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The Alternate Hemp Industry

The viability of hemp agriculture to develop energy efficient materials whilst addressing agro-rural socio-economic opportunities in the Eastern Cape

Phivo Luke Artemides



A research report submitted to the Faculty of Engineering and the Built Environment, School of Architecture and Planning, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of a Master of Urban Studies in Sustainable Energy Efficient Cities



i. Declaration

I declare that this research report was unaided and completed by myself which has been completed after the registration for the degree of a Master of Urban Studies (Sustainable energy efficient cities) at the University of Witwatersrand, Johannesburg, South Africa. This work has not been previously included in any other prior research report submitted to this or any other university, institution or to aid in any degree or qualification.

Phivo Luke Artemides

.....

Signature of Candidate

01 October 2021

ii. Abstract

The recent fascination with industrial hemp *(Cannabis Sativa L.)* is due to the effects of climate change and the need to redefine industries to manufacture sustainable and environmentally friendly products. The research investigates the enquiry into hemp as an industrial crop for the processing into energy efficient products. It further examines the notion of hemp's applicable anatomical structures being processed into four different products, hemp hurd and fibre as a building material, hemp fibres for bioplastic, hemp biomass and seeds for biofuel and hemp fibres for textiles.

A provincial analysis of the Eastern Cape revealed the socio-economic opportunities, agricultural potential and biophysical climatic conditions pertaining to the successful cultivation of hemp. The findings from the literature review detail the appropriateness of hemp in the South African agricultural and industrial sector. The results of the energy efficient applications section critically examines the versatility and performance of hempcrete, biocomposites, biofuel and textiles in a sustainability paradigm. The findings from the semi-structured, open-ended interviews through online meeting software platforms advances the understanding of the viability of industrial hemp agriculture.

The research finds that the hemp industry could play an important role to develop energy efficient products whilst addressing agro-rural socio-economic opportunities in the Eastern Cape.

iii. Dedication

In memory of my most beloved late mother, Christine Artemides, you gave me life and I will live it to the fullest.

Your son, Phivo.

iv. Acknowledgements

I would like to thank my father for all his endearing love and dedication to enabling my life with the most bountiful opportunities. He has helped me foster a greater mind through his commitment to ensuring I am able to follow my passions and educate myself. To my ever-loving sister, she has supported me every step along the way with the most thoughtful of touches and gifts. To my brother whom represents the courage and strength of my mother, his continual guidance and presence in my heart has aided me to become the person I am today.

To my dear friend, Jason Macfee, who has been by my side throughout this experience of writing up my research report. He has showed me to trust myself and believe in my own actions and their impact. Thank you to him for his support and friendship throughout this life-changing learning experience.

To my friend, Charl Van Schoor, thank you for being with me in times of stress and for expressing your patience and compassion to help me fulfil my passion for hemp agriculture and the development of energy efficient products.

To my supervisor, Dr. Brian Boshoff, thank you for supporting my topic choice and guiding me through the forest of information into the clearing.

Lastly, to the omnipresent guidance I receive from God and the Universe every day, I am eternally grateful for every message and path I see.

A quote from Marcus Aurelias is one that has resonated with me throughout the writing of this research report:

"Accept whatever comes to you woven in the pattern of your destiny, for what could more aptly fit your needs? Look well into thyself; there is a source of strength which will always spring up if thou wilt always look"

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vii. List of definitions

- Agro-ecological: The communities living within an agriculturally active region which solely rely upon employment opportunities from agriculture and its ancillary uses.
- Anemophilous: Wind-pollinated.
- Cannabinoids: These are phytocannabinoids indigenous to hemp and marijuana with scientific enquiries proving the medical applicability of specific cannabinoid treatment to combat various diseases and syndromes.
- *Cannabis:* This terms will be used to describe both marijuana (recreational) and hemp (industrial). The taxonomic classification of the genus *Cannabis Sativa L.* will be used to describe cannabis sativa strains primarily for industrial uses. The etymology of the Latin name *Cannabis* is derived from the Greek word 'Kannabis' and the Latin translation for the word 'sativa' means cultivated whereas Cannabis Indica means 'Cannabis from India'.
- Dioecious: In this context, it is a plant species containing separate male and female reproductive organs in individual plants
- Genotype: The genetic code which gives expression for the phenotypic structure (some phenotypical structures can be influenced by environmental circumstances).
- Hemp: Refers to the non-psychoactive plant within the Cannabaceae family. Industrial hemp contains less than 0.3% Tetrahydrocannabinol (THC) (this amount varies depending on ruling legislation in the country) and is cultivated for its high fibre content, building potential, nutritional value, medicinal value, energy potential, agro-ecological significance and climate combating effects.
- Hemp retting: the use of moisture to generate a microbial interaction to separate the bast fibre from the inner woody core of hemp for different industrial applications.
- Marijuana: a psychoactive inducing plant with a higher proportion of THC used for recreational purposes whilst contributing towards medicinal research.
- Phenotype: In relation to hemp, it defines the observable traits of the morphological structure in terms of colour, height, flower size and leaf sizes
- Phyto/bioremediation: the planting of specific flora in an environment to accumulate pollutants, heavy metals, contaminates and other toxins via interactions and uptake of water from the soil.
- Terpene: Terpenophenolic compounds which are categorically identified for their aromatic fragrance yet have substantial medical and agro-ecological interest.

viii. Abbreviations/Acronyms

- BCE: Before Common Era
- CBD: Cannabidiol
- DALRDD: Department of Agriculture, Land Reform and Rural Development
- DEA: Department of Environmental Affairs
- ECRDA: Eastern Cape Rural Development Agency
- ECHPPI: Eastern Cape Hemp Pilot Project Initiative ()
- NDP: National Development Plan
- SDG Sustainable Development Goal
- THC: Tetrahydrocannabidiol

1. *Cannabis* in context

The increase in global climatic temperatures is mostly caused by anthropogenic induced climate warming (DEA, 2017.) This is due to the increasing rate of greenhouse gas emissions, an intensive use of resources and as a result, large scale biodiversity loss (DEA, 2016). In order to combat these negative effects, innovative systems of industrial production must adopt environmentally friendly and resilient processes. The commercial cultivation of industrial hemp (*Cannabis Sativa* L.) is proving to be a versatile and multi-beneficial product for the energy, construction, bioplastic, textile and other industries (Karche and Singh, 2019).

Hemp is a multi-purpose crop which is easy to grow, has a high seed yield, mechanically strong fibre properties and medicinal value.

The cultivation of industrial hemp and the production of hemp-based products may provide an ecologically sustainable and economically viable opportunity for agro-rural economies in the Eastern Cape. The need to integrate sustainable farming methods, such as agroforestry, permaculture, regenerative and restorative agriculture, in dormant farms and unproductive land will bolster the green economy[2] and increase the value-added supply chain of the proposed hemp industry. Hemp-based biocomposites can provide climate-friendly alternatives for energy intensive products. By facilitating growth strategies for small-holder farms, the *cannabis* plant and its multiple benefits can be a keystone project for South Africa's third decade of the twentieth century. The research hopes to uncover this paradigm of the hemp industry. The focus of the study is to ascertain whether hemp farming is a sustainable socio-economic asset for rural space economies in the Eastern Cape, whilst discerning whether it is a financially viable biocomposite material for production in South Africa. Furthermore, the research explores the variety of applicable uses, such as hemp as a building material, hemp-based biopolymer structures, hemp as source of bioenergy and hemp textiles that relate to energy efficiency and sustainability within South Africa.

1.1. The *Cannabis* Commodity

The current global socio-political climate surrounding hemp is evolving to utilise the beneficial aspects of *Cannabis* in a commercial paradigm. This perspective allows for the use of hemp in medicine, food, construction, textiles, paper, bioplastics and the energy sector. The cannabis sativa plant has three sub-types: *sativa, indica and ruderlis*

[2] The Green Economy describes resource efficient, less carbon intensive and socially inclusive systems of production and transaction.

(Baldini, Ferfuia, Zuliani and Danuso, 2019). For the consideration of this paper, *cannabis* will refer to *Cannabis Sativa L.* – otherwise known as industrial hemp. Industrial hemp is considered an alternative natural biocomposite commodity due to its environmental benefits, economic potential and energy saving product development potential.

Cannabis Sativa L. comprises of less than 0.3%[3] delta 9-tetrahydrocannabinol (THC) which is the psychoactive ingredient in marijuana global discussions taking place regarding the required amount of THC allowed in hemp (Karche and Singh, 2019). This implies that industrial hemp is a non-psychoactive inducing plant, cultivated for its high fibre content, nutritional value, medicinal value, energy potential, agro-ecological significance and climate combating effects.

The hemp industry in South Africa has the potential to create a localized value-added supply chain (Ingrao, Giudice, Bacenetti, Tricase, Dotelli, Fiala, Siracusa and Mbohwa, 2015). According to Fike (2016), the environmental and socio-economic benefits boost the green economy whilst implementing climate combating techniques in many industries. These avenues are explored and reviewed in the research report.

The recent fascination with *Cannabis* is due to the versatile and dynamic uses it offers. It can be used as medicine, food, paper, textiles, bioplastic, cosmetics, biomass, building materials, animal feedstock and much more (Thayer, Burley and Held, 2017)(Karche and Singh, 2019). South Africa recently promulgated the commercial use of *cannabis* cultivation in February 2020 (GSA, 2020). This will create opportunities for nation-wide commercial-scale farming with a mutual increase in the value-added supply chain and government revenue. The following research paper will attempt to extrapolate a South African perspective on the viability of hemp agriculture as a potential sustainable substitute material for resource intensive industries. Furthermore uncovering an energy perspective on the manufacturing of hemp based products whilst explicating the intersection of the hemp industry with the socio-economic opportunities for agro-rural space economies in the Eastern Cape.

1.2. Problem statement and rationale:

The influence for this study is because of the negative impact of climate change and the correlating effects in rural areas in South Africa. The negative effects associated with climate change, such as drought, food security and health risks, force the human civilisation to adapt and create new systems of production which operate in light of their environmental

[3] At the time of writing, global conversations are changing the amount of THC allowed in hemp plants as 0.3% is seen as an arbitrary value.

and socio-economic impact. Associated climate risks are more harmful to those in vulnerable positions (Gray,Clarke and Trigiano, 2016). Therefore, the purpose of this research paper is to look at the hemp industry holistically in terms of its environmental, industrial and socio-economic sustainability in agro-rural space economies in the Eastern Cape.

The increasing carbon footprint of resource intensive industries can be minimized with eco-friendly competitors, such as hemp-based products. Therefore the purpose of this research paper is to discuss hemp cultivation as a versatile material for construction, biofuel and bioplastic composites whilst acknowledging this untapped resource may prove to be a sustainable economic asset for rural spaces in the Eastern Cape (Novakova, 2018) (Karche and Singh, 2019). The decreasing costs of production and environmental benefits of hemp-based materials provides a new economic and ecological opportunity for South Africa.

