following themes were identified: (i) Challenges encountered while cultivating honeybush, (ii) Dissatisfaction with the price of wet honeybush tea, (iii) Marketing in the industry, (iv) Capital and (v) Additional activities on the farm.

**Table 23:** Details of the honeybush tea cultivation duration, size of cultivated field, harvest periods, and chosen honeybush tea species for cultivation and the reasons for species selection at the enterprises belonging to Participants 6 to 9.

| Participant | Duration | Hectares | Harvest duration | Cultivated species | Reason(s) for species selection/ experience with species |
|---|---|---|---|---|---|
| **Participant 6**<br>(producer) | 2020 – 2023 | 1,1 | Every year | *C. subternata*<br>*C. maculata*<br>*C. longifolia*, | ● *C. subternata* was encouraged to be grown.<br>● *C. maculata* had the "best biomass".<br>● *C. longifolia* had a "decent biomass". |
| **Participant 7**<br>(producer) | 2013 – 2021 | 1 | Three times every two years | *C. subternata*<br>*C. longifolia* | ● *C. subternata* was encouraged to be grown.<br>● A row of *C. longifolia* was also grown.<br>● *C. intermedia* was planted but it "grew too slowly" ("It was harvested in the third year while *subternata* and *longifolia* were already on their second harvest."). |
| **Participant 8**<br>(producer and nursery) | 2013 – 2023 | 1,7 | Every two years and every two and a half years for seeds | *C. subternata*<br>*C. maculata*<br>*C. longifolia*, | ● *C. subternata, C. maculata* and *C. longifolia* were planted, and *C. maculata* was noted to "seed quickly."<br>● The only one that did not do well was *C. intermedia.* |
| **Participant 9**<br>(producer) | 2017 – present | 2 | Last harvested two years ago | *C. subternata*<br>*C. maculata*<br>*C. longifolia*<br>*C. intermedia* | ● *C. intermedia* seeds were bought but "everything (*C. subternata, C. maculata, C. longifolia* and *C. intermedia*) came out."<br>● *C. subtenata* grew well initially, was harvested three years later, and saw two more harvests before the plants started doing poorly.<br>● There are one or two *C. maculata* and *C. longifolia*. |

#### 4.3.1.1) Challenges encountered while cultivating honeybush

For the four participants, the decision to enter the honeybush industry emanated from generational knowledge (Participant 7), word-of-mouth (Participants 8 and 9) and residing in an ideal location (Participant 6). This was elaborated by the participant:

> *"There were limited choices with what I could plant* (in the area) *and one of them was honeybush."* – Participant 6.

Besides Participant 7, whose family members had previously harvested honeybush, the participants had *no prior experience* with cultivating honeybush. All the participants acquired information on cultivating honeybush tea via consultations with industry experts and workshops. However, during cultivation, the participants encountered knowledge gaps. Participant 9 elaborated by stating that:

> *"Not growing up as a farmer makes it difficult because you don't know what to do most of the time."* –Participant 9

Participant 6 noted a 20% *mortality rate during seedling translocation*. To combat the issue, soil was prepared, and seeds were planted directly into the soil where a dripper was installed. polyvinyl chloride (PVC) pipes were used around the seedling to retain moisture. This decreased the mortality rate. Participant 7 encountered *pests,* mainly ants, in their honeybush fields. At certain times of the year, the ants would target stems and cause issues for the plant. Less severe pests in the honeybush fields were thrips (also present in Participant 9's honeybush fields) and nematodes. The impact of thrips was less severe during colder months. Participants 7 and 9 encountered die-offs with their *C. subternata* species, which they could not explain. The confusion is expressed below:

> *"They die and we don't know why. It could be alvurm* (nematodes), *we don't know why."* – Participant 9

Participant 9 was *unaware that there were different species of honeybush*. They bought and planted *C. intermedia* seeds; however, after the plants grew, an expert told them that they had a mixture of *C. intermedia, C. subternata, C. longifolia* and *C. maculata* in their fields (unbeknownst to them). Figure 57c illustrates two different species (*C. subternata* and *C. maculata* in one field). Honeybush plants in poor (i.e., dry) conditions, indicated by their brown colour, are illustrated in Figure 57a. Some plants were dead, as illustrated in Figure 57b, indicated by the darkened, leafless plant next to a healthy green honeybush. Participant 9 expressed their gross mortality rate on their enterprise below:

> *"The whole top part died.... It's been two years since we last harvested but it's looking terrible. Normally, my tea is twice this size."* – Participant 9

**Figure 57:** (a) The participant reported honeybush fields in poor condition (indicated by their brown, dry state). (b) A dead honeybush plant (left) next to a healthy honeybush plant. (c) Different species of honeybush in a field (i.e., *Cyclopia subternata* indicated by the darker green bushes and *C. maculata* (tall, bright green plant) in the foreground). (d) *C. intermedia* (indicated by the bright yellow-green plants) at Participant 9's enterprise.

#### 4.3.1.2) Dissatisfaction with the price of raw materials

Participants 6, 8 and 9 were *dissatisfied with the price of wet honeybush tea* (ZAR 10.00 per kilogram). After 10 years of cultivating honeybush, Participant 8 produced approximately a kilogram more than when they first started. However, the price for that raw material remained the same. Participant 8 mentioned that:

> *"The ZAR 10.00 takes you three years* (to make)*, including irrigation, labour, and inputs... I wouldn't mind doing maculata and* C. longifolia *again, but only if the prices changed… because ZAR 10.00 a kilogram is not worth it."* – Participant 8

Participant 8 further mentioned that in some countries; it is £3.00 for a cup of tea (ZAR 60.00). However, from the farmer's side, "we get ZAR 10.00 for 3 days' worth of work", thus making cultivation no longer feasible. Participant 8 is no longer doing their nursery because of the price. They highlighted how cultivation was no longer economically viable below:

> *"The price that is offered for the raw material was no longer financially viable."* – Participant 6

Participant 9 stated that they used to get ZAR 13.00 a kilogram, five years ago, and now they get ZAR 10.00. They highlighted how this impacted their enterprise operations below:

> *"Everything costs more now, and then you end up regressing and going backwards. The income* (approximately ZAR 45,000) *could not even cover the wages of the labourer."* – Participant 9

#### 4.3.1.3) Marketing in the industry

*Marketing for honeybush tea affected all four participants*. Participant 6 would have stayed in the honeybush industry if there was assurance for their wet tea selling (i.e., having a consistent client base requesting a fixed amount of tea). If they returned to the industry, they would venture into green honeybush tea since there is a better price difference. Participant 7, states that there was no market for them to sell their tea at the time; processors were mainly interested in buying wet *C. intermedia* and not the species they were cultivating (*C. longifolia* and *C. subternata*). The participant further stated that the market needed to improve for farmers to produce. Participant 8 believed that marketing is generally done well for the Rooibos industry and suggested that the market be opened for the honeybush industry. Participant 9 was under the impression that the global market wanted honeybush tea; however, after the COVID-19 pandemic, they found that "demand vanished". However, Participant 9 noted the popularity of *C. intermedia,* which they have managed to cultivate illustrated in Figure 57d and intends to pull out all the other species. They further mentioned that:

> *"I am going to take out all my subternata and plant intermedia. I have planted a patch to see what intermedia would look like, and it is doing quite well."* – Participant 9

### 4.3.1.4) Capital

Natural and financial capital were required for the success of honeybush cultivation. The main *natural capital to cultivate honeybush* included having: (i) an ideal climate (i.e., sufficient rainfall), (ii) land (i.e., sufficient land to grow honeybush) and (iii) ideal soil (i.e., sufficient conditions for a legume). Additionally, financial capital was needed to compensate for any lack or limitation of natural capital (i.e., if the area does not have adequate rainfall, artificial water sources such as dams, drippers and boreholes are necessary).

***Ideal climate***

Participant 6 had sufficient rain in the winter and had not watered their crops in more than 2 months. The area was too dry for Participant 7. In 2022, the area experienced four days which were over 50 ºC. Additionally, most of the summer days were between 35 and 45 ºC. They highlighted a reality they encountered while cultivating *C. subternata*:

> *"Subternata needs more water than what they say."* – Participant 7

Additionally, water infrastructure (i.e., financial capital) was an issue (the participant's taps were leaking). Their plants were therefore water-stressed. Participant 8 mentioned that all their species got the same amount of water. *C. maculata* (which grew tall and had a decent harvest) and *C. longifolia* (which grew fast and had a decent harvest) did not need a lot of tending, while their *C. subternata* did. Participant 8 was in an area that "*never dries*" and did not need to water their fields for 3 months due to sufficient rainfall. However, other climate-related conditions associated with their honeybush fields were the seldom presence of frost on the enterprise (not severe) and wind, which may have played a role in bending and uprooting some of the stems illustrated in Figure 58b. They found that honeybush plants grew well in fields planted between rows of apple trees (which acted like windbreaks). Participant 9 was in a dry area and did not have sufficient water for their enterprise. They further elaborated, stating that:

> *"My biggest problem is that I haven't got enough water to go bigger than what I am. I would love to have 10 hectares of tea because then I can rotate. Do three this year, then three next year, and so forth – because it's every three years that you can harvest. Because if you can rotate like that, then it's worth it."* – Participant 9

They are not in a catchment area and thus are reliant on borehole water (i.e., financial capital). They are considering potentially adding another borehole or a dam. They used to use overhead sprayers, but they used a lot of water. Then they used bottom sprayers (which worked well for their tea). They are currently experimenting with different times to water their tea. Instead of watering their tea twice a week, they were advised to water it once a week for a longer period. They are currently testing drippers (i.e., they think they should leave them on for 5 or 6 hours instead of 2 hours). They noted that they can't pump at night with no solar energy (required financial capital) so they are limited to when and how long they can pump water for.

### *Ideal land*

Participant 7 did not have large yields from their fields. The processor had a wet honeybush tea quota of half a tonne (500 kg). However, the participant's fields could sustainably produce 300 kg of wet honeybush tea. Therefore, the participant had to harvest more than the sustainable amount to meet the quota, which ultimately stressed the plants. The participant noticed a substantial amount of die-off.

Participant 8 had enough land to successfully plant the desired species (i.e., *C. maculata* and *C. subternata* illustrated in Figures 58a and c.). However, the participant noted inconsistencies with their *C. subternata* plants, where one subset would do well while another would not. They expressed their findings below:

> *"It's honeybush. Sometimes, you will be lucky to have a quarter of a kilogram... I had one subternata bush, which was 17 kg. If you could reproduce a plant like that, can you imagine?"* – Participant 8

An example of a *C. maculata "mega plant"* was found in Participant 6's enterprise, which had a biomass of 13 kg. Another example of a large honeybush plant occurred in Participant 9's enterprise, where 8 kg was harvested from one *C. subternata* plant. Although harvests from most *C. subternata* plants were between 5 and 8 kg, the majority only had 1 kg.