1.3. Research aims:

The research will explore the potential impact of hemp cultivation in terms of environmental characteristics, energy use and socio-economic sustainability in the production of alternative biocomposite products in the Eastern Cape.

The objectives are:

- To analyse the hemp industry in South Africa, primarily focusing on the cultivation of industrial hemp, by first understanding the history of hemp domestication. Furthermore, it will frame the government's role in climate change and poverty through an integrated and inter-sectoral hemp industry.
- To discuss the anatomical and biochemical composition of industrial hemp (*Cannabis Sativa L.)* in terms of its environmental significance:
    - Reveal the chemical composition of the plant.
    - Reveal the agro-ecological interactions of hemp farming.
    - Detail what the environmental impact is, of cultivating hemp for industrial purposes.
- Uncover the commercial viability of the alternative hemp industry, the socio-economic potential, the environmental impact in terms of resource consumption and the use of biotechnology in the production stage:
    - The study will uncover the resource (water, land, energy) consumption levels for various products.

- Discuss the potential of various products in the market. This will explain what the economic potential is, of the product, thereby indicating its viability in the South African market.
- Indicate the performance of various products in application.

- Explore the socio-economic opportunities for the alternative hemp industry in the Eastern Cape:
  - The environmental and socio-economic conditions of the various agriculturally viable spaces for hemp cultivation.
  - Identify needs and challenges in agro-rural economies in the Eastern Cape.
  - Describe how localized systems of hemp production facilitates sustainable development in communities.

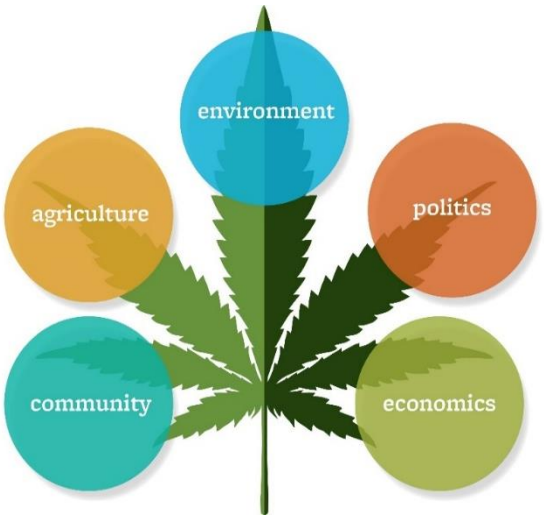


Figure 1: The potential impact of the hemp industry

1.4. Research questions and sub-questions

How can the hemp industry contribute to the sustainable production of viable hemp-based products and contribute towards the socio-economic sustainability of agro-rural space economies in the Eastern Cape?

- What are the factors of hemp cultivation that exhibit resilient and sustainable characteristics?
- What is the economic viability of the alternative hemp industry?
- To what extent can industrial hemp cultivation, production, manufacturing, and distribution contribute towards the socio-economic opportunities in the Eastern Cape?
  - How can the alternative hemp industry foster sustainable socio-economic objectives for agro-rural spaces in the Eastern Cape?
  - What is the government's role in the *Cannabis* Industry?
  - How can the alternative hemp industry align with government objectives towards achieving sustainable development goals?
  - Which alternate applications for hemp would be the most viable in South Africa, and more specifically, the Eastern Cape?
- What are the limitations of hemp cultivation?

1.5. Research Methods

The qualitative study and research methods used will incorporate an exploratory case study of the Eastern Cape conducting a critical literature review academic and grey literature. The academic literature will consist of peer-reviewed scientific journal articles and published books whereas the grey literature will primarily be supportive anecdotal information from relative news platforms and trending information about the industry. The sampling methods used purposive sampling for key members to interview based on expertise, relevance towards answering the answering the research question and exposure in the *cannabis* industry.

The study will use climatic and spatial socio-economic development indicators to assess the challenges of agro-rural communities in the Eastern Cape. For the purposes of this research paper, the following was utilised:

- Data analysis:
  - EasyData by Quantec: acquiring a spatial socio-economic profile of local municipalities in the Eastern Cape.
  - South Africa Risk and Vulnerability Atlas
  - Agricultural Research Council institute for Soil, Climate and Water.
- Qualitative interviews (with preventative measures for COVID-19 regulations):
  - Foresty South Africa, Fields of Green for All, Agr8, Cheeba Africa, Licensed Cannabis Farmer, leading apiarist, African Cannabis Advisory, Eastern Cape Professional Cannabis and Hemp Consortium, Canadian Industrial Hemp Corporation, Cannabis Industry Development Cooperative Western Cape and Crafted Hemp Farms.
  Online semi-structured interviews with selected participants ('Zoom', 'Microsoft teams', phone calls). This method of interviews was used in order not to circumscribe the interviewee.
  - Field research of current hemp-based product development projects in the Eastern Cape.

A study on the current hemp development projects in the Eastern Cape will allow for the research to be set in a geographical location. The ethical considerations ensure that any companies' production methods or production costs will be made anonymous. Furthermore, the information from the conversation is used to address the aim and research questions of the report.

1.6. Limitations of research:

A limitation regarding the data from the Eastern Cape came in the form of conflicting numbers stating that there were more people employed than the population in a specific district. Furthermore, the specific fields of data regarding some local municipalities were non-existent. Therefore, the most relevant demographic data was used in order to address the aims of the research.

The current socio-political and scientific inquiry in *Cannabis Sativa L.* is evolving. It is a relatively new plant under research and development. Therefore the research report used applicable information in the current field of inquiry about hemp. The limitations of the COVID-19 pandemic inhibited field visits within enough time to integrated findings. In order to address these limitations, the research made use of a desktop analysis with interviews aimed to deepen the inquiry into the topic.

1.7. Outline of research report

Chapter One: Explains the research aim and objectives whilst framing the hemp industry and its potential. The chapter further explains the reason for choosing the topic.

Chapter Two: This chapter serves as the literature review starting with understanding hemp from a broad perspective, until narrowed into the focus of the intersection of hemp agriculture with agro-rural socio-economic opportunities in the Eastern Cape. To this extent, the chapter briefly unpacks the history of hemp with Homo sapiens in order to create an awareness of the significance to the reader. The report then uncovers the basic cellular composition of the plant identifying the health benefits and the significance of hemp as a plant for industrial uses. The current global situation of hemp is discussed whilst focusing on the value of implementing hemp as an agricultural commodity in Africa. This aims to explain why hemp is in a pioneering position in terms of economic growth, social equity and sustainability in South Africa and the Eastern Cape.

Chapter Three: A provincial data analysis on the demographic and biophysical indicators of the Eastern Cape. It uncovers the socio-economic structural challenges facing the province whilst explicating a regional agricultural analysis. This chapter helps to orientate the reader about the Eastern Cape and the potential of the hemp industry to impact and address these challenges.

Chapter Four: The analysis of the four hemp-based products chosen for this research report. It helps define the energy efficiency of hemp-based products and the contemporary need for hemp-based products in the green economy.

Chapter Five: The results chapter integrates the researcher's interview data with the literature findings whilst collating and discerning the relevance between the respondent's data and the literature. The chapter addresses the possibilities regarding the viability of hemp to develop energy efficient products whilst addressing agro-rural socio-economic opportunities in the Eastern Cape.

Chapter Six: The concluding chapter provides a summary of the research and postulates avenues for further investigation and recommendations for the Eastern Cape.

2. Literature Review: The Alternate Hemp Industry in South Africa

The following literature review will unpack a brief analysis of the history of hemp cultivation in the Neolithic era. The evidence will encompass the socio-cultural and geo-political significance of this plant. The next section will develop the anatomical and biochemical framework of industrial grade hemp. This section will explicate the medical and industrial importance of breeding and harvesting hemp for multiple purposes. Following this reading, a section on the agro-ecological and environmental perspective will collate the importance of industrial hemp for agricultural ecosystems and crop development. The next section creates the platform as to why industrial hemp is important for Africa and what the positionality of this agro-industrial crop is in terms of its economic, technological, cultural and political perspective. Concluding with the integration of a policy and strategy governmental outlook of the Eastern Cape. This identifies the agricultural potential and provincial perspective of industrial grade hemp in the Eastern Cape.

These sections are circumscribed within a socio-economic and environmental paradigm and therefore do not have an extensive scientific analysis.

2.1. Hemp and Homo sapiens

Cannabis and Homo sapiens share an interwoven story of co-evolution, spanning thousands of years. *Cannabis* first originated in northern temperate climatic zones, occurring out of Eastern Eurasia (Clarke and Merlin, 2016). *Cannabis* from the *Cannabaceae* family is presented by Clarke and Merlin (2016), Liu, Hu, Du, Deng and Yang (2017) and Andre, Hausman and Gurriero (2016) as one of earliest plants to be domesticated by post-glacial-interglacial cycle civilisations[4] in the early Holocene era.

Agricultural domestication was the precursor for the modern day civilisation. The Neolithic age beginning 12 000 years ago was coupled with the rise of animal and plant domestication. The shift from a subsistence based, nomadic lifestyle to surplus community crop and livestock domestication brought forth a new age for Homo sapiens and plant life (Harari, 2014). Domestication practices are characterized by identifying ideal qualitative morphological traits in specific plants and amplifying the production of that particular plant characteristic through artificial human selection (Clarke and Merlin, 2016). The *Cannabis* plant was believed to attract the attention of early human cultivators based on the aromatic flower and multiple uses. The archaeological findings of hemp remnants in past human

[4] Glacial-interglacial cycles occurred in the Northern hemisphere, with the most recent glacial cycle ending 11 500 years ago at the advent of the agricultural revolution.

settlements indicates the use of hemp for applications such as rope, pottery, medicine and other materials (Liu et al. 2017).

Based on multiple sources relating to the chronology of *Cannabis* domestication, Central Asia, South-West Asia and South Asia are the geographic origins of *Cannabis* (Clarke and Merlin, 2016)(Gray et al. 2016)(Andre et al. 2016)(Liu et al. 2017). The use of *Cannabis* has been dated to 10 000 Before Common Era (BCE) with hemp retting[5] imprints on a pottery bowl in modern day Taiwan (Liu et al. 2017). Hemp, as a domesticated agricultural crop, spread 4500 years ago throughout Central Asia and Europe (Demske, Tarasov, Leipe, Kotlia, Joshi and Long, 2016) (Kuddus, Ginawi and Al-Hazimi, 2013).

In a study conducted by Demske et al. (2016), high amounts of *Cannabis* pollen records show evidence of hemp retting in the foothills of the Himalayas in 4600 BCE. The palynology findings revealed extensive hemp retting in Garhwal and Kumaun Himalayas, which are densely forested regions. It is believed that early trade and knowledge movement of *Cannabis* to India was through the Himalayan trade routes (Kuddus et al. 2013) (Gray et al. 2016). Furthermore, Murphy, Ben-Yehuda, Taylor and Southon (2011) analysed evidence of hemp remnants in rope in Israel that was used inRoman and Chalcolithic times. Analogous to this was the use of *Cannabis* in Ancient Egypt as a medicinal substance.



Figure 2: Ancient Egyptian *Cannabis* symbol dated 2000 BCE

Clarke and Merlin (2013) identify three evolutionary landraces of *Cannabis* population types based on taxonomist studies; *Cannabis* which grows in a wild settings, *Cannabis* which is domesticated and *Cannabis* which escaped domestication and occurs in areas occupied or once occupied by humans practicing flora cultivation. Clarke and Merlin (2013) classify *cannabis* into four different physical descriptive groups; Broad leaf hemp (BLH), Narrow leaf hemp (NLH), Broad leaflet drug (BLD) and Narrow leaflet drug (NLD). These have been such classified into a 21st Century *Cannabis* taxonomy of five distinct gene differentials:

1. *Cannabis sativa subspecies sativa (Narrow-leaf hemp)*
2. *Cannabis indica subspecies chinensis (broad-leaf hemp)*
3. *Cannabis indica subspecies indica (narrow-leaf drug)*

[5] Hemp retting is a microbial process using moisture or water to decorticate hemp (remove the fibrous epidermis with the woody, pulp core).

4. *Cannabis indica subspecies afghanica (broad-leaf drug)*
5. *Sinsemilla*[6] *cultivation groups (varied)* (Clarke and Merlin, 2016)

Cannabis genotype expression manifests in its phenotypic characteristics. Specific qualitative morphological traits such as; flower size, stalk height, colour and secondary metabolites were indicators for past civilisations domestication practices. Whereasquantitative traits such as yield size, became more present as domestication grew in its dynamism. Clarke and Merlin (2016) elaborateon the relationship of *cannabis* diversity with movement of agricultural communities throughout history. The relationship comes to fruition when humans settled in 'new land' and brought with them *cannabis* seeds. This bottlenecked diversity for *cannabis* strains within a limited genome diversity.

Historically, *Cannabis sativa* was domesticated for its fibre, food and medicinal properties (Fike, 2016). Whether it was the use of the plant as an entheogen[7] or anxiolytic which led to alternative applications, still remains unclear (Kuddus et al. 2013). It is important to mention that the adaptability of *cannabis* in diverse human settlements in different locations displays the environmentally resilient nature of *Cannabis*. Historically, the evidence of *cannabis* domestication throughout past human civilisations indicates a significant co-relationship of Homo sapiens and the domestication of *Cannabis sativa* strains (Malmo-Levine, 2009).

2.2. Anatomical and biochemical composition of hemp:

Legal hemp cultivation in other countries, such as Canada and France, has allowed for a scientific enquiry into the biochemical composition of industrial hemp. This has created a new understanding as to why industrial hemp is significant for multiple applications. The area of interest for industrial hemp consists of the inner woody core (the hurd), the fibrous epidermis (bast fibre), seeds and the plant as a whole (Prade,

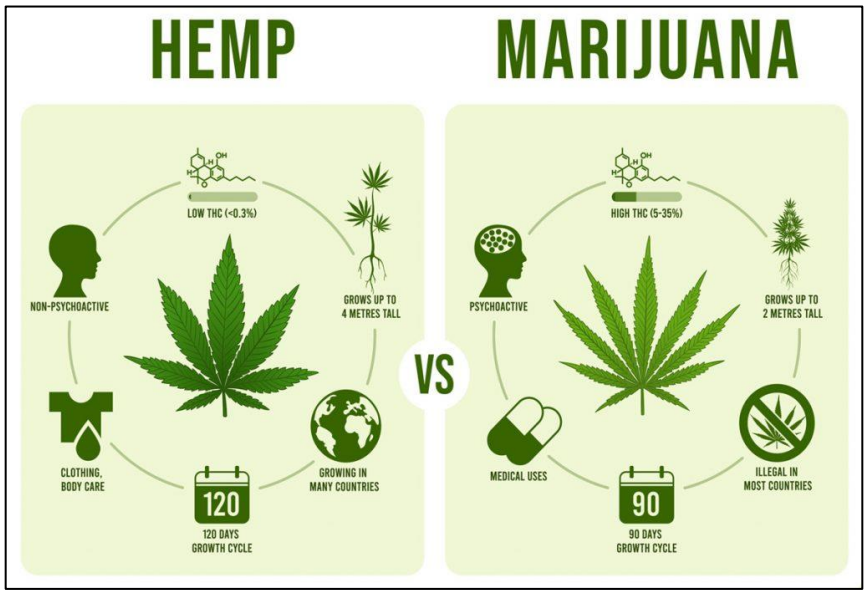


Figure 3: The key differences between Hemp and Marijuana

[6] Domesticated *Cannabis* which has a high concentration of psychoactive agents (Clarke and Merlin, 2016).
[7] It is a stimulant induced experience relating to euphoria or feelings of 'spiritual' attainment.

2011). For the purposes of this research paper, the medicinal and full spectrum biochemical composition will not be examined. The medical and biochemical information surrounding *Cannabis* will pertain to the significant features which are important for the health factors and industrial applications.

Cannabis sativa L. is an annual herbaceous plant belonging the Cannabaceae family (Kuddus et al. 2013). The plant is a dioecious anemophilous (wind-pollinated) herb with aromatic properties (New Frontier Data, 2019). Industrial hemp requires sunlight, moisture and sufficient drainage in soils (Thayer et al. 2017).

Hemp has successfully spread from Central Asia throughout the world. This postulates that hemp has resilient growing properties which allow it to successfully integrate into new climatic zones with different edaphic conditions. Hemp (containing less than 0.3% THC[8]) provides a relatively high biomass quantity in a shorter time period than other lignocellulosic biomass sources. The stem of hemp provides woody and cellulosic fibres, with the cortex comprising of cellulose fibres (bast fibres) and the inner woody core consisting of lignin (pulp/hurd) (Andre et al. 2016).

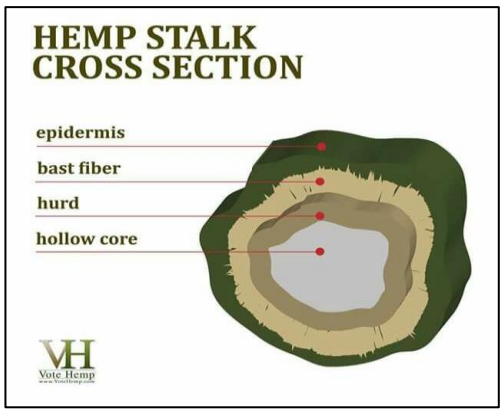


Figure 4: Cross section of hemp stalk showing anatomical composition

In terms of the health attributes of *Cannabis*, one must examine its effect on the human anatomy. The human body has an inherent system called the endocannabinoid system (ECS). The ECS was recently discovered in the 1990's. The ECS was so named after *Cannabis* based on the fact that the body produces endocannabinoids which resemble the molecular structure of phytocannabinoids, found in hemp and marijuana. The ECS is one of the most important endogenous systems which help maintain the physiological and cognitive health of the body. The ECS contains two nerve receptors found all over the body, relating to the CB-1 and CB-2 receptors. The ECS contains inherent arachidonate-based lipids (fats)

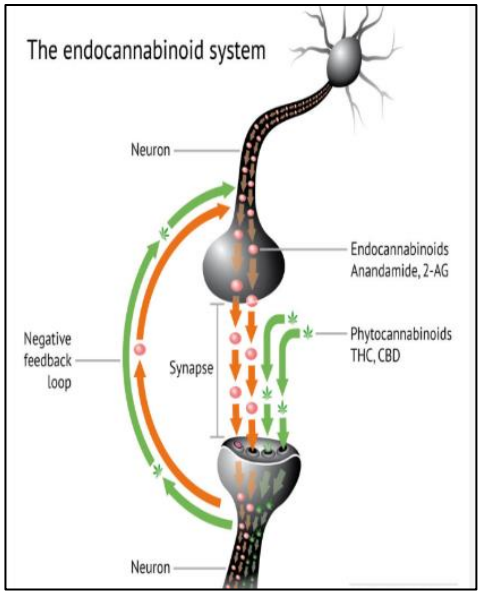


Figure 5: Diagram showing the basic neurochemical transmitters of cannabinoids in a synapse

[8] Tetrahydrocannabinol (this defining amount of THC in industrial hemp is being challenged globally by interest parties as an arbitrary and unscientific amount)

whilst serving as neurotransmitters. There are two main endogenous ligands[9], anandamide which serves as a fatty acid neurotransmitter and is an essential omega-6 fatty acid (the word Ananda is Sanskrit for 'joy, delight and bliss') and 2-arachidonylglycerol, which is predetermined for the CB-2 receptor, and is a product from the omega-6 fatty acid (Andre, Hausman and Guerreri, 2016).

After the endocannabinoids are made available, enzymes breakdown and synthesize the targeted endocannabinoid. These are received by the CB-1 and CB-2 receptors located in the central and peripheral nervous system. This describes the ability of cannabinoids to trigger ideal processes in the human body when they bind to specific receptors of a neuron. Ultimately, the ECS is an endogenous process in the human body which regulates various physiological processors, such as; regulation of the immune system, key communication between cells, pain-mediation, appetite, memory, mood, insulin levels, inflammation and energy and fat metabolism. The ECS serves to maintain homeostasis of primary autonomous functions, thereby displaying the recent medical investment and interest in the viability of cannabinoids medicine to address multiple diseases and syndromes (Borrelli, Pagano, Romano, Panzera, Maiello, Coppola, De Petrocellis, Buono, Orlando and Izzo, 2014).