**Figure 58**: (a) *Cyclopia maculata* cultivation field at Participant 8's enterprise. (b) Uprooted *C. maculata* plant suspected of being pushed over by the wind (c). *C. subternata* cultivation field (in the foreground of the photo) at Participant 8's enterprise.

Participant 9 reckoned that they do not have enough land yet to plant the desired, sustainable amount to make honeybush tea cultivation financially viable, expressed below:

> *"Unless you go big, it may not work for you, especially in the Langkloof."* – Participant 9

Participant 9 also noted the importance of understanding that honeybush plants may grow differently in the fields relative to what is stated to occur in theory. They found that:

> *"With* C. subternata*, you cannot plant it closer than 1 m apart because the bush grows too big. With* C. intermedia*, you can plant about 75 cm apart because the bush does not get that big. They tell you that on a hectare, which is 10 000 m squares, you can get 10 000 plants. You can do it, but once you start looking at the end results, you may have about 6 000 plants. Some of them grow horizontally, and vertically, and some just die out."* – Participant 9

### *Ideal soil*

Participant 8 planted their own seeds and grew seedlings (in a nursery). They bought the correct soil for the area (which has since stopped being sold). They have since started using rhizobium from Pretoria to grow their plants. Participant 9 conducted soil samples to see what was in the soil. Two harvests later, they did another soil sample to compare the differences but could not tell the differences with their limited knowledge. Participant 9 suggested that soil experts should guide farmers regarding the conditions of their soil and what inputs to add, to inform further management. For instance, they would want to know that:

> *"…because you have taken out x amount* (nutrients)*, now you have to add y amount."* – Participant 9

Participant 4 reported that rhizobium and water are good factors to consider for growing tea. They managed to grow *C. intermedia* (which isn't traditionally used in cultivation) on flat slopes. They found that:

> *"… as long as you give it* (*C. intermedia*) *water."* – Participant 9

### 4.3.1.5) Additional activities on the farm

For all participants, *honeybush cultivation was not the only activity that generated income*. Participant 6 began transitioning to pecan nut farming (due to residing in a favourable climate). They currently have 180 trees. Participant 7 was a beekeeper (who sold honey) and had sheep and cattle. Participant 8 intends to continue with wild honeybush harvesting (of wild *C. intermedia* on the enterprise). The participant will also be adding vegetables and almond trees. They find other endeavours more economically viable, highlighted below:

> "*A bakkie load of honeybush tea gives you ZAR 5,000. A bakkie load of almonds gives you ZAR 90,000 for the same work."* – Participant 8

Participant 4 used to have sheep and cattle, but the area was too dry to support grazing. They have since planted pecan nut trees and intend to grow more. They currently have 260 trees.

### 4.3.1.6) Organic certification

Participant 6 mentioned that there was a push for honeybush tea to become organic. However, they had issues with alvarum and could not treat it (since treatment would potentially not comply with organic standards). They also could not use traditional fertilizers, which made cultivation difficult. Participant 9 mentioned that if they wanted to be organic, they would have to sign up and pay for it. However, they acknowledged that they *were too small for it to be financially viable*. They further elaborated by stating that:

> *"If you don't have 50 ha, then it's not worth it"* – Participant 9

### 4.3.1.7) Reflections from the participants

Participant 7, who initially enjoyed cultivating honeybush, struggled as a single worker on the enterprise. They had no trouble producing wet honeybush, but they found that the cost of honeybush cultivation (i.e., marketing, research, adapting to market demands, and applying personal investment) was higher than the income it generated. The participant mentioned that rooibos has also taken a dip before it rose again, and that could happen for the honeybush tea industry (which is endemic to South Africa). They believe the industry needs support, highlighted below:

> *"… it's a niche market, and you need contacts to help."* – Participant 7

Participant 8 was sceptical about the future of the industry. They mentioned that they were doing better than most people, but ultimately, it was not economically viable from a producer's perspective. They believe that tea is a luxury in the context of the world's shortage and demand for food. Participant 9 enjoyed being a part of the industry and still thinks it is worth it. They noted that if they had more water, they would have increased the size of their enterprise as described below:

> *"… the bigger you are for the same effort, then it's better."* – Participant 9

Participant 9 further recommended more understanding and knowledge of honeybush tea cultivation. They also implored potential interested producers to be realistic and stated their reality below:

*"There was a big expectation; we were thinking we were going to make hundreds of thousands. We didn't even make tens of thousands. They were telling people that you should at least get 2 kilograms from a plant. That's where the sums came in."* – Participant 9

### 4.3.2) Community project enterprises

Three cultivation honeybush tea community project members served as participants for Objective 3. These participants are involved in community projects related to honeybush cultivation, illustrated in Table 24. Participant 10 received necessary training from the ARC and helped establish honeybush tea community projects in Thornham, Clarkson and Guava Juice in the Eastern Cape. Participant 11 worked on a farm which cultivated rooibos tea and honeybush tea. Participant 12 was approached to manage the community project in Thornham (which is a family set-up from the Thorns and the Cunninghams). They established a nursery in which people from the community worked together to run. Themes that arose from the interview notes are: (i) Experiences with cultivation, (ii) Challenges in the community projects (i.e., management issues, species-based challenges, accessibility to land and marketing) and (iii) Natural and financial capital challenges.

**Table 24:** Details of the honeybush tea cultivation duration, size of cultivated field, chosen species for cultivation and the reasons for species selection at the enterprises belonging to Participants 10 to 12.

| Participant | Duration | Hectares | Cultivated species | Reason(s) for species selection/ experience with species |
|---|---|---|---|---|
| **Participant 10** (entrepreneur) | Not cultivating yet | N/A | *C. subternata* | ● *C. subternata* was naturally growing in the area.<br>● Participant also wants to plant *C. longifolia* |
| **Participant 11** (producer) | 2004 – present | 4 | *C. subternata* | ● *C. subternata* was selected because it grew fast.<br>● *C. intermedia* was initially selected, but grew slowly (which was not ideal for them) |
| **Participant 12** (nursery and producer) | 2019 – present | 5–6 | *C. subternata*<br>*C. longifolia* | ● *C. subternata* was naturally growing in the area. |

#### 4.3.2.1) Experiences with cultivation

Participant 10 was involved in setting up Thornham (whose role was to produce and sell seedlings for commercial use), Clarkson (whose role was to establish commercial honeybush plantations) and Guava Juice (whose role was to produce and sell honeybush seeds for commercial use). Participant 11 mentioned that they had a pleasant experience with cultivating *C. subternata*. In the initial stages, drippers were used. However, once the crops started growing, regular watering was not necessary. All cultivation was natural and organic, and they grew well without too much attention. Harvesting was employed with caution. When starting, the tops of the bushes were trimmed to allow them to grow from underneath, promoting large bushes. Participant 3 runs a nursery, illustrated in Figures 59a, b and d. They planted seeds obtained from ARC, illustrated in Figure 59c. They usually get an order which they then must produce. They currently have about over 50 000 seedlings. They have recently obtained *C. maculata* which they will also start planting with their *C. subternata* and *C. longifolia.*

**Figure 59:** (a) Honeybush nursery (exterior) at Participant 12's enterprise; (b) Honeybush nursery (interior) at Participant 12's enterprise; (c) Community members planting honeybush seeds into seed trays; (d) Seedling trays.

In terms of cultivation, the participant finds it easy to grow the plants in the field. In 2022, they prepared fields in which unpurchased, excess seedlings were translocated, illustrated in Figure 60a. As seen in Figure 60b, the workers only prepare soil in the specific location where they will plant the honeybush (in the form of circles). They planted the honeybush 2.5 m apart with rows that are 1 m apart from each other. Figures 60d and e illustrate what a seedling looks like relative to the prepared soil (before and after planting, respectively). They have managed to produce flowering honeybush plants illustrated in Figure 60e. There was grass in between the rows of honeybush, in which a grass cutter is employed. In terms of harvesting, they harvested above a knee distance from the ground.


**Figure 60:** (a) Honeybush cultivation field at Participant 12's enterprise; (b) Community members preparing the soil for seedling translocation; (c) Seedling tray with excess seedlings from the nursery; (d) Seedling relative to prepared soil; (e) Seedling in the field; (f) Successfully flowering honeybush plant.

### 4.3.2.2) Challenges in the community projects

Within community project setups, challenges arose in the form of: (i) management issues, (ii) species-based challenges, (iii) accessibility to land and (iv) marketing.

***Management issues***

Participant 10 noted hostility within community projects where multiple parties are involved in management. They stated that:

> *"There has been a lot of fighting and management issues within the community projects (including changing from a cooperative to a proprietary company (PTY))."* – Participant 10

Participant 12 had substantial land available, but the participant mentioned that there were issues with "politics" in the community. Additionally, there was notable illegal harvesting occurring in the natural areas around Thornham, which added to distrust amongst the community.

***Species-based challenges***

Participant 10 noted that within the community projects, there was a natural die-off of plants in the fields, exacerbated by management issues. Participant 11 mentioned that compared to rooibos, honeybush was more challenging to grow from the production side. Additionally, the cultivated fields had seen impacts from IAPs (i.e., black wattle). The participant mentioned that fires had also impacted the cultivation of *C. subternata*. However, they found that their crops could grow again after a fire, but the losses were still financially costly for them. They did not receive financial assistance for the fire damage as expressed below:

*“The government provided a grant to aid in establishing cultivation. However, they did not assist when there were fires.”* – Participant 11

Participant 12 encountered pests on the *C. subternata* through their rigorous plant checks. Additionally, they had seen about a 20% die-off in the plants in their cultivation sites that the community planted in surrounding fields in the area.

***Accessibility to land***

Participant 10 noted that accessibility to land was a growing issue for community projects. They mentioned that there was private land (on forestry land) in which honeybush grows naturally and could be grown. However, people in the community could not access that land. This issue was also emphasised by Participant 11, who mentioned that a lot of commercial farmers have land where tea was growing on but were reluctant to let people come in and harvest.

***Marketing***

Participant 10 mentioned that marketing overseas merely requires quality tea, and they want to be part of growing the export market. However, they mentioned that getting into marketing is not easy, and it needs to be improved. According to Participant 12, it was relatively easy to run the nursery, and they were able to grow substantial, healthy seedlings. However, the participant lacked enough buyers.

#### 4.3.2.3) Natural and financial capital challenges

Participant 11 mentioned that producers must have all the necessary equipment, which is often a challenge for small-scale farmers. In the beginning, drippers were used. However, once the crop started growing, regular watering was not necessary. All cultivation was very natural and organic, and they grew well without too much attention. The participant mentioned that cropping depended on the plant and needed to be employed with caution. From the bigger and thicker plants, more could be taken off. When starting, they would trim from the top so that it could grow from underneath and create a big bush. Participant 12 mentioned the challenge of water in the community. They do not have municipal services such as water and streetlights (the community is responsible for all its own services). The water comes out of a borehole, into a dam, which is then distributed from the dam to the households. The pump in the dam ran on ESKOM. However, people do not want to pay, which led to a month without water. Fortunately, they received water assistance from the MTO Group.