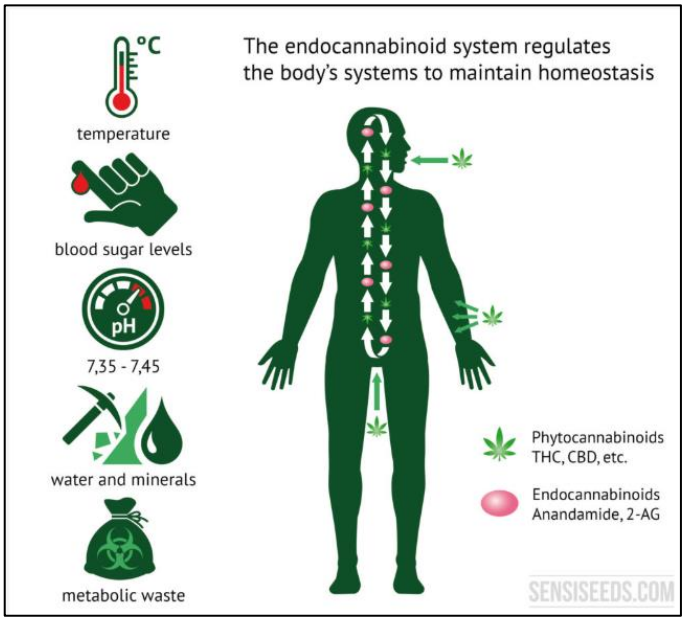


Figure 6: A depiction of the endocannabinoid systems

Cannabis sativa L. has a basic composition of cellulose polymeric chains, with very similar primary metabolites to most other plants (Karche and Singh, 2019). The secondary metabolites consist of cannabinoids which are terpenophenolic compounds, formed from secretary cavities in the glandular hairs (trichomes) of the plant. The aromatic molecules in *Cannabis* belongs to what are known as terpenenoids (terpenes). These have regulatory functions with biotic processes, such as the attraction of pollinators, anti-pest agents whilst amplifying pathogen blockers. Furthermore, these terpenoids are classified according to five carbon building blocks (CBB) in their sub-groups, being; Isoprene (5 CBB), Monterpenes (10 CBB), Sesquiterpenes (15 CBB) and Triterpenes (30 CBB). This is relevant when decoding the chemovars[10] of

[9] Ligand: Ion/Molecule which forms a complex biomolecular structure to serve a biological function.
[10] Chemovars represent the breakdown of a particular plant species with reference to its chemical properties.

cannabis. Terpenoids are potent metabolites and have been proven to have significant effects on animals and humans when inhaled (Aleferis and Bernard-Perron, 2020). These are attributable to almost all species in the Kingdom Plantae. Andre et al. (2016) found that *Cannabis* has over 100 terpenoids whilst Russo (2011) suggested there are over 200 terpenoids, with only a few being recognised for their significant health benefits and agricultural potential.

These are:

- **Pinene** is the most abundant terpene found in nature. It has properties which contain anti-inflammatory and insect-repellent properties. It contributes to the combative agents against a strain of methicillin-resistant *Staphylococcus Aureus*[11] (MRSA). This terpene is known to have antibiotic effects as well as having properties to stimulate focus and memory.
- **D-limonene** is a monoterpene and has immune-stimulating attributes with anti-cancer agents for breast cancer. The unique element of this terpene is the bioavailability and fast metabolism characteristics whilst having anti-fungal stimulation in the plant (Skrobin, 2018).



Figure 7: Hemp terpene analysis

- **B-myrcene** is a monoterpene and is the most common terpene is the commercial cannabis industry. It is recognised as attributing to anti-inflammatory, anxiolytic and analgesic properties.
- **Linolool** was discovered in 2001 and has anti-anxiety, anti-epileptic and analgesic properties. Linalool is produced by many plant species and has been used in medicine for itsanti-convulsing properties. It is commonly found in lavender.
- **B-Caryophyllene** is a sesquiterpene and has been identified as having a gastric protector agent whilst having anti-inflammatory properties. An interesting characteristics of this terpene is the anti-fungal and insecticidal properties (Andre et al. 2016) (Skrobin, 2018) (Russo, 2011).

The secondary metabolites consist of over 120 terpenophenolic cannabinoids, known as phytocannabinoids (Andre et al. 2016). The phytocannabinoids mentioned below are found

[11] *Staphylococcus aureus* is a harmful bacterium that can be found in all mammalian life and MRSA is an antibiotic resistant strain which becomes difficult to treat (Mandal, 2019).

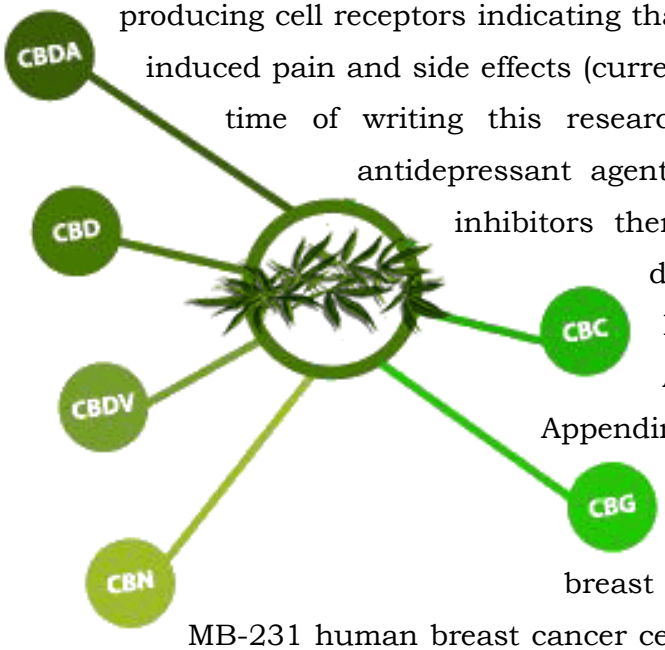
in *cannabis* and are received by the endocannabinoid neurotransmitter receptors in the human body when ingested or inhaled. This can only happen after a process of decarboxylation (removal of a carbon atom) which involves a low heat exposure to the cannabinoids. The most abundant secondary metabolites and their key differences are:

- **CBGA** (Cannabigerolic acid) is no-psychotropic cannabinoid and is proposed as the mother cannabinoid leading to the formation of THCA and CBDA. However, there are only trace amounts of CBGA found in most cannabis strains (less than 1%). As the precursor to the most popular secondary metabolites, it holds intrinsic value for the human body. CBG acts upon the indigenous CB1 and CB2 receptors within the endocannabinoid system. Studies revealed that CBG naturally increases the level of dopamine, this contributes to mood, sleep and appetite regulation. Furthermore, CBG has been identified as an effective treatment for certain conditions such as:
  - Cancer: CBGA is showing promising support signs as a cancer-fighting agent. In a study conducted by Borrelli et al. (2014), CBG in vivo showed to interact with target cells relating to carcinogenesis. The molecular structure blocks specific transient receptors whilst activating essential cells which cause cancer cell development. Furthermore, CBG inhibited colorectal cancer cells in vivo with laboratory mice. This displays new evidence for cancer-combating cannabinoids.
  - Antibiotic properties: CBG was found to have antibiotic properties against MRSA. Furthermore, in a study conducted by Appendino, Gibbons, Giana, Pagani, Grassi, Stavri, Smith and Rahman (2008), CBD, THC and CBN were found to have a potent bioactivity against MRSA.
  - Glaucoma: CBG is effective in reducing and minimizing the intraocular forms of pressure that are typical of glaucoma.

- **THCA** (Tetrahydrocannabinol acid) which is the major cannabinoid in 'marijuana'. It is important to mention that the cannabinoids are more effectively absorbed by the endocannabinoid receptors when coupled with THC. However, this phytocannabinoid will not be discussed as the focus of the paper is on industrial hemp which contains low amounts of THC (Andre et al. 2016).

- **CBDA** (Cannabidiolic acid) is currently the most prevalent phytocannabinoid for health. CBD (decarboxylated CBDA) is a non-psychotropic metabolic compound attributed to anti-anxiety, anti-cancer, anti-arthritic, anti-psychotic, anti-nausea, anti-inflammatory agents and supporting immune system benefits for humans (Andre et al. 2016) (Challa, Misra, and Martynenko, 2020). When CBDA is absorbed by the endocannabinoid system, it interacts by inhibiting the release of what is known as the cyclooxygenase-2 (COX-2) enzyme. This enzyme is primarily associated with

inflammatory agents, thereby revealing that CBDA can reduce inflammation and relieve the associated pain. It acts a palliative substance by affecting the 5-HT serotonin producing cell receptors indicating that it can reduce the nausea and chemotherapy-induced pain and side effects (currently undergoing more extensive research at the time of writing this research report). CBDA has similar properties to antidepressant agents by affecting the selective serotonin uptake inhibitors thereby providing natural medication to combat depression in various doses (Havelka, 2019). Furthermore, according to Havelka (2019), Aleferis and Bernard-Perron (2020) and Appendino et al. (2008), CBDA has studies indicating that it may inhibit the migration of a particular highly aggressive component which consists of breast cancer in females (this is known as the MDA-MB-231 human breast cancer cells). Furthermore, this multi-applicable natural substance is linked to insomnia conditions by providing a sleep sedative effect when consumed in large amounts. More importantly, it addresses some of the constituents which cause insomnia, such as pain and/or anxiety. CBD medicine has been approved by the United States Federal Drug Association in treating epileptic seizures such as the Dravet syndrome and the Lennox Gastaut syndrome (Takeda, Okajima, Miyoshi, Yoshida, Okamoto, Okaka, Amamoto, Watanabe, Omiecinski and Aramaki, 2012).



- **CBNA** (Cannabinolic acid) is derived from THC when exposed to heat or oxygen. This has been isolated and identified as a sedative. It acts as a prolonged sleep enhancer, and has been suggested to improve sleep when combined with THC. Furthermore, this isolated molecule has been reported as a potential stimulant for growth in bone tissue. Studies have suggested that CBN activates stem cells which allow for the growth of new bone. This can be used to address bone fractures with increased healing time.,Various additional studies have found that CBN has analgesic, anti-inflammatory and anti-biotic applications.

- **CBCA** (Cannabichromic acid) is dominant in young plants and tends to decline with maturity. This cannabinoid has been identified as a promising constituent for medical research. Specific pain receptors in the body; vanilloid receptor1 (TRPV1) and transient receptors potential Ankyrin (TRPA1), are linked with the endocannabinoid system where CBC is proven to effectively bind. This implies that CBC may be used as a natural alternative to pain medication which is indicative of the anti-inflammatory properties effectively treating conditions such as arthritis. CBC has been linked as a cancer-combating agent, however not in the same way as the CBG in terms of inhibiting cancer

cell growth. The unique nature of CBC is the mutually reinforcing relationships it has with other cannabinoids. A hemp lexicon coined 'entourage effect' implies the synergizing effects of cannabinoids optimally functioning to increase the positive attributes associated with each one. CBC is a key participant in this action (Russo, 2011).

- **CBDV** (Cannabidivarin) has a molecular similarity to the CBD structure. However, its' intrinsic value displays treatment for neurological conditions such as Parkinson's and epilepsy. CBDV can deter seizure-events whilst administering before seizures may completely disable the seizure as well as reducing the intensity and length of event (Andre et al. 2016).