#### 4.3.2.4) Reflections from the participants

Participant 10 expressed that they want the honeybush tea industry to be successful. Additionally, they mentioned that wild harvesting is unsustainable, and thus there is a need to increase efforts in cultivation. Participants 11 and 12 believed that the honeybush tea industry can be prosperous. Participant 11 even referred to honeybush cultivation as their “love job”. However, participant 11 has emphasised that there is a lack of interest in the younger generation to be part of and to continue the industry. They advised that:

*“There is a future for honeybush. The youth must be targeted.”* – Participant 11

Participant 12 emphasised that there needs to be an improvement in the awareness of honeybush and the industry itself. They mentioned that not many people in the country know about honeybush, so information and samples need to be presented to the public. This will ensure the industry’s success and sustainability.

**KEY FINDINGS**

**CHAPTER 4**

**1) Updated cultivated honeybush tea inventory for 2023 (mapped)**

- Since 2020, three new enterprises started cultivating honeybush tea.
- Of the 40 cultivated enterprises, 13 were producing, 10 (small-scale) had exited the industry, 4 were not producing and the status of 12 enterprises was unknown.
- Approximately 325.9 ha of cultivated honeybush tea was in production in 2023.
- Enterprises cultivating more than one honeybush species were more resilient.

**2) Five case studies: interviews, mapping, plant survey, biodiversity survey, soil survey, cost estimations per hectare**

- All enterprises meet all pillars of sustainability. Analysed themes: (i) The problem of invasive species (very rampart), (ii) Choosing which honeybush species to cultivate (cultivating what grows naturally in the area), (iii) Ensuring quality in the industry (standards set pre-, during- and post-harvest), (iv) Biophysical conditions associated with the industry and (v) Enterprise operations (enterprises entail multiple operations).
- Fynbos land cover is greater in and around enterprises (that largely cultivate resprouters).
- Woody species have mainly increased in and around the enterprises.
- Resprouters tend to be physically larger and more long-lived than reseeders.
- Cultivated sites (particularly those with resprouters) were more diverse than non-cultivated sites.
- Soil nutrients were mainly higher in the non-cultivated sites (for enterprises with reseeders).
- Break-even point (resprouters): year 9–10 for *C. intermedia* and year 9 for *C. genistoides*
- Break-even point (reseeders): year 5–6 for *C. subternata* and *C. longifolia*

**3) Challenges in the cultivated honeybush tea industry: interviews**

- Analysed themes: (i) Challenges encountered while cultivating honeybush (i.e., general lack of knowledge, crop mortality rate and inexperience with species), (ii) Dissatisfaction with the price of wet honeybush tea (it is not economically viable for small-scale enterprises), (iii) Lack of marketing in the industry (iv) Lack of capital (i.e., infrastructure, land and water) and (v) Other farm activities are more economically viable than honeybush.
- Analysed themes: (i) Experiences with cultivation, (ii) Challenges in the community projects (i.e., management issues, species-based challenges, accessibility to land and marketing) and (iii) Natural and financial capital challenges (i.e., lack of infrastructure for agriculture).

# CHAPTER 5

This research aimed to investigate aspects of sustainability that influenced the success and failure of cultivated honeybush tea enterprises to provide insights toward a more sustainable and resilient future. This was conducted through four research objectives: (i) compiling an updated inventory of the cultivated honeybush tea industry, (ii) examining the environmental, economic, and social practices at successful cultivation enterprises, and (iii) identifying challenges faced by unsuccessful, transitioning, and community-based enterprises. Objectives 2 and 3 (which represent the successful enterprises and challenges that made enterprises exit the industry) will be synthesised and integrated together. This final chapter will propose a sustainable resource use framework, integrating findings based on the environmental, economic, and social considerations which exist to support the cultivated honeybush tea industry.

## 5.1) Inventory of the cultivated industry: considerations of scale (spatial and temporal), climate, species selection and composition

*Scale (spatial and temporal) of enterprises*

The map visually illustrated where inventory changes occurred, particularly the production status and size (hectares) of enterprises (Figure 16). The industry declined from 2020 to 2023 (37 to 30 enterprises) in which nearly 50% were inactive. Small-scale enterprises (0–5 ha) were most vulnerable. Major challenges that led to three small-scale enterprise owners leaving the industry included: the dissatisfaction with the price of wet honeybush tea that was not economically viable for their enterprise scale and a lack of marketing in the industry, which resulted in no sales. These findings correlate with Stringer et al. (2008) who found that globally, small-scale farmers face socio-economic challenges such as global food market dynamics, a lack of resources, agricultural policy changes, and maintaining sustainable livelihoods. Small-scale farmers also face biophysical challenges such as climate variability, disease outbreaks and land degradation which play a substantial role in small-scale farmer productivity (Stringer et al., 2008). This research found that a lack of natural capital (i.e., sufficient land to sustain viable crop yields and/or water for production) and financial capital (i.e., water facilities such as irrigation and water storage) delayed or halted production and enterprise success. Mbuli et al. (2021) highlighted the interconnectedness between small farmers' productivity, climate change and food security, especially in Africa.

*Climate across the honeybush distribution range*

Small-scale farmers, who especially rely on rain-fed agriculture to feed their families and nations, are often neglected amidst climate change challenges in the Global South (Mbuli et al., 2021). The cultivated honeybush enterprises largely occur within semi-arid areas of the country (which are divided into winter, all year and very late summer rainfall) (Figure 4). The summer rainfall belt is poorly distributed, and areas within it often experience droughts (Bennie & Hensley, 2001). All ten farmers who exited the industry occurred in this region and one participant mentioned the detrimental effects this had on their produce (due to financial constraints and scale, they could not install irrigation facilities). This correlates with the findings of Mbuli et al. (2021) who found that there is a general lack of adaptability of small farmers to the instability in temperature and rainfall, which ultimately affects their output, profitability, and survival (Mbuli et al., 2021). Vulnerability to climate variability can be linked to the choice of species for cultivation.

*Species selection across different enterprises*

The most cultivated species in 2020, produced at all 34 enterprises, was *Cyclopia subternata* (historically promoted as the most suitable species for cultivation) (Joubert et al., 2011). The least cultivated species were *C. intermedia* and *C. maculata* (four enterprises respectively). Short-term production goals were more suited to *C. subternata.* However, regarding long-term goals, this may not be the case. Other species cultivated included *C. maculata* and *C. longifolia,* which were ideal because they were fast-growing (in favourable conditions) (Joubert et al., 2011) and could be harvested annually, which was ideal for the enterprise scales (Table 1). Since *C. intermedia* grew slowly and could only be cropped after three years, it was the less popular choice for cultivation (Joubert et al., 2008). Overall, the lack of experience in cultivating honeybush, and knowledge gaps were prevalent during cultivation. However, in 2023, half of the known enterprises stopped cultivating *C. subternata*. Participants in this research attributed this to the species' substantial mortality rates, especially after 7 years (with one participant's crops dying well before the species' expected 7-year cycle) (Joubert et al., 2011), drought in the area (combined with the lack of water facilities) and changing markets (i.e., one participant believed that the industry would prefer *C. intermedia* and decided to remove their *C. subternata*).

*Species composition across different enterprises*

In 2023, eight enterprises, out of 21 in 2020, still cultivated one species on their enterprise. Five enterprises, out of 10 in 2020, still cultivated two different species. Four enterprises that cultivated at least three species in 2020 remained active in 2023. More than 60% of the enterprises that only cultivated one species in 2020 were less successful compared to those with a variety of species (Table 11). The findings indicated that 50% of enterprises that cultivated two species and 100% of those that cultivated more than three species remained active in 2023. Makate et al. (2016) found that diversification of species at a single enterprise can enhance resilience (i.e., food security and household income) and productivity for small-scale farmers at the forefront of changing climates. They further recommend diverse cropping systems (i.e., a combination of perennial and annual crops) to adapt to the ever-changing climate to increase resilience (Makate et al., 2016; Baker et al., 2023).

This inventory analysis of honeybush tea enterprises provided the most up-to-date information on the cultivated honeybush tea sector. Considering where honeybush species naturally occur, it is important to understand what scale to plant and what species to cultivate. This map served as a starting point to identify successful, persistent enterprises for further investigation. Insight into sustainable practices in successful enterprises was necessary to help build the framework.

## 5.2) Environmental, economic, and social practices in successful cultivation enterprises

The second objective of this research was to assess the overall sustainability of five successfully cultivated honeybush enterprises according to the UEBT Standard Framework. The framework provided a methodical approach for comparison of the five enterprises in terms of the three pillars of sustainability, investigated through the five principles of the framework: (i) Conservation of biodiversity, (ii) Sustainable use of biodiversity, (iii) Fair and equitable sharing of benefits derived from the use of biodiversity, (iv) Socio-economic sustainability (productive, financial and market management), (vi) Respect for the rights of actors involved in BioTrade activities. As this framework aligns the CBD and SD goals, it served to promote the relevance of this research in a global context of product sourcing, which regenerates local ecosystems and ensures a sustainable future for the producers and harvesters involved in cultivation (Stamboulakis & Sanderson, 2020). Data on the enterprises was collected through on-site interviews with the owners, followed by field surveys of honeybush plant allometry, biodiversity and soils. Understanding of the environmental conditions of the enterprises relative to surrounding lands was further developed by desktop mapping of land cover change over time and *Cyclopia* species distribution modelling. The combination of qualitative and quantitative methods of data collection and analysis (described as a mixed methods approach by Creswell (2014) served to support a richer and more complete understanding of the whole system. Mixed approaches to data collection and analysis are a feature of sustainability science which deals with complex problems (Kates, 2012) that typically require multi-disciplinary approaches (Clark & Harley, 2020). The key findings of the research are discussed below in relation to the three pillars of sustainability: environmental, economic and social regarding relevant theory.

## A) Environmental sustainability

One of the main environmental-related principles in the UEBT framework states that cultivation practices should foster the sustainable use of biodiversity. It encourages cultivation that promotes natural and regenerative processes. These practices extended to soil, water and air in cultivation sites (UEBT, 2020). This principle aligned with the Aichi Biodiversity Target, which aims to (i) "reduce the direct pressures on biodiversity and promote sustainable use and (ii) "Enhance the benefits to all from biodiversity and ecosystem services". Therefore, it was worth investigating the environmental aspects of successful enterprises.