The biosynthesis and isolation of specific cannabinoids would allow for medical practitioners to intercede the spread and/or conditions of appropriate patients thereby increasing the demand and potential impact of *cannabis* in the health and well-being paradigm of sustainable development. However, as previously mentioned, the unique bioactivity of the cannabinoids work in an 'entourage effect'. The synergism and molecular diversity of specific cannabinoids facilitate palliative conditions in cancer patients when in a full-spectrum. The medical and bioanalytical field of inquiry for *cannabis* derivatives is currently undergoing extensive research and development.

There are over 538 different chemical constituents from *cannabis*. Of these, the importance of the elements consist of the:

- Terpenoids
- Cannabinoids
- Hydrocarbons
- Sugars
- Essential fatty acids
- Simple and Amino acids
- Simple ketones
- Proteins
- Glycoproteins
- Enzymes
- Vitamin B1, B3, B6, C, E and K
- Flavonoids
- Nitrogenous compounds (Kuddus et al. 2013).

The importance of cannabinoids is due to their significant natural health attributes for humans. Hemp seed oil contains 80% polyunsaturated fatty acids whilst being significantly rich in linoleic acid (omega 6) as well as two alpha-linolenic acids (Omega 3) (Challa, Misra and Martynenko, 2020). These are essential for the maintenance of long-term health. The food metabolomics industry categorizes hemp as strong component of natural-based nutrition supplement. However, Aleferis and Bernard-Perron (2020), argue that the biochemical structure of the food and the interactions of the terpenoids, primary and secondary metabolites and various other components in *cannabis,* pose a multi-complex situation for the integration of *cannabis* derivatives into food as a nutritional supplement. Hemp seeds have been reported to help with weight loss as they boost metabolism which increases the potential fat-burning effect. Hemp contains a proportionally high protein content. This protein is known as Edestin which has antibodies and is vital to the homeostatic of the digestive tract and immune system. Hemp seeds provide vital nutrients and a unique balance of the nine essential amino acids for human consumption. Edible hemp seeds have comprehensive health benefits by improving cardiovascular diseases, dermatological improvements and reducing menstrual cramps. These various health factors evident in *cannabis* have the potential to address nutritional health standards in communities in South Africa and more specifically, the Eastern Cape (more to be discussed in Chapter 4).

Andre et al. (2016) and Asquer, Melis, Scano and Carboni (2019) highlight that epigenetic engineering can create the ideal phenotypic characteristics of *cannabis* plants. This will contribute to a sustainable output of industrial crop with improved and fortified health benefits. These improvements could manifest as evergreen hemp farms, a very high fibrous content, minimal seed shattering, increase in potency and bioavailability of CBD and other phytocannabinoids, fast growing and drought resistance. The evolutionary nature of *cannabis* expressed by its behavioural resilience, multi-purposeful applications and agro-ecological interactions are directly related to the web-like network of chemical relationships. This identifies the *cannabis* plant as being a significant natural medicine for multiple diseases, syndromes and conditions. Therefore, *cannabis* as a natural medication can be used combat health issues and provide better regulation to the autonomous functions within the body.

2.3. Agro-ecological value of Cannabis sativa L.

Cannabis is a significant crop for commercial and small-scale agricultural cultivation due to its significant interactions in an agricultural landscape. *Cannabis* has numerous agro-ecological relationships which support the biodiversity of agroecosystems. However, O'Brien and Arathi (2019:1) make a point by identifying that Cannabis is a relatively new crop under

scientific enquiry and thereby: *"the ecological value has not been explicitly investigated"*. Aliferis and Bernard-Perron (2020) coined the term '*Cannabinomics',* describing the nature of the cannabis industry and how this new industry will become an extensive and dynamic industry.

Agricultural landscapes must attempt to decrease the negative effect on environments with complex systems of indigenous pollinating insect life. Hemp does not have nectar, yet the male (staminate) hemp plant provides an abundance of pollen, which are vital nutrients for honey bees, pollinating bees and other pollinating ecosystem agents (Flicker, Poveda and Grab, 2019) (O'Brien and Arathi, 2019). Male hemp plants grow taller than female plants and release large quantities of pollen for up to six to seven weeks. The height of male hemp plants is a determining factor for bee specie richness and abundance (Flicker et al., 2019). As previously mentioned, hemp is a wind-pollinated herbaceous plant. Therefore it serves diverse purposes for functional ecosystem integration.

South Africa is home to a unique and diverse set of pollinating agents (Eardley, Kuhlmann and Pauly, 2010). According to Eardley et al. (2010), there are 2755 Afrotropical bee species identified in sub-Saharan Africa, with a third of that population existing in South Africa. The nature of pollination is complex, due to different plants needing different pollinating agents. However, Flicker et al. (2019) and O'Brien and Arathi (2019) conducted studies in New York and Colorado (respectively), which surmised that pollen supply in an agricultural region coincides with the senescing of other pollinating crops. Therefore, hemp pollen provides vital nutrients at an integral time to maintain the biodiversity of Hymenoptera (large order of insects) in agricultural landscapes. Other conclusive data shown in these studies identified that the height and temporal flowering of male hemp plants are key aspects for the resilience of pollinator communities within agroecosystems (Flicker et al. 2019). Therefore, the strategic use of hemp within agriculturally productive regions can provide an essential ecosystem service which facilitates a natural-based solution to crop monoculture and seasonal pollen scarcity. Hemp can be used an off-seasonal pollen producing crop to help mitigate the extremities of pollen scarcity in the Eastern Cape as well as an additional income source for hemp farmers.

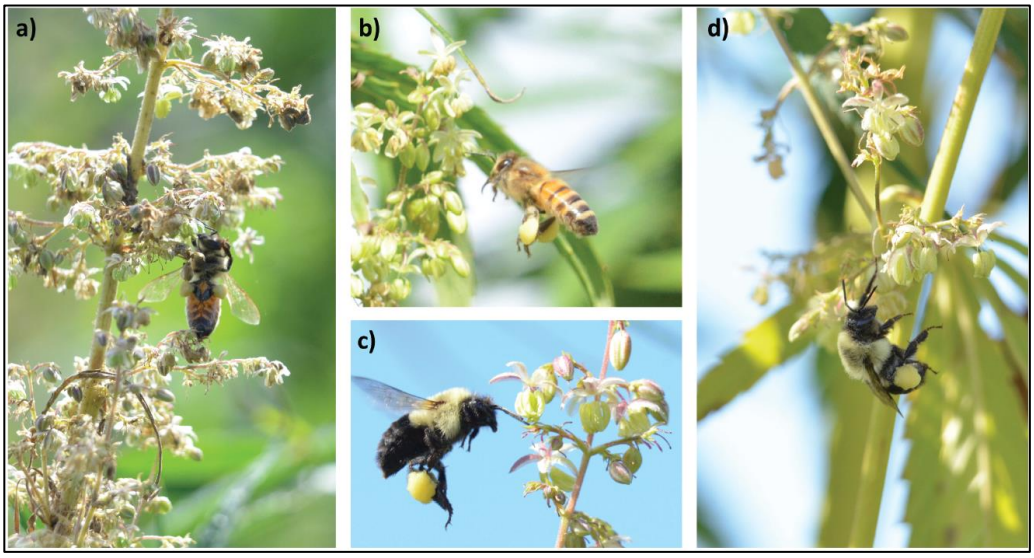


Figure 8: Pollinating ecosystem agents (a) *Apis Mellifera Capensis* (Cape Honey Bee) and (c) *Bombus impatiens* (Common Eastern bumble bee) on industrial hemp pollen sacs (Flicker et al. 2019:199)

An interesting secondary revenue stream proposed by Medical Cannabis Primer (2020) for hemp farmers, is natural cannabinoid-infused honey. The study explains the relationship of the male hemp plants pollen with pollinating ecosystem agents, such as the African or Cape Honey Bee. Pollen provides protein, minerals, fats and essential vitamins which is needed for a nutrient development when feeding young bees. The worker bees pack the pollen which is rich in cannabinoids into pollen sacs which they return back to the hive. These pollen sacs are mixed with their saliva which is enzymatic and this contributes to the development of bee bread which is nectar and pollen stored away for fermentation and is then converted into honey. The amount of cannabinoids is dependant of the amount of pollen within the nectar mix. The bioavailability of cannabinoid-infused honey is higher than most of carrier-modes for cannabinoid absorption due to its ability to pass the Blood-Brain Barrier more efficiently. The opportunity to make cannabinoid infused honey has the potential for high-value added whilst contributing to the restoration of the Cape Honey Bee in the Eastern Cape.

The delicate nature of honey bee pollination is hung in the balance between the Apis Mellifera Capensis (Cape Honey Bee) and the Apis Mellifera Scutellata (African Honey Bee) in South Africa. The Eastern Cape forms the invisible border between the populations of the African Honey Bee and the Cape Honey Bee. However, the Cape Honey Bee is more common.

Sraka, Skevin, Obranovic, Butorac and Magdic (2019) and Ahmad, Tehsin, Malik, Asa, Shahzad, Bilal, Shah and Khan (2015) emphasised that *cannabis* contains a certain combination of chemical constituents which act as a natural herbicide. This is of vital importance to the overall health of a bioengineered ecosystem, as indigenous insect-life will

not be as negatively affected as other crops due to the less toxic type of herbicide, insecticide and pesticide needed for *cannabis* cultivation.

In a study conducted by Sraka et al. (2019), hemp seed yield and hemp fatty acids yield was analysed from 2016 to 2017 in the Pannonian agricultural region in the Republic of Croatia. The data took into account the agro-ecological conditions, a 30 year climatic data average, the rate of hemp evapotranspiration of plants, agro-technologies and harvest methods. While Andre et al. (2016) states that the concentration of phytocannabinoids is dependent on the age, tissue type, growth conditions (nutrition, light, humidity), harvest time and storage. In a comparative study, Andre et al. (2016) observed that there were high traces of cannabinoids (particularly THC) found in 5 out of 11 hemp seed oil samples in from the Croatian hemp market. *"Contaminations are due to improper processing procedures and the illegal use of drug-type hemp for nutritional purposes"* (Andre et al. 2016:3). Whilst Challa et al. (2020) investigates how hemp processing (drying and removal of cannabinoids) imposes limitations on the final cannabinoid quantities. Further stating that "*drying methods currently practiced in the industry have several limitations"* (Challa et al. 2020:8). These multiple dialogues investigating the diverse elements affecting the final hemp product indicates that the *cannabis* industry is currently in the process of more comprehensive research and new development avenues.

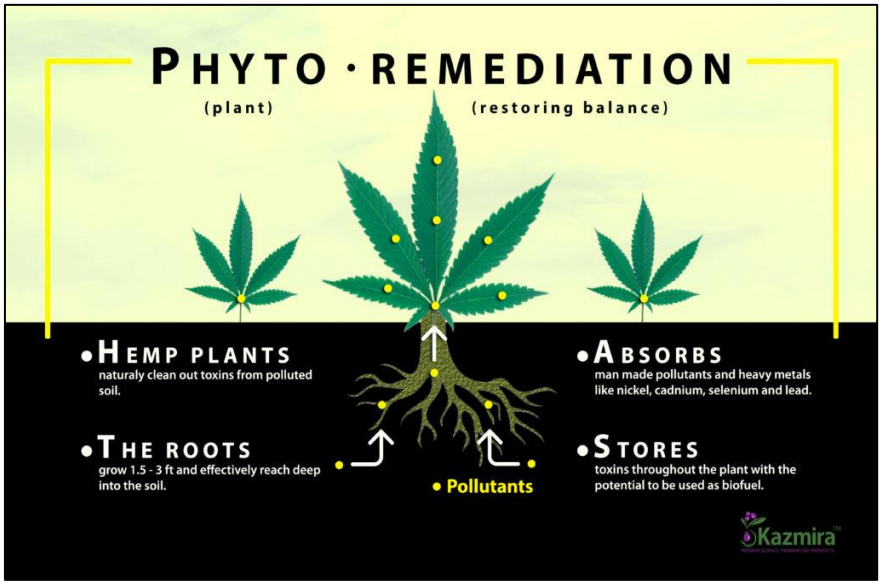


Figure 9: The ability of hemp to remediated the soil

Industrial hemp has another agro-ecological relationship that is, by itself, a formidable characteristic for the regeneration and stabilization of commercial and small-scale farms. Hemp has an ability to revitalise the health of the soil. This is due to the action of phytoremediation which is the plant roots interaction with the edaphic properties (Ahmad et al. 2015) (Amaducci, Zatta, Raffanini and Venturi, 2008) (Prade, 2011). Hemp essentially 'cleans' the soil. Prade (2011) and Jami et al. (2019) mention that hemp is an ideal plant to sow for crop rotation due to the

bioremediation properties and nematode[12] resistance. This supports the agro-economic situation for many non-hemp farmers based on the increase in the performance of the revitalized soil after hemp remediation.

Pioneer studies of hemps' ability to hyperaccumulate heavy metal in soils was conducted in the Ukraine in 1998. Hemp was specifically utilized for the action of removing toxic contaminants surrounding Chernobyl after the nuclear meltdown (Ahmad et al. 2015). The determining factors of this study were the root length, root length diameter, short life cycle of growth (100-180 days) and the high biomass of hemp. Due to these attributes of hemp, it proved to reduce the contamination in this specific site. The evidence revealed a high uptake of copper, cadmium, chromium, lead, zinc and nickel in hemp leaves from the contaminated heavy metals in the soil. This is because plant life contains cells and tissues which protect themselves from certain oxidative damage via the absorption of antioxidant properties. Hemp contains stress responsive and tolerant genes. Ahmad et al. (2015) expressed that genetic manipulation of the heavy metal stress tolerant genes[13] in hemp can be amplified to increase the hyper accumulator properties, thereby displaying positive signs for hemp cultivation to restore and regenerate abandoned mine quarries and mine dumps in South Africa and the Eastern Cape for agricultural production or development.

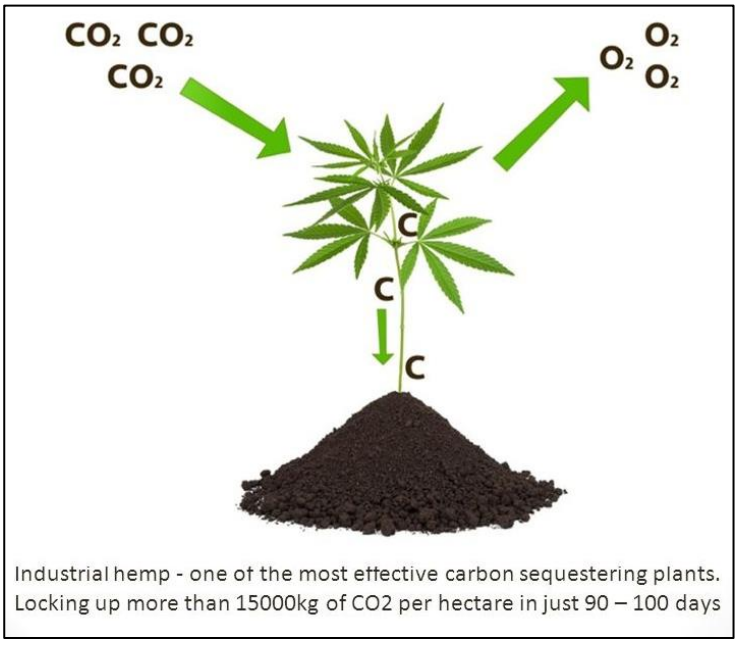


Figure 10: Industrial Hemp as a carbon sequestrating crop (indicating a different carbon sequestrating rate)

Hemp is a carbon sequestrating plant thereby offsetting the total carbon footprint of a hemp-based product (Novakova, 2018). According to Vosper (2019), one hectare of industrial hemp has the ability to absorb 22 tonnes of carbon dioxide. This suggests that hemp cultivation can be used for carbon farming to combat sector emission targets for various industries in South Africa. The nature of hemp cultivation is that nothing goes to waste. The offcuts after harvesting can also been used as animal feed or animal bedding (New Frontier Data, 2019).

[12] Nematodes are microscopic multicellular insects that feed on plants and are known to carry bacteria and viruses on them. *Cannabis* is observed to be rarely infested by them, therefore proving as a vital crop rotation plant for other crops which are commonly infested by nematodes (McPartland and Glass, 2001).

[13] Glutathione-disulfidereductase (GSR) and phospholipase D-*a* (PLD*a*) (Ahmad et al. 2015)

2.4. The Global Cannabis Industry and Africa's Hemp Positionality

The global *cannabis* community is growing in size, complexity and abundance in terms of its supporters, legislation and applications. The *cannabis* industry is the emergence of raw plant material for industries, agriculture, health and international trade. In the 1960's, *Cannabis* was stigmatized in the western world as a psychotropic drug, labelled as a 'gateway drug' to harmful narcotics. This has poised the medically beneficial and multi-applicable plant as only a psychoactive stimulant which leads to crime, conflict and poverty. Many countries battled with the conflict of deciding a positive discourse between marijuana and hemp. This reversed the potential of the industrial hemp to be an economic and medical asset and set the motion of *cannabis* being labelled as only an illicit substance which induces a 'high' (FOGA, 2019).

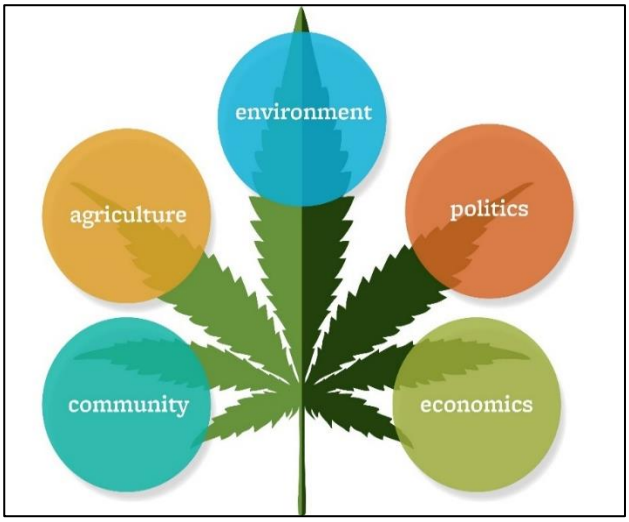


Figure 11: The impact of legal *Cannabis* cultivation

However, some countries, such as France, have lengthy historical collaboration of hemp legislation. In 2016, France was cultivating more than half of the total Europeans Unions hemp (17000 hectares of 33 000 hectares). China is the top hemp cultivator at 45 000 hectares and then Canada with 31 000 hectares. Europe's hemp industry culminated in the 'All Hemp: International Congress of Hemp' held in Paris on the 5th February 2019 (InterChanvre, 2020). This promoted the rise of domestic hemp-based products and domestic hemp farming in viable European agronomic regions (Guba and Dufton, 2019).

A significant point made by Morrissey, MacCann, Torres and Whitney (2019), is that there are more than 50 countries which have, in some form, legalized *cannabis* for medical use. With reference to the image below, the global demand value for *cannabis* is estimated at $344.4 Billion. The potential of the *Cannabis* industry is now being given foundation on which to grow. This is being spearheaded by leading scientists, medical experts, businesses and governments which provide professional data to this new market and widened the doors for C*annabis* trade. The market perception of *cannabis* will be led by digital media which will boost awareness and connect consumers on a virtual scale. The economic viability of hemp in emerging markets has the potential to propel sustainable development, technology driving efficiency and capital investment in the industry (Morrissey et al. 2019).

Turning our attention to Africa, the unprecedented potential of hemp cultivation is due to the primarily agro-based economy which inherently exists in most African countries (New Frontier Data, 2019). According to the New Frontier Data (2019), Africa is estimated to currently have an 11% market value of the global cannabis industry. Data of the *Cannabis* industry is the correlation with hemp's multiple applications and farming methods contributing to the achievement of the United Nations Sustainable Development Goals (SDGs) (New Frontier Data, 2019) (Morissey et al. 2019). The dynamic opportunities and challenges facing the emerging markets and economies of Africa can be coupled with the formidable global *Cannabis* movement and in turn, proactively address sustainable development through hemp agriculture and hemp-based applications. With the current socio-political and economic crisis amoungst the COVID-19 pandemic, many economies require innovative and effective financial means of gaining revenue. This is a unique opportunity to integrate the vast applications of hemp in Africa's economies.