### 5.2.1) Conservation of biodiversity at the forefront of IAPs

A primary concern for all enterprises was the problem of invasive species. IAPs, specifically *Acacia mearnsii* (Australian black wattle), *Acacia melanoxylon* (black wood), *Hakea sericea* (silky hakea), *Pinus L* (pine), *Solanum mauritianum* (bugweed) and *Myrtus communis* (myrtle) were noted as the most commonly occurring threats to biodiversity both in and around cultivated sites of honeybush. According to the landcover change analysis, field surveys and interviews, problem areas (where there was increased woody species cover through IAP invasion) were found in all enterprises. These were particularly prevalent in Enterprises 2 and 5 (Figures 25 and 50). The cost of clearing aliens was seen to be prohibitively costly, such that a focused approach of keeping cultivated lands, wetlands and river courses free of IAPs was the only practical way to deal with the problem of IAPs. Honeybush tea cultivated in old black wattle areas failed to succeed, likely because black wattle is allelopathic, reduces sunlight penetration and alters soil properties (González-Muñoz et al., 2014; Lazzaro et al., 2014). In rangelands, black wattle significantly altered the physicochemical soil characteristics, affecting grass production (Gwate et al., 2021).

### 5.2.2) Land transformation and biodiversity-minded agriculture

*Honeybush cultivation and biodiversity*

Land transformation through agricultural activities is recognised globally (Díaz et al., 2019) and at the fynbos biome scale (Skowno et al., 2018) as a major threat to biodiversity. However, the agricultural sector, particularly rainfed agriculture, is essential to meet the livelihood and food security needs of an estimated 224 million people in Southern Africa (Mutengwa et al., 2023). For this research, it was necessary to analyse the LULC practices of successful enterprises to gauge their impact on the environment. A summary of changes in land cover of the five enterprises from 1990 to 2022 is presented in Table 25. According to the findings of this research, at Enterprise 1 and 2, the cultivation of honeybush improved aspects of biodiversity through an increase in shrubland area (green cells), high levels of plant diversity and low incidence of IAPs. The surrounding extent of shrubland fynbos at these two sites also increased.

**Table 25**: Summary of key findings of the changes in land cover (ha), from 1990 to 2022, in surrounding areas and within the enterprises for fynbos, woody species and agriculture. Area decreases (ha) are highlighted in red, and area increases (ha) are highlighted in green.

| Enterprises | Land cover area | *Fynbos | **Woody Species | ***Agriculture |
|---|---|---|---|---|
| Enterprise 1 | Around enterprise | 152.89 ha | Minor change | 37.92 ha |
| | In enterprise | 238.96 ha | 157.56 ha | 9.03 ha |
| Enterprise 2 | Around enterprise | 279.16 ha | Minor change | 228.72 ha |
| | In enterprise | 32.62 ha | Minor change | 82.44 ha |
| Enterprise 3 | Around enterprise | 33.62 ha | 123.76 ha | 12.86 ha |
| | In enterprise | 0.21 ha | 0.27 ha | Not present |
| Enterprise 4 | Around enterprise | 650.37 ha | 629.9 ha | 7.99 ha |
| | In enterprise | 265.85 ha | 209.53 ha | 3.62 ha |
| Enterprise 5 | Around enterprise | 275.09 ha | 347.78 ha | 94.64 ha |
| | In enterprise | 78.95 ha | 66.25 ha | 32.21 ha |

***Land cover class *Fynbos*: shrubland fynbos' (1990) and 'low shrubland (fynbos)' (2022); **Landcover class *Woody species*: 'indigenous forest' (1990), 'dense forest and woodland' (2022), 'contiguous and dense plantation forest' (2022), 'contiguous (indigenous) forest' (2022) and 'contiguous low forest and thicket' (2022); ***Landcover class *Agriculture*: 'cultivated commercial fields (low)' (1990) 'cultivated commercial fields (medium)' (1990) 'cultivated commercial fields (high)' (1990) and 'commercial annual crops rainfed/ dryland' (2022).**

Table 25 also highlights a slight increase in fynbos cover and a slight decrease in woody species (which dominate the surrounding areas) at Enterprise 3. IAPs were manually cleared and replaced with indigenous honeybush cultivation. Natural germination was promoted, which grew amongst 19 species from 12 families, reflected in the biodiversity survey. This was a vast improvement of the land compared to the surrounding areas, which largely comprised IAPs. (Figure 17). The cultivation of honeybush, with biodiversity considerations, should be considered as positive compared to the Rooibos industry (the most successful tea industry in South Africa), which caused landscape degradation through ploughing thousands of hectares of mountain fynbos for rooibos tea monoculture (Wynberg, 2017). In 2017, 60 000 ha were cleared for rooibos, increasing the number of species being threatened with extinction to 300% (Wynberg, 2017). Apart from honeybush cultivation improving plant diversity, it was worth noting its effects on soil properties.

*Honeybush cultivation and soil properties*

Soil is responsible for housing important microorganisms whose role is to decompose organic matter, releasing nutrients and generating humus (Reganold et al., 1990). Soil, therefore, needs to be well-maintained to ensure the industry's environmental sustainability. Conventional farming practices tend to leave soil uncovered for long periods, impacting the Soil Organic Matter (SOM) found in the topsoil (Gomiero et al., 2011). A summary of important differences between soil nutrients found at cultivated and non-cultivated sites is presented in Table 26.

**Table 26**: Soil nutrients found in honeybush tea cultivated and non-cultivated sites.

| Enterprise | Site | pH | Calcium (Ca) | Magnesium (Mg) | Phosphorus (P) | Potassium (K) | Sodium (Na) | Copper (Cu) |
|---|---|---|---|---|---|---|---|---|
| 1 | Cultivated | | | | | | | Same |
| | Non-cultivated | | | | | | | |
| 2 | Cultivated | | | | | | | Same |
| | Non-cultivated | | | | | | | |
| 3 | Cultivated | | | | | | | |
| | Non-cultivated | | | | | | | |
| 4 | Cultivated | | | | | | | |
| | Non-cultivated | | | | | | | |
| 5 | Cultivated | | | | | | | |
| | Non-cultivated | | | | | | | |

Similar values | Slightly higher | Substantially higher

Two enterprises which had cultivation systems incorporating more of the surrounding biodiversity (in a 'natural-like' state) may account for similar soil properties (and high calcium and phosphorus). Enterprises 3–5 had a higher percentage of nutrients in the non-cultivated sites, possibly due to honeybush (reseeder) taking up and allocating more resources aboveground for reproduction and growth (which makes them likely to have higher nutrient requirements than resprouters) (Power et al., 2011). It may be that they deplete the nutrients more rapidly than resprouters. The decrease in mineral nutrients in cultivated honeybush lands (particularly from Enterprises 3–4) may imply that fertiliser application is needed to prevent degradation of the soil as well as to add necessary nutrients back into the soil. With this said, enterprise owners need to be mindful of micro- and macro-nutrients that go in and out of the honeybush cultivated fields. As suggested by one of the participants, enterprises with reseeders need to monitor and manage soil properties in their cultivated honeybush lands. With the kind of biodiversity-conscious approach demonstrated by Enterprises 1, 2 and 3, the honeybush industry can contribute to achieving COP15 goals of restoring 30% of degraded ecosystems, conserving 30% of land and marine areas, and halving invasive species introductions (CBD, 2022). However, since the cultivated honeybush industry is only around 30 years old, it was worth investigating the distinct geographical distribution of the individual species, especially enterprises that managed to successfully cultivate the species, as these considerations could inform the conditions for successful cultivation.

### 5.2.3) Considerations for honeybush cultivation

*Geographical location of the enterprise*

Species distribution modelling helps address the spatial patterns of species diversity and climate change-related changes to species distributions (Pearson & Dawson, 2003). Broadly, honeybush (*Cyclopia* species) occurs in the mountains and valleys formed by the Cape Fold Mountains (across the Western and Eastern Cape Provinces) that have acidic, nutrient-poor soils, which are ideal for fynbos vegetation (Vlok & Schutte-Vlok, 2015). This region experiences hot, dry summers and winter rainfall. The natural distribution of the four key honeybush species was modelled in Figures 26, 33, 39, 45 and 50. Enterprises 1 and 2, successfully cultivated their respective species in the probability of occurrence range of 0.25–0.50 of the natural distribution range. Enterprise 2, near the coast, successfully grew the Kirstenbosch ecotype of *C. genistoides* (also known as 'coastal honeybush tea'). It is likely that cultivating where the species' natural requirements are met, cultivation may be more successful. This approach was followed in a study by Lötter & le Maitre (2014) who used SDM for *Aspalathus linearis* (rooibos). They developed the estimated realised niche for the wild rooibos and locations suitable for commercial production (Lötter & le Maitre, 2014). SDM has been used in other agricultural industries cultivating medicinal species (Peng et al., 2019; Xu et al., 2020). The SDM of species could help with decision-making regarding selecting species to cultivate. Cultivating a species in a region where it naturally occurs may be easier as it would be adapted to the local environmental conditions. Cultivating outside a species' distribution range may require significant inputs to replicate natural conditions. For instance, the other enterprises in this research, which occurred just below their distribution ranges, successfully cultivated their species with substantial irrigation assistance. However, there are risks associated with this form of cultivation such as genetic contamination (i.e., through pollination or seed dispersal) (Wynberg, 2017). There should be sufficient spatial isolation between cultivated fields and wild populations, and regular monitoring and regulation of these areas.

*Honeybush species ecology*

Another important consideration involved in the environmental sustainability of honeybush is its ecology. The models of honeybush cultivation presented by McGregor (2024) are based on the species' survival strategy and cultivation intensity, with the highest applying to the reseeders and the lowest applying to the resprouters. Both survival strategies have benefits and limitations from an agricultural perspective. For instance, the benefit of reseeders is that they can be cropped every year and thus act as cash crops. In the case of *C. subternata*, it has the second-largest distribution range (Figure 39), but they have a shorter life span (7 years) and often requires more inputs (Joubert et al., 2011). It was recommended to also have a resprouter on their establishment.