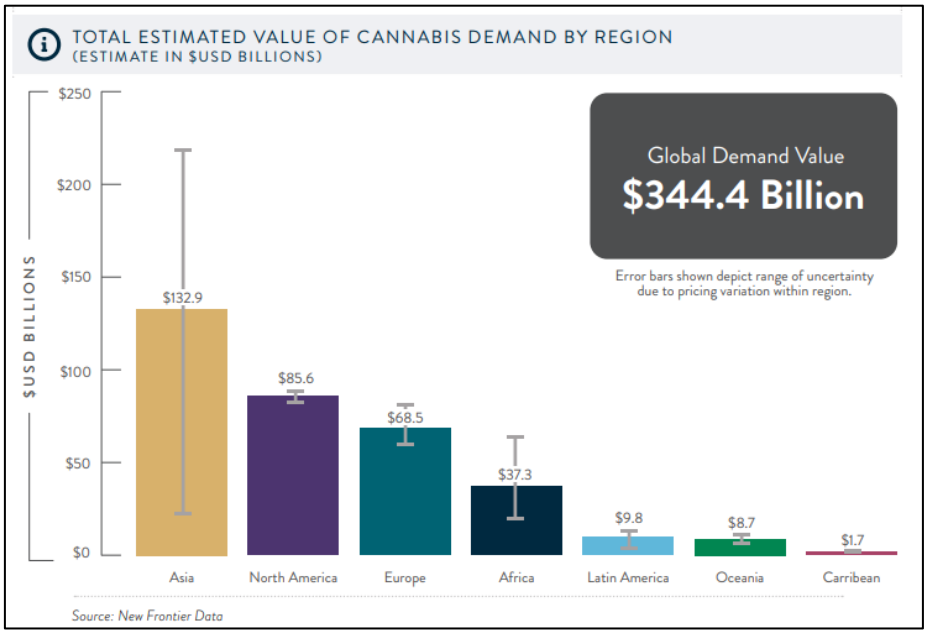


Figure 12: The demand of *Cannabis* globally

"The Sub-Saharan construction industry is forecasted to reach $12.9 trillion US by 2022…" (New Frontier Data, 2019:6).

According the New Frontier Data (2019) and FOGA (2019), a few Southern African countries have reformed drug prohibitions and have established a regulated market for *cannabis* industries. Lesotho pioneered a legal market in Africa in 2017 with Zimbabwe following suit in 2018 (South Africa to be discussed later). Africa has specific factors which encourage the integration of hemp agriculture to address economic growth, overall health improvement and access to education. Africa is poised to increase in population by 50% in 2050, thereby increasing the availability of human resources. Improving economies are seen in gross domestic product increase of 3.5% in the last two years, with the East-African region growing the fastest.

There is a distinct foreign investment from the Chinese government in Africa with China's flagship project being the Belt and Road Initiative. China is steadily increasing its monetary investment in Africa through various Chinese-fund projects such as Eastern Industry Zone in Ethiopia and two different railway infrastructure projects in Nigeria and Kenya. Furthermore, construction in Sub-Saharan Africa[14] is expected to rise, this allows for many low to mid-tech hemp applications, such as hempcrete and hemp cellulose based aggregate insulation, to propel and integrate hemps' sustainability and ecological benefits in the development paradigm.

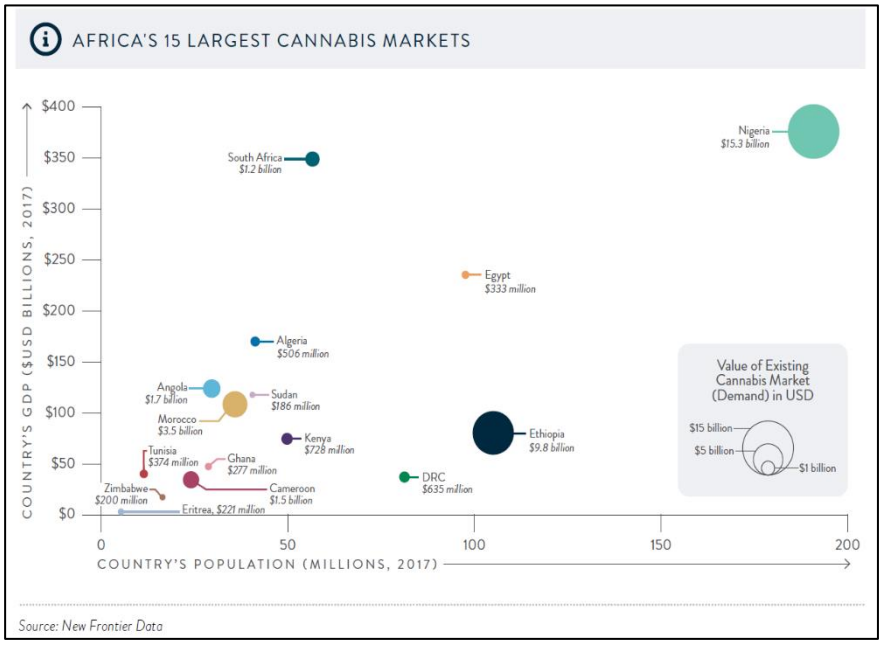


Figure 13: African cannabis markets. Indicating South Africa to have a $1.2 Billion market

The availability of arable agricultural land in Sub-Saharan Africa is an opportunity for hemp farming to become an integral asset for agro-based economies. This will bolster the employment in the agricultural sector with already 60% of the current income and employment being based in and from the agricultural sector. The predicted increase in population in Africa must be coupled with a mutual rise in employment options, thereby indicating the critical nature of expanding upon labour-intensive industries (New Frontier data, 2019). Lastly, the element of tourism and ecotourism plays a massive role in the countries of Africa. Through large-scale commercial hemp farming with multiple cultivars and unique phenotypic characteristics, "Cannatourism[15]" can become an ecologically sustainable and economically viable proponent in a countries annual gross domestic product.

[14] Sub-Saharan Africa includes 46 of the 54 African countries.
[15] 'Cannatourism' is an ecologically sustainable form of touristic methods focused on the cannabis industry.

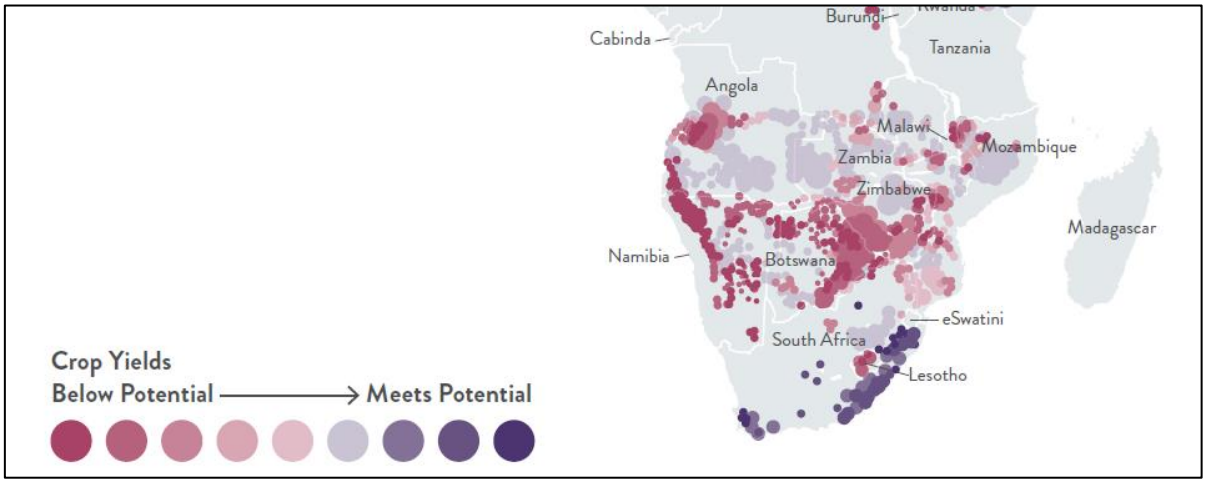


Figure 14: Diagram indicating South Africa's potential for hemp agriculture

In a more comprehensive model for hemp integration as a sustainable development tool, the United Nations 2030 Agenda for Sustainable Development Goals (SDGs) can harness the hemp industry as a viable resilient and sustainable resource to address these goals. New Frontier Data (2019) found that of the 17 SDGs, the most applicable to Africa were SDG 8 being decent work and economic growth, SDG 2 enacting zero hunger and SDG 3 addressing good health and well-being. In terms of SDG 8 which aims to have *"…inclusive and sustainable economic growth with decent work for all",* hemp industries or medical cannabis can increase jobs for unskilled and skilled workers whilst providing a platform for foreign direct investment into a downstream economies of scale and higher value-added supply chains (New Frontier Data, 2019:21). However, foreign ownership must be regulated in order to generate local empowerment and participation. SDG 2 aims to create healthy citizens of all ages by addressing food security and improving nutritional standards via sustainable farming methods. The legalization of medical *Cannabis* has the potential to provide affordable healthcare treatment for those with specific *Cannabis*-treatable diseases. Using hemp seeds as a superfood, many nutritional benefits can address malnourishment and help maintain healthy citizens to be able work productively. SDG 9 tackles industry, innovation and infrastructure which has a strong correlation with the innovative nature of the expanding hemp industry, thereby coinciding with the notable strategic position of the hemp industry in Africa and especially, South Africa (New Frontier Data, 2019) (FOGA, 2019).

A contributing factor towards hemp's formal integration in Africa, can be seen via the African Continental Free Trade Agreement (AfCFTA). This invites a free trade agreement set to open on the 1st July 2020 (however, COVID-19 delayed this commencement). The AfCFTA provides an intra-African trade partnership which supports a more integrated African continent with fewer import expenses and open access to trade agreements amoungst the ratified countries (Tralac, 2020). In a recent briefing paper by Putri (2020), the World Health

Organisation (WHO) addressed an intervention for the WHO's perspective on *cannabis.* Most importantly, this intervention aimed to recognise the benefits of medicinal cannabis and remove certain words such as 'tinctures and extracts[16]' from the scheduling within the psychotropic drugs convention. Furthermore, by removing cannabis from the Schedule IV of the 1961 Convention of Narcotic Drugs, international laws governing cannabis regulations can be surpassed by the host nations. Alongside other stipulations, the reformed outlook on *cannabis* from the WHO opens an opportunity to medical and industrial cannabis programs with less stringent protocols to support local-small holder farmers. The Commission on Narcotic Drugs (CND) are set to have specific topic-related meetings throughout the year of 2020 with the final culmination in the 63rd reconvention of the CND set to discuss key *cannabis* points in Vienna in December 2020. The position of the *Cannabis* industry is a key sign for leading policy makers, government officials, foreign investors, entrepreneurs and industries to fast-track and adopt sustainable ways of practicing and facilitating growth in the hemp industry in Africa.

2.5. South Africa's Hemp situation

The government of South Africa has recently been promulgated *cannabis* as commercial asset with potential for international markets (GSA, 2020). With the State of the Nation Address in February 2020, President Cyril Ramaphosa stated that:

> *"…we will open up and regulate the commercial use of hemp products, providing opportunities for small-scale farmers; formulate policy on the use of cannabis products for medicinal purposes, to build this industry in line with global trends"* (GSA, 2020).

The statement made by President Ramaphosa opens up a market for industrial hemp applications. According to FOGA (2019), South Africa (SA) is the fourth largest producer and consumer of *cannabis* worldwide. This implies a potential for tax revenue for government, trade and local manufacturing and an intra-South African *cannabis* market. Furthermore, the advent of legal cannabis development programmes and scientific research will mitigate the misappropriate criminalisation of cannabis users by the South African Police Service. In the State of the Nation Address of 2021, President Cyril Ramaphosa aims to deliver industrial growth with a focus of local manufacturing for international and local market, thereby providing fertile soil for the implementation of agro-processing manufacturing plants for energy efficient hemp-based product development.