**Table 27:** The synthesis of the average allometry of key honeybush tea species at the different enterprises over time (where green indicates an increase and red indicates a decrease).

| Survival strategy | Species | Ages | Height | Crown | Basal circumference | Stem count | Stem diameter | Yield |
|---|---|---|---|---|---|---|---|---|
| Reseeder | **C. subternata* | 4,7 | | | | | | ***N/A |
| | ***C. subternata* | 4,7 | | | | | | |
| | ****C. longifolia* | 4,5,7 | | | | | | *****N/A |
| Resprouter | *C. genistoides* | 3,7,14 | | | | | | |
| | *C. intermedia* | 7,12,17 | | | | | | |

| Substantial increase | Slight increase | Slight decrease | Substantial decrease |
|---|---|---|---|

***C. subternata* at Enterprise 3; ***C. subternata* at Enterprise 5; ****C. longifolia* also acts as a resprouter; ****N/A yield**

**measurements were not taken as the owner was not harvesting; *****Yield was only collected for plants that were 4 years old (only age being harvested).**

*Cyclopia longifolia* plants take on a combination of reseeder with resprouter tendencies. These characteristics allow for heavier cropping with good recovery as demonstrated at Enterprise 4. However, this species has a limited distribution range (Joubert et al., 2011) and still requires irrigation. In contrast, *C. genistoides* (resprouter) requires no irrigation and has a large distribution range (particularly in the western part of the Western Cape province) and a production lifespan that begins to decline in year 14. However, a disadvantage is that the plants can only be harvested every two years (Table 1). The benefits of *C. genistoides* cultivation are also seen with *C. intermedia*. The species has the largest distribution range compared to the other species (spanning across the Western and Eastern Cape) and has a production lifespan that begins to decline in year 17. However, the main disadvantage the species has is that it can only be harvested every three years (which was not ideal for three of the successful enterprises as well as three of the enterprise owners that exited the industry). The differences between reseeder and resprouter plant species are well documented. Reseeders tend to grow faster since they allocate their resources to their stems (as opposed to underground lignotubers as noted in resprouters) (Parra & Moreno, 2017; Verdú, 2000). Reseeders further prefer winter rains and short summer droughts (common in the mountainous areas of the southwestern CFR) (Ojeda, 1998). Resprouters, on the other hand, are physiologically less sensitive to rainfall patterns and showed little drought-related mortality compared to reseeders (Ojeda, 1998; van Blerk et al., 2021). It is therefore ideal to have cultivation setups with both reseeders and resprouters.

*Mixed-production systems*

Mixed-production systems are the most common form of farming in low- and medium-income countries and are increasingly seen as a climate change adaptive approach (Baker et al., 2023). Here, producers have set-ups combining annual and perennial crops, livestock and other agricultural productions (Baker et al., 2023). Examples in this research included orchards (Enterprise 2) or a hotel and a polo club (Enterprise 4). Additional sources of income from participants outside of the case studies came from livestock and beekeeping (Participant 7), and wild honeybush harvesting (Participant 8). These activities helped sustain the overall enterprise compared to enterprises that had one product (Participant 6). However, mixed production systems related to honeybush tea cultivation factor in cultivating both reseeder and resprouter species at a single enterprise to achieve benefits from both (i.e., a cash crop from reseeders and a long-lived, consistent crop from resprouters). Additionally, due to the extreme consequences of soil ploughing, perennial crops are also encouraged instead of annuals (Gomiero et al., 2011). Enterprises 1 to 5 all had more than one honeybush species in their establishments (Table 2). Enterprise 1 and 2 both had a resprouter and reseeders. Enterprises 3–5 only had reseeders. This type of diversification could help enterprises buffer against climate change risks to food production systems (Baker et al., 2023). This form of diversification could also help with one of the challenges that made three honeybush owners leave the industry (i.e., the market did not prefer their cultivated species at the time). It is worth cultivating species that successfully grow in their environment and are in demand. Mixed-production systems could result in increased livelihood resilience, food security, and resilience. Additionally, it is seen as an example of sustainable agriculture which includes crop rotation, crop diversification, soil conservation, low input use of fossil fuels, irrigation water, fertilisers and pesticides (Goldman, 1995). However, for this to be employed, enterprise owners need to have sufficient land to allow for mixed-production systems. In addition to the mixed-production systems, it is worth having several elements of the honeybush supply chain to remain sustainable.

## B) Socio-economic sustainability

*Staff considerations*

A key social principle in the UEBT framework requires that cultivation practices promote respect for human and workers' rights with decent labour conditions along the supply chain that align with national regulatory frameworks (UEBT, 2020:

25). All enterprises comply with this principle. Every enterprise employed staff from the local community with different skill levels and employment contracts (Table 28), and their role was to work at the various enterprise operations. Staff received regular training and skills development (e.g., Enterprise 1 supported staff with obtaining driver's licences), and their wages were paid following national laws (or better). This small industry, therefore, contributes to the livelihoods of staff in municipalities with high unemployment rates (i.e., the Garden Route District Municipality and Bitou Local Municipality). In these areas, the agriculture GDPR is small, but employment in the sector is important. Most of the population within the four municipalities are people of colour who have historically been marginalised in South Africa under the Apartheid government (Vink & Kirsten, 2022). Consequently, there have been nationwide subsidies for black farmers and workers aimed at correcting the former racial biases (Vink and Kirsten, 2022) and the honeybush industry can therefore assist with creating employment opportunities and improving local livelihoods. It forms part of the agricultural sector (which has created employment opportunities, especially for those identified in Table 28).

**Table 28:** The different types of employment at each honeybush tea enterprise, in their socio-economic contexts.

| **Industry** | **Workers at the enterprise** | | **Socio-economic setting of the enterprise** | | |
|---|---|---|---|---|---|
| **Enterprise** | **Workers** | **Type of employment** | **District municipality** | **Population makeup** | **Unemployment rate** |
| 1 | 12 | Mixed-term contract (6 months) | Cape Agulhas Local Municipality | Coloured (65.7%). Black (14.7%) White (18.2%) | Low |
| 2 | 5 | Permanent worker (from orchard operations) | Swellendam Local Municipality. | Coloured (83.3%). Black (11.9%) White (5.6%) | Low |
| 3 | 1 | Permanent worker | Knysna Local Municipality | Black (42.3%) Coloured (38.8 %). White (18.5%) | High |
| 4 | 4 | Management service level agreement | Bitou Local Municipality | Black (52.6%) Coloured (29.2 %). White (18.2%) | High |
| 5 | 10 | Contract-based | Bitou Local Municipality | Black (52. %) Coloured (29.2%). White (18.2%) | High |

*Enterprise operations*

The cultivated honeybush industry's production chain is maintained by different operations that occur in an enterprise. Operations range from (i) producers (which focus on cultivating high-quality honeybush plants and managing field operations), (ii) nurseries (which focus on propagating and germinating high-quality honeybush seedlings which are supplied to the industry) and (iii) processors (which focus on post-harvesting activities such as fermenting, drying, cutting, and packaging honeybush; processors determine the final quality checks of the product and present it to the market). Some enterprises have single operations, while others may combine the operations. A key economic principle in the UEBT framework states that cultivation practices should promote the integration of the relevant requirements in the Ethical BioTrade Standard in operations and management systems (including quality and traceability systems) (UEBT, 2020: 22). High-quality standards are required in the industry, particularly with those involved in export markers, to ensure that tea maintains consistent flavour profiles, meets rigorous export requirements, and adheres to ethical and environmental practices. The enterprises in this research benefited from having different elements of the honeybush supply chain within their enterprises (Table 29). This helped with assessing quality from production to processing and packaging.

**Table 29:** Supply chain elements across the five honeybush tea enterprises.

| Enterprise | Nursery | *Own seed | Production | Processing | Packaging |
|---|---|---|---|---|---|
| Enterprise 1 | | ■ | ■ | ■ | ■ |
| Enterprise 2 | | ■ | ■ | | |
| Enterprise 3 | | ■ | ■ | ■ | ■ |
| Enterprise 4 | ■ | ■ | ■ | | |
| Enterprise 5 | ■ | ■ | ■ | ■ | |

***The enterprise owners source seeds from their cultivation sites.**

There are benefits and challenges involved in having multiple on-site elements of the supply chain (Table 29). Enterprises with a full on-site supply chain can benefit from:

- *Increased profit margins:* Transportation, processing and third-party packaging costs are reduced or eliminated (Enterprises 1, 3, 4 and 5).
- *Quality control*: On-site quality control helps maintain high-quality standards throughout production (pre-, during- and post-harvest) and processing (Enterprises 1, 2 and 5).
- *Value addition:* Owner benefits from the profits incurred by to the raw materials (Enterprise owners 1, 3 and 5). For instance, their ready-to-sell products fetched a higher cost than the wet materials (which was the reason for the departure of three enterprise owners unsatisfied with getting ZAR 10.00 per kg).
- *Swifter market access*: On-site packaging allows direct distribution to consumers, retailers and markets, allowing owners to respond to market preferences as they evolve or change (Enterprises 1 and 3).
- *Employment opportunities:* All enterprises created employment for locals as they had more operations.
- *Branding*: Direct control of branding can improve marketability (i.e., Enterprise 1 and 5 are organically certified and could add that to their brand, too).
- *Improved product traceability:* Enterprise owners who all source their seeds from their plants can track which fields their wet material comes from. This allows them to contain potentially contaminated output.
- *Diversification of revenue streams*: Enterprise owners 4 and 5 grow seedlings, which could be sold. Enterprise owners 1 and 3 could process for other enterprises or industries (e.g., Enterprise owner 3 also processes sceletium).

There are also challenges involved with the on-site supply chain:

- H*igh initial set-up costs*. Enterprise 5 purchased expensive, modern processing facility equipment. Enterprise 1 purchased second-hand processing machinery, and the owner of Enterprise 3 saved costs by building their equipment (with their engineering knowledge).
- *Strict regulation compliance*: Must be met when owning a processing facility. All enterprises need standard operating procedures (mostly in the factories). On the factory side, standards such as ECOSERT, SA-GAP, GlobalGAP, Personal Protective Equipment (PPE), and HAZOP (risk assessment for processing) were followed. The enterprises, particularly those that are organically certified, must ensure that food is safe for consumption and that equipment and machinery are kept hygienic.
- *Complex the system*: complexity requires more skilled management and labour.
- *Access to a market*: An unreliable market was one of the main reasons two enterprise owners exited the industry.
- *Maintenance costs*: There are associated with processing (i.e., upgrading equipment and staff training).
- *Risk of overproduction:* This could lead to production surpluses and inventory loss. Enterprise 3 had substantial stock that they had not sold.

*Financial considerations (reseeder versus resprouter)*

The establishment costs of the reseeder *C. subternata* and *C. longifolia* are highest due to a high planting density of 10 000 plants per hectare. As the fast-growing plants can be harvested in the second year, revenue is produced early in the crop lifespan, with high average yields per plant and high annual revenue (ZAR 55,000). Annual variable costs are also high: The lands must be weeded regularly at a cost of ZAR 10,951; while annual harvesting is labour intensive (16 labour days per ha at a total cost of ZAR 3,530 per year) given the high density of plants and the care that must be taken with cropping to avoid plant damage. These species have a relatively short lifespan of 7 years for *C. subternata* (plants senesce) and 9 years for *C. longifolia* (plants become too woody) and would therefore need to be replanted within two to three years of reaching the break-even point. Both these species, which naturally occur along drainage lines and in seeps, are vulnerable to drought with high mortality in drought years (if not supported with irrigation).

The resprouters have long lifespans and will bear a reasonable yield for up to 15 years for *C. genistoides* and 22 years for *C. intermedia*. Establishment costs are lower due to low-density planting. Annual revenue is lower because there are fewer plants and harvest intervals of 2 and 3 years for *C. genistoides* and *C. intermedia* (respectively) are practised. The intervals give the plants time to replenish their rootstock post-harvest. In the case of *C. intermedia*, the revenue is highest per kilogram, at ZAR 14.00 /kg, but the annual revenue is only ZAR 25,200. Resprouter plants persist even in drought years and respond well to heavy cropping. The low-density planting allows natural fynbos plants to establish around the crop, and weeding is not necessary beyond the first year of establishment. The annual revenue from the higher-yielding reseeder *C. subternata* and reseeder/resprouter *C. longifolia* is double that of the long-lived *C. intermedia* (ZAR 55,000 and ZAR 25,200 respectively), but both these species are limited by short productive lifespans of only a few years beyond the break-even point. *C. genistoides* performs best as yield is high and the years of profit are prolonged.

*Addressing assumptions about financial considerations*

There are many practices which vary depending on the farmer's experience, farm location, annual conditions and these are not catered for in this basic accounting exercise because they are highly variable. Most farmers irrigate in the first 2–3 years while their crop is established. They are to rely on natural annual rainfall thereafter and do not continue to irrigate. Weeding frequency is likely to decline as plants mature and outcompete low-growing weeds (particularly for large-sized *C. longifolia*). Some farmers add fertilisers in various forms (dry or via drip irrigation). Depending on seedling mortality, seedlings may be replaced to keep the density high. Replanting age estimate is known for *C. subternata* and *C. longifolia*, but *C. genistoides* and *C. intermedia* may be viable beyond age 15 and age 22, respectively. In economic terms, annual inflation, risk and opportunity cost are not built into the calculations. Capital investment in land and farm equipment is not factored in as all enterprises are assumed to have the necessary machinery/equipment (already established farms). Transport of the harvested crop to the processor is not factored in as a cost as it varies across enterprises and across time and is not specific to species and enterprise model. Rather, transport cost relates to agreements with the processor (which may be on-farm), availability and size of transport vehicle and volume of material harvested, all of which are highly variable.

## 5.3) Challenges within the cultivated industry: a lens into exiting and community enterprises

The honeybush tea industry is involved in a range of community-based projects to promote social, economic, and environmental benefits to the local community. These initiatives, supported by government bodies (i.e., the Western Cape Agricultural Research Council) and industry stakeholders, often focus on promoting sustainability, uplifting rural communities, and preserving biodiversity. This research investigated a community nursery in Thornham to identify challenges in those setups. Two major challenges included *management* and *marketing issues*. Regarding management issues, there has been hostility within community projects where multiple parties are collectively involved in management. Such problems have been noted in communities investigated by Lasker & Weiss (2003). Additionally, tension and distrust increased in the community after illegal harvesting occurred in the surrounding natural areas around the community nursery. Tension within community projects is anti-productive to the cause as communication and engagement are key to sustainable and successful projects (Ohmer et al., 2022). Although there was available land with cultivation potential, issues were raised regarding what the land should be used for (and ultimately, this caused a standstill for the community). The political sphere within communities often leads to unsettling social environments (Lasker & Weiss, 2003).

Due to the *lack of municipal services in the community* (i.e., water), they rely on water pumped from a dam. However, the pump (which ran on ESKOM) could not pump water for a month because community members could not pay for it. This impacted the nursery (located in a dry, hot region) negatively. One of the participants who exited the industry also financially struggled due to the lack of water infrastructure and resources (with many of their *C. subternata* dying off). Due to being small-scale, their available capital was not substantial for them to remain economically viable. Exiting and community enterprises have also faced challenges in marketing and suggested that it needs to be improved. Entering the markets has been a difficult feat for the community nursery. They successfully produced good-quality seedlings; however, they lacked interested buyers and therefore had to start planting their seedlings in their fields. It was emphasised that there needs to be an improvement in the awareness of honeybush and the industry itself (this challenge was expressed by participants that exited the industry). One of the participants recommended getting the youth in the community involved (further encouraged by Ohmer et al. (2022)). They mentioned that not many people in the country know about honeybush, so information and samples need to be presented to the public. This could help with the industry's success and sustainability.

## 5.4) Cultivated industry sustainability framework

The final component of this research was to develop a sustainability framework for the cultivated honeybush industry using lessons learned from successful enterprises that used different cultivation models (identified in Table 1). The sustainability framework, which provides an overview of the cultivated honeybush tea industry focusing on the successes and challenges of enterprises, is presented in Figure 61. The focus revolved around these enterprises' environmental, economic and social aspects. Relevant aspects from the environment-agriculture-trade framework by Ortiz et al. (2021) were incorporated to strengthen the framework from the perspective of the cultivated honeybush tea industry. The cultivated honeybush tea industry consists of a supply chain from cultivated honeybush resources harvested by enterprise staff and delivered to processors. They all depend on the landowners, farmers, and land uses, including private land and community enterprises. Achieving a consistent, quality supply of cultivated honeybush tea (while simultaneously preserving the wild resources) could be achieved by harmonising social, economic, and environmental aspects within a formal sustainability framework.

Key factors that were identified that achieved *environmental sustainability* were; (i) being situated in an ideal location (within the natural distribution of the honeybush resource), (ii) favourable climatic conditions (ideally one that is rain-fed to reduce irrigation costs), (iii) having diverse plant species (within and around the cultivated lands), (iii) selecting the right species for the area (which is also marketable) and (iv) controlling for IAPs. Key factors identified that achieved *economic sustainability* were; (i) the scale of the enterprise, (ii) sufficient financial capital to run enterprise operations, (iii) sufficient natural capital (such as favourable rainfall and soil within the area) to reduce costs of inputs (such as irrigation or organic fertilizers) that would be required had there not been any natural capital, (iv) having a mixed-farming approach that incorporates diversified honeybush species (i.e., having a resprouter and reseeder set-up on rotation as opposed to just one species) or diverse agricultural activities (i.e., beekeeping, orchards, vegetable gardens and livestock farming) to support the enterprise, (iv) controlling as much as the value chain as possible (i.e., being a nursery, producer, processor and packager to maximise on associated profits) and (v) certification which allows consumers to trust that the product is sustainably sourced. Key factors that achieved *social sustainability* were; (i) having well-trained staff to oversee enterprise operations, (ii) encouraging skills development within the staff (i.e., through training and opportunities to better their livelihood such as learning to drive), (iii) providing fair wages to the staff, (iv) ensuring that the staff understand their working conditions and also that they are fair and safe.

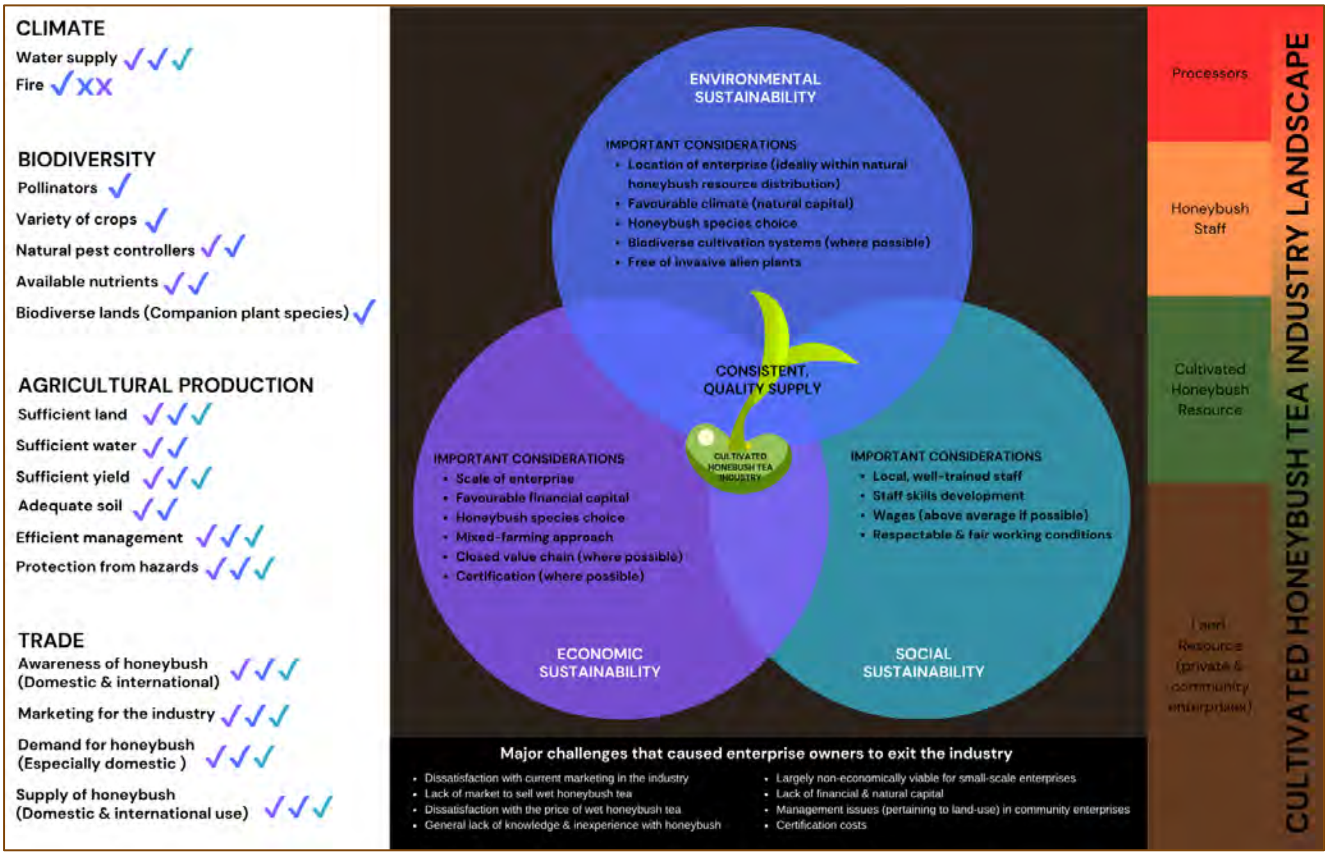


**Figure 61:** Cultivated honeybush tea industry sustainability framework with input incorporated with the environment-agriculture-trade framework on the left column (Ortiz et al., 2021). The framework presents the aspects of environmental, economic and social sustainability that could be considered in the cultivated honeybush tea landscape (cultivated honeybush resources, staff, and processors).

The relationship between social and economic well-being, sustainable resource use, and environmental conservation must be maintained for the long-term viability of the cultivated honeybush tea industry. However, it was found that many enterprise owners exited the industry (due to various challenges). Therefore, it was worth noting the challenges involved in the cultivation industry. Some of these challenges included; (i) disaffection with the pricing of wet material (which especially made small-scale enterprises non-economically viable), (ii) dissatisfaction with the marking within the industry (especially domestically), (iii) lack of financial and natural capital which also made the enterprises non-economically viable), (iv) lack of certification (which was too costly for small-scale enterprises (and the resultant reduced prices for raw materials they produced), (v) knowledge gaps were prevalent with regards to species selection and care (many enterprises had to rely on trial-and-error practices as well as generalised information from professionals in some cases), (vi) inexperience with the species and (vii) scale (the high financial costs and limited output made enterprises non-economically viable). In most cases, the enterprise owners who left the industry were able to successfully cultivate honeybush tea but were frustrated with the lack of markets to sell the product to (forcing them to leave the industry or adapt).