[16]Largely interchangeable, a tincture is a concentrated herbal extract by mainly using an alcoholic based solvent. An extract is concentrated herbal solvent dissolved in any non-alcoholic based solvent.

Many past cannabis users have been harshly prosecuted and detained based on their use of cannabis. The notion of equality and civil rights must be respected and adhered to by the law enforcing agents in SA (FOGA, 2019).

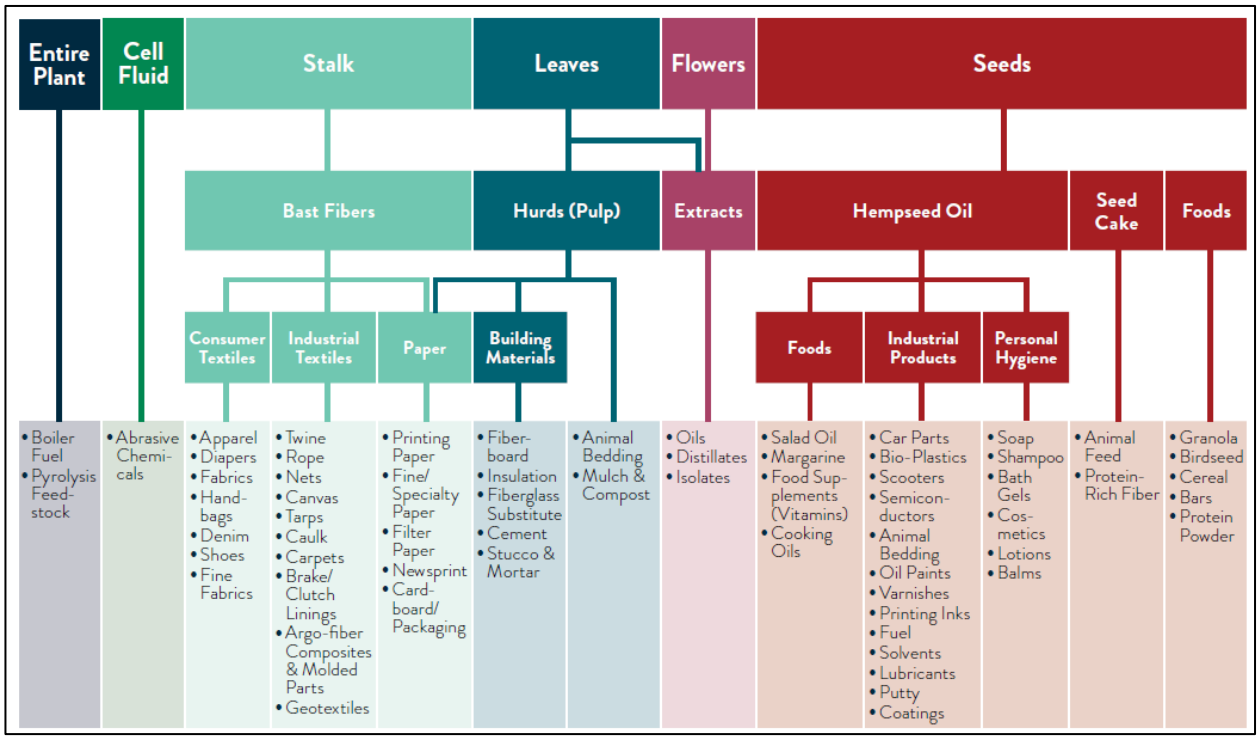


Figure 15: Some of the 22 000 uses for hemp

It is important to note that SA's history of 'dagga' (the colloquial term for *cannabis* in SA) prohibition stems as far back as the early British and Dutch governance structures of the 1800s. According to FOGA (2019), the Medical and Pharmacy Act of 1891 categorised 'Indian Hemp' (Cannabis Indica) as a poison. This drove the Union of SA in 1910 to solicit a ban on the consumption and trade of 'Indian Hemp' nationally. Furthermore, in 1924, the Customs and Excise Duties Act prohibited the use and trade of opium, this prohibition coincided with President Jan Smuts' letter to the League of Nations to support the international drug policy on 'dagga'. This legislative action rippled throughout the consecutive South African governments. A pivotal reactionary policy called the 'Report of the Inter-departmental Committee on the Abuse of Dagga 1952' lacked extensive scientific data on hemp but was adopted by the United Nations Convention on Narcotic Drugs in 1961. Further ratifying the consensus for nations to prohibit hemp as a medicine and industrial material, based on solely on marijuana's psychotropic attributes (FOGA, 2019).

The United States of America (USA) and South Africa (SA) have had an entwined experience of *cannabis* regulation (Minnar, 2015). Due to the formidable research endeavours and leading westernized authority of the USA, SA followed suit with many drug prohibition campaigns set forth by the USA. In 1971, SA signed the Convention on Psychotropic Drugs which was supported by the US Presidents Nixon's 'war on drugs', seemingly coincidentally,

SA imposed the 'Abuse of Dependence producing Substances and Rehabilitation Centres Act 1971', which led to the incarceration of mainly black males in the first couple of years of implementation. This draconian measure was one of the by-products of the Apartheid regimes' tools to enact forceful measures against people of colour (Minnar, 2015) (FOGA, 2019). The last remnants of the Apartheid perspective against drugs was the 'Drugs and Drug Trafficking Act 1992'. This was an amendment of the 1971 Act mentioned above.



Figure 16: Hemp as a misappropriated plant now representing South African flags

It must be emphasised that the past legislative prohibitions of *Cannabis* in South Africa have acted completely against the potential medicinal and industrial applications of this versatile plant matter. This further degraded the societal perspective of hemp and prolonged its industrial and medical integration in a functional economic, social and health system. Haffajee (1998) alludes to the Apartheid government's import expense of what was labelled 'Dronabinol'. This is an isolated delta-9 Tetrahydrocannabinol (THC) used to address symptoms of cancer, multiple sclerosis, AIDS and other diseases. However, the company, 'Elevat' (a South African multinational corporation) used this pseudonym to avoid being identified by the legislation, whilst the Drugs and Drug Trafficking Act amended the legislation to ensure that this pharmaceutical company could exploit the notion of cannabis trade. 'Elevat' (a sub company owned by Pharmacare) was benefitting from this trade and there were multiple claims against this practice, however all claims were to no avail. The objectors presented the case that there is a strong possibility that 'Elevat' was growing crops in South Africa and linking the financial remuneration with the Apartheid South African Government (FOGA, 2019). This evidence suggests that corruption and malpractice was evident in South Africa's past hemp industry, with the monetary success being shared amoungst the few and kept away from the many. With this understanding, the current leading political party, the African National Congress, has a responsibility to South Africa to ensure that the *cannabis* industry embraces the full potentiality of the beneficiation of products versus directing profits for the elite whilst nepotistic ideals are being enforced by the government. South Africa must develop a *cannabis* industry to fully assist in addressing its vital challenges of poverty, unemployment and education.

In what was called the 'Trial of the Plant' in the Pretoria High Court in 2017, the 'Dagga Couple'[17] contested the non-regulation of Cannabis. This operated in tandem with the ruling in the Western Cape High Court in March of the same year, which effectively allowed for the decision to 'decriminalise' *cannabis* use. The ongoing support and activism of the 'Dagga Couple' finally erupted in September 2018 when the Constitutional Court ruled it legal for private properties to grow and consume marijuana for personal adult-use on private property. The September court ruling found certain sections of the Medicines and Related Substances Act, 1965 (Act 101 of 1965) to be unconstitutional[18]. This court ruling removed cannabis and its chemical constituent, tetrahydrocannabinol (THC) from a Schedule 7 narcotic list. Furthermore, CBD is categorised as a Schedule 4 Drug except when it has complementary medicinal instructions and dosages such as only 6000mg of CBD per product and providing daily dosages of 20mg per serving. When these specifications are met, CBD is regulated as a Schedule 0 substance (SAHPRA, 2019). A CBD product must contain 0.001% or less trace amounts of THC. At the time of writing this research report, the current legislation around phytocannabinoids does not pertain to the manufacturing and trade of a 'full spectrum'[19] cannabinoid product.

The Constitutional Court is set to expedite their decision in 24 months from the September 2018 ruling, therefore, by September 2020 there will be further regulations set forth by SAHPRA and other departmental organizations. These regulations have been recently promulgated by removing cannabis from a Schedule 7 category, with THC (the psycho-active ingredient) being listed as a Schedule 6 substance. The 1961 Single Convention on Narcotic Drugs ensures that South Africa abides by a specific notion that all Schedule 6 (which is THC) drugs must be sold by acquiring a license. This international policy aligns all participants to this ruling.

However, since 1994, SA has conducted hemp pilot projects for medicinal use and cultivation methods specifically needed in SA's vulnerable climate. This was legally recognised in April 2018 by the South African Health Products Regulatory Agency (SAHPRA) who granted the first medical license to grow hemp (New Frontier data, 2019). However, a specific regulation set forth by SAHPRA pertains to industrial grade hemp which is required to contain 0.2% or less THC in the plant. This is an extremely stringent requirement and will be a barrier for small-scale farmers and other synergistic industries because of the genetic requirements needed to engineer a strain which has this reduced amount of THC. In other cannabis regulating countries, 1% and 0.3% are the requirement for THC. This

[17] The 'Dagga Couple' is a pro-cannabis lobbyist organisation founded in and for South Africa.

[18] Section 22A (9)(1)(a) "No personal shall… acquire, use, possess, manufacture or supply at Schedule 7 or Schedule 8 substance, or manufacture any specified Schedule 5 or Schedule 6 substance unless he or she has been issued with a permit by the Director General for such acquisition, use, possession, manufacture or supply" (SAHPRA, 2019: 2)

[19] 'Full spectrum' is a cannabis lexicon terminology explain the wide range of phytocannabinoids

poses an obstacle for industrial hemp farming in South Africa (DoE, 2020). Some European strains are required to have a 0.2% THC limit in the upper third of the plant. This will allow for the importing of European seeds into South Africa but may pose financial constraints on acquiring the genetics. At the time of writing this paper, the regulatory laws involving industrial hemp and the THC requirement are constantly changing. A recent promulgation by the European Industrial Hemp Corporation announced a new limit of 1% THC to be allowed in industrial hemp crops. Furthermore, under the Medicines and Pharmacy Act, importers of CBD and products containing CBD will need to have a Medicines Import license whilst wholesalers will need a Medicines Wholesale license and distributors will need a Medicines Distributors license. This