It is also worth noting outside factors that influence the sustainability of the cultivated industry, such as climate, biodiversity, agriculture and trade (left column). These factors, which are specific to the honeybush tea industry, are ticked/crossed out in relation to the sustainability pillars (blue and purple circles). ‘Climate’ and ‘biodiversity’ do not meet all the criteria of the pillars of sustainability, whereas the other factors fully align with the aspects. Climate plays a crucial role in supplying water to agricultural lands in which a consistent supply of water (especially at the forefront of drought) would be favourable to environmental and economic sustainability (and thus social sustainability). It is important to consider the aspects. The prevalence of fires (synonymous with climate change and natural in the fynbos biome) could be hazardous to enterprises with reseeders, whereas enterprises with resprouters would not lose their crop (i.e., they would resprout from their lignotubers) (Joubert et al., 2011). Cultivated lands could be improved with sufficient biodiversity in and around the cultivated lands. For instance, the presence of pollinators (responsible for plant reproduction), natural pest controllers (which reduce the reliance on pesticides), having other fynbos species present in cultivated lands and nutrient availability (enhancing ecosystem health) could mainly improve environmental sustainability. Agricultural production largely contributes to environmental, economic and social sustainability. This factor includes having sufficient land (to plant honeybush), sufficient water (to water the plants when necessary; especially if enterprises are located in dry areas), sufficient yields to sustain the enterprise (thus having a mixed-farming approach would be ideal), having adequate soil to sustain the honeybush, efficient management to ensure that the enterprise is successful and protection from hazards (i.e., fire breaks if enterprises have reseeders). Overall, trade influences the industry whereby awareness of honeybush is required, demand needs to be ensured, and then supply needs to support the demand. The industry largely exports dry honeybush tea to international markets, leaving a large gap for domestic markets (which could help support enterprises). Therefore, awareness needs to be raised about the product within South Africa (in which the species is endemic).

To improve the cultivated industry, stakeholders across the cultivated honeybush landscape need to address the challenges that exist in the industry. Support for subsidising financial costs (such as certification, land and water infrastructure) should come from relevant actors such as the government and policymakers (especially to promote the unique, indigenous tea for the betterment of the local and regional economy). Biodiversity-friendly farming approaches and climate-adaptation measures need to be encouraged to improve enterprise resilience. More importantly, marketing of the existence and importance of the product needs to be improved.

## 5.5) Limitations

*Sampling:* This research used purposive sampling (where enterprises were known, and participants were willing). Additionally, only enterprises in the Western Cape were used. Two well-known, periodically successful community enterprises (Ericaville and Genadendal) were not investigated due to the research's confined temporal scope. Future research could investigate the sustainability of (i) cultivated enterprises in the Eastern Cape as well as more community enterprises (and their experiences).

*Mapping:* The updating of the cultivated inventory relied on voluntary, expert knowledge of the status of the enterprises. However, not all the information on the enterprises could be provided due to a lack of information or knowledge (12 with an unknown status).

*UEBT sustainability framework:* The UEBT sustainability framework was criticised as being too European-biased and did not consider certain, local contexts that not only applied to a South African context, but a southern hemisphere context. Future research could see that local sustainable frameworks are developed to account for the South African landscape.

*Incomplete yield figures:* The yield measurements could not be taken at Enterprise 3 (because the owner was not harvesting during data collection and thus honeybush plants could not be measured ideally during harvesting). Additionally, yield measurements for one age could only be taken at Enterprise 5 (because the owners were not harvesting at the time of data collection). Future research could investigate the yield for the species at different along the natural honeybush distribution. Additionally, the yield at more ages could be captured for more accurate allometric models to be generated.

*Biodiversity survey:* A rapid plant biodiversity survey was employed due to a general lack of botanical knowledge. In future, having a botanist present could improve biodiversity methods and plant identification.

## 5.6) Conclusion

Honeybush tea is a versatile and unique natural resource, endemic to South Africa, representing a small but growing industry with significant potential. As the second most consumed beverage globally, the tea market offers a valuable opportunity for honeybush tea to thrive. The genus is ideal due to its vast geographical range across the Western and Eastern Cape Provinces. Additionally, the species has a fire-survival strategy which is either a: *resprouters* (which can be cropped at low- or moderate-densities, are long-lived (persist up to 17–20 years with cropping every 2 to 3 years) and do not require irrigation) or *reseeders* (which have conventional, intensive cultivation practices, may need irrigation (if the area is not rainfed) and can be cropped yearly). It is also worth noting that the break-even point for resprouters was calculated to be 9–10 years for *C. intermedia* and 9 years for *C. genistoides.* The break-even point for reseeders was 5–6 years for *C. subternata* and *C. longifolia.* The geographic location and available capital at an enterprise is therefore worth considering to ensure its long-term sustainability.

The genus, which serves as a BioTrade resource (i.e., sustainably harvested in and amongst biodiversity; especially in the case of resprouters), is also ideal due to its nutraceutical benefits, which align with growing, global health-conscious lifestyles. However, more markets are needed (especially in a local context) to increase demand for the product. The industry has already contributed to the local livelihoods of farmers, harvesters and processors (especially in municipalities that have high employment rates). In addition to alleviating poverty in local contexts, the industry has also contributed to the skills development of staff who are employed at the various enterprise operations (at nurseries, seed sourcing and production, harvesting, processing and packaging).

For the first time in the industry's history, the annual harvest from cultivated stands surpassed the wild-harvested populations in 2022–2023. This was pivotal for the industry, which previously saw the decline of two fundamental wild honeybush species due to factors such as unlawful harvesting, fires, overharvesting, and IAP encroachment. This growth in the cultivated honeybush industry can further alleviate pressure on the wild-harvested populations while continuing to ensure a consistent supply of high-quality cultivated honeybush products. To achieve this, enterprises involved in the cultivated industry need to understand the diverse environmental and socioeconomic characteristics that influence the cultivated honeybush tea industry. The environmental aspects (i.e., elevation, geology, soil composition, vegetation type, and rainfall) need to be considered before species are selected for cultivation. For instance, species grown in areas where they naturally occur (respecting and not contaminating existing wild varieties in the area), may require little to no financial and natural capital to establish and maintain. Honeybush species planted out of their distribution could still grow (if enterprise owners have the necessary patience and capital to simulate natural conditions for the fields).

Private and community stakeholders involved in the cultivated industry (many who started with limited knowledge of the industry) continue to persist and evolve with the industry. Successful enterprises often employ a mixed-farming approach (i.e., cultivating more than one honeybush species within their enterprise). Other mixed-farming approaches involved honeybush enterprise owners also being involved in additional agricultural activities (i.e., orchards, vegetables, livestock farming and beekeeping). However, the honeybush industry faces several challenges; IAPs (which degrade soil, take up large areas and are costly to remove), general lack of knowledge, high crop mortality rate and inexperience with species, dissatisfaction with the price of wet honeybush tea (it is not economically viable for small-scale enterprises), lack of marketing in the industry, lack of capital (i.e., infrastructure, land and water) and preference for other agricultural activities which are more economically viable than honeybush. It is also worth investigating new markets, especially domestically.

**CHAPTER 6**

## 6) References

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## APPENDIX

### Appendix A: International Legislative Context of BMP

**Table 30**: International treaty or convention to which South Africa is a Party (Balayer, 2021).

| International treaty or convention | Description |
|---|---|
| **The Convention on Biological Diversity (CBD)** | • The CBD has three main objectives: (i) conservation of biodiversity; (ii) sustainable use of its components; (iii) fair and equitable sharing of its benefits arising from the utilisation of genetic resources<br>• As a signatory to the convention, South Africa needs to meet its commitments |
| **Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation to the Convention on Biological Diversity (ABS)** | • This protocol was ratified by South Africa in 2013<br>• It is a supplementary agreement to the CBD and provides the legal framework for the effective implementation of the CBD's third objective: fair and equitable sharing of its benefits arising from the utilisation of genetic resources |
| **Aichi Biodiversity Targets and biodiversity mainstreaming** | • In 2010, the CBD adopted the Strategic Plan for Biodiversity (2011 – 2020) in Nagoya, Japan.<br>• It set out 20 Aichi Targets to achieve global biodiversity<br>• Target 12 is relevant to the BMP: "By 2020, the extinction of known threatened species has been prevented for their conservation status, particularly those most in decline, has neem improved and sustained" (Balayer, 2021: 3) |
| **Convention on International Trade in Endangered Species of Fauna and Flora (CITIES)** | • Neither species of importance are included in CITES despite being an internationally traded species |

## Appendix B: National Legislative Context of BMP

| National legislation/ policy | Description |
|---|---|
| **The Constitution of the Republic of South Africa of 1996** | • This is the supreme, founding law of post-Apartheid South Africa<br>• Section 24 of the Constitution states that "everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent ecological degradation and secure ecologically sustainable use of natural resources while promoting justifiable economic and social development" (Balayer, 2021: 4).<br>• Section 33 of the Constitution states that "everyone has the right to administrative action that is lawful, reasonable and procedurally fair and, in the event that such rights have been adversely affected by administrative action, the right to be provided with written reasons" (Balayer, 2021: 4). |
| **The National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA)** | • This Act provides the conservation and management of biodiversity in South Africa (including indigenous biological resources in a sustainable manner as well as the sharing of their benefits among relevant stakeholders)<br>• Section 57 of NEMBA outlines a list of species that need protection or are threatened (in a TOPS list) which is relevant to harvesting of wild *C. intermedia* and *C. subternata*<br>• Section 43 of NEMBA allows for the above species to be placed in the BMP |
| **Threatened or Protected Species (TOPS) Regulations – 2007** | • The latest draft TOPS list includes *C. intermedia* and *C. subternata* as species that require protecting<br>• Provincial permits are needed for activities relating to the cultivation, wild harvesting, and processing of *Cyclopia species*. However, this is online in Eastern Cape. *Cyclopia species* in the Western Cape do not have a protected status<br>• A standardised permitting system is needed for both provinces |
| **Bioprospecting Access and Benefit Sharing (BABS) Regulation of 2008 as amended in 2015.** | • This is outlined in Chapter 6 of NEMBA (2004)<br>• The purpose of this legislation is to "(i) prescribe the notification process for the discovery phase of bioprospecting involving any indigenous genetic and biological resources contemplated in section 81A (2) of the Act; (ii) prescribe the permit system set out in Chapter 7 of the Act insofar as that system applies to bioprospecting involving any indigenous genetic and biological resources or export from the Republic of any indigenous genetic and biological resources for the purpose of bioprospecting or any other kind of research; (iii) set out the form and content of, and requirements and criteria for benefit-sharing and material transfer agreements; and d) set out the administration process of the Bioprospecting Trust Fund." (Balayer, 2021: 5). |
| **Protection, Promotion, Development and Management of Indigenous Knowledge Systems Act 6 of 2019** | • The aim is to "to prevent the unauthorised use and misappropriation of knowledge developed over time by the country's indigenous communities. It promotes use of the knowledge in the development of novel, socially and economically applicable products and services… but only with appropriate involvement and compensation for the indigenous knowledge holders" (Balayer, 2021: 5).<br>• This act aligns with Aichi Targets 16 and 18 which deal with objective three of the CBD. |
| **Provincial ordinances that regulate *C. subternata* and *C. intermedia* harvesting in the wild** | • Wild harvesting of *C. subternata* and *C. intermedia* is controlled by the respective provincial biodiversity conservation authorities in the Eastern Cape and Western Cape provinces<br>• Only the Eastern Cape provides permits to growers<br>• After the TOPS regulations are published, both provinces will have the same legislation |

## Appendix C: UEBT Checklist adapted from the (The Union for Ethical Biotrade, n.d.)

| UEBT FULL FIELD CHECKLIST: Small-scale farmer/producer<br>Updated January 2022<br>(for the UEBT standard version July 2020) | |
|---|---|
| **No.** | **Question** |
| **PRINCIPLE 1: Conservation of Biodiversity** | |
| 1 | What are the threats to biodiversity in the cultivation or collection areas? |
| 2 | What type of risk assessment tools do you use, if you use any? |
| 3 | Do you have easy access to sources of information to assist you? |
| 4 | What actions are implemented to maintain, regenerate, or enhance biodiversity in cultivation areas? |
| 5 | How is the status of the biodiversity monitored and assessed? Frequency? Who does it? |
| 6 | Are there any current remedial processes to restore unintended/adverse consequences on biodiversity? |
| **PRINCIPLE 2: Sustainable use of biodiversity** | |
| 7 | Are invasive species introduced as a result of cultivation collection? What types of preventatives and/or mitigating measures are in place? |
| 8 | How are suitable varieties to plant decided upon (species inventories, scientific studies or local knowledge)? |
| 9 | Are there guidelines available on the purchasing of seed and planting material from reputable and/or certified organisations? |
| 10 | What actions are taken to ensure that the seeds, seedlings, and new plants are free from pests, fungal infections and seeds from toxic weeds? |
| 11 | How do you ensure a well-established cropping system? |
| 12 | Do the farmers, workers and other relevant actors have the skills to implement cultivation practices and address unintended negative effects? |
| 13 | Have you adapted cultivation collection practices to climate influences (e.g., drought, fires)? |
| 14 | How do you gather information on the level and quality of ground and surface water in cultivation collection sites? |
| 15 | How do you adapt, assess and train practices in cultivation collection to conserve and enhance the quality of surface and ground water? |
| 16 | How do you gather information on the soil structure, fertility and nutrient contents, stability, moisture and drainage conditions? |
| 17 | How do you adapt, assess and train practices to conserve water and soil? |
| 18 | Do you use agrochemicals, if so, which ones? |
| 19 | Do you use integrated pest management practices in cultivation sites? |
| 20 | Do you have practices in place to reduce the use of herbicides and/or synthetic fertilisers? |
| 21 | How is the storage, cleaning and disposal of agrochemicals done? |
| 22 | What type of measures are in place to optimise energy use, improve waste management and reduce contamination from energy use and waste in cultivation collection sites? |
| **PRINCIPLE 3: Fair and equitable sharing of benefits derived from the use of biodiversity** | |
| 23 | Are producers and their communities in cultivation areas are periodically consulted on local development needs and goals? |
| 24 | Is priority given to workers from communities in cultivation areas? |
| 25 | Are there projects in place to support local livelihoods and capacities or advance other local development goals? |
| **PRINCIPLE 4: Socio-economic sustainability (productive, financial and market management)** | |
| 26 | Do you have Procedures and practices are in place to meet the quality requirements? |
| 27 | How are quality deviations and continuous improvement processes addressed? |
| 28 | How is quality ensured during harvesting and post-harvest? |
| **PRINCIPLE 6: Respect for rights of actors involved in BioTrade activities** | |
| 29 | Are the wages of workers paid at least in line with official minimum wage regulations, collective bargaining agreements, or other applicable official wage regulations? |
| 30 | Are workers informed in writing, local language and understandable manner of the job conditions related to their work, including their job position, working hours, level of wages, payment of wages, legal rights and duties, sick leave, and permitted vacations? |
| 31 | Are workers doing seasonal work for small-scale producers/farmers, smallholders employing seasonal workers, verbally informed about the employment conditions? |
| 32 | Are there specific channels in place for hearing concerns, complaints, and grievances from workers? |
| 33 | What type of measures are in place (or a policy) regarding health and safety culture (working with machinery, equipment and other processes) |
| 34 | Is training provided to relevant workers on health and safety risks? |
| 35 | Is first aid equipment available, and safety instructions and procedures for accident prevention? |

| | |
|---|---|
| 36 | Are workers trained in using fire protection and emergency equipment and procedures? |
| 37 | Are empty agrochemical containers triple-rinsed and punctured after use? |
| 38 | Have any cultural, environmental and social concerns and interests of indigenous people in local communities been identified? |
| 39 | Are any traditional practices and uses of biodiversity in cultivation implemented |

**Table 31:** Principles implemented by the UEBT standard in cultivation and wild collection sites (Stamboulakis and Sanderson, 2020; UEBT, 2020).

| Principles | | Explanation |
|---|---|---|
| 1 | Conservation of biodiversity | "This principle sets out a framework for practices to maintain, regenerate, and enhance biodiversity. The specific practices to be adopted depend on the context. Principle 1 requires assessing the local situation and aligning practices with local strategies." (UEBT, 2020: 12). |
| 2 | Sustainable use of biodiversity | "This principle fosters cultivation and wild collection practices that advance sustainable use of biodiversity. It encourages cultivation and wild collection practices that promote natural and regenerative processes. This may include organic farming practices, which are promoted but not required. Principle 2 practices concern key components of biodiversity such as species diversity and genetic diversity. These practices also extend to soil, water and air in cultivation and wild collection sites. When practices differ for cultivation or wild collection this is specifically mentioned." (UEBT, 2020: 14). |
| 3 | Fair and equitable sharing of benefits derived from the use of biodiversity | "This principle advances long-term relationships and payment of fair prices to producers – that is, the local pickers or farmers collecting or cultivating plants used for natural raw materials. It seeks to ensure such activities contribute to local development needs in the cultivation and collection areas. Moreover, it promotes compliance with legal requirements and good practices on access and benefit sharing (ABS)." (UEBT, 2020: 20). |
| 4 | Socio-economic sustainability (productive, financial and market management) | "This principle promotes the integration of relevant requirements in the Ethical BioTrade Standard in operations and management systems, including quality and traceability systems. The integration of requirements in criteria 4.1 and 4.2 takes place at the level of UEBT member organisations. Criteria 4.3. and 4.4. also apply at the cultivation and wild collection level (i.e. processing companies)." (UEBT, 2020: 22). |
| 5 | Compliance with national and international legislation | "This principle promotes and facilitates compliance with principles, laws and regulations relevant to the cultivation, collection, supply, research, processing or commercialisation of natural raw materials. It identifies certain national laws and regulations, as well as international agreements, with particular relevance to Ethical BioTrade practices." (UEBT, 2020: 24). |
| 6 | Respect for the rights of actors involved in BioTrade activities | "This principle promotes respect of human and workers' rights and decent labour conditions along the supply chain, taking into account relevant conventions of the International Labour Organisation (ILO) and national regulatory frameworks. It focuses on respect for rights at the level of UEBT member companies, as well as in cultivation and wild collection activities (i.e. producers and local processing companies)." (UEBT, 2020: 25). |
| 7 | Clarity about land tenure, right of use and access to natural resources | "This principle defines practices that respect rights over land and natural resources, particularly the relevant rights of Indigenous peoples and local communities in cultivation and collection areas." (UEBT, 2020: 39). |

**Appendix D: Interviews for the exiting and community enterprises**

| No. | Question |
|---|---|
| 1 | How big is your farm? |
| 2 | How did you find out about the honeybush tea industry? |
| 3 | When did you start cultivating honeybush? |
| 4 | How long have you been cultivating honeybush? |
| 5 | How many ha of honeybush did you have? |
| 6 | What species of honeybush do you farm? |
| 7 | What made you choose that species in particular? |
| 8 | Was honeybush the main crop generating income?<br>If not, what other produce do you have? |
| 9 | What kind of cropping system did you use (from (a) sourcing seeds or seedlings, (b) planting them, (c) maintaining them? |
| 10 | What are the difficulties you have encountered? |
| 11 | Did you get any internal and external aid for your crops? |
| 12 | Why did you decide to leave the industry? |
| 13 | Where do you think the cultivated industry is going? |

## Appendix E: Physical Characteristics of each site

**Table 32**: International treaty or convention to which South Africa is a Party (Balayer, 2021).

**Transect GPS Codes** **Size:** ______________

| | |
|---|---|
| Corner 1 | |
| Corner 2 | |
| Corner 3 | |
| Corner 4 | |

**Site Description**

| | | |
|---|---|---|
| **Date** | | |
| **Site No.** | | |
| **Site Age** | | |
| **Site Name** | | |
| **Site Species** | | |
| **Time** | | |
| **Slope** | | |
| **Aspect** | | |
| **Elevation** | | |
| **Weather** | | |
| **Surrounding Vegetation** | **Height** | |
| | **Density** | |
| | **Diversity** | |
| | **Ground** | |
| | **Other** | |
| **Other** | | |

## Appendix F: Ethics approval form

**Rhodes University Human Research Ethics Committee**
PO Box 94, Makhanda, 6140, South Africa
t: +27 (0) 46 603 7727
f: +27 (0) 46 603 8822
e: ethics-committee@ru.ac.za
**NHREC Registration number: RC-241114-045**

**https://www.ru.ac.za/researchgateway/ethics/**

7 November 2022

Miss Tafadzwa MAKHUZA

Email: g18m5182@campus.ru.ac.za tafadzwamakhuza@gmail.com

Review Reference: 2022-5734-7238

Dear Miss Tafadzwa MAKHUZA

**Title:** Aspects of the sustainability of the cultivated honeybush tea industry, South Africa

Researcher: Miss Tafadzwa MAKHUZA

Supervisor: Ms Gillian McGregor

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Human Research Ethics Committee (RU-HREC). Your Approval number is: 2022-5734-7238

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying you when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated.

Sincerely,

Janet Hayward

**Dr Janet Hayward**

**Chair: Rhodes University Human Research Ethics Committee, RU-HREC**

cc: Ethics Coordinator

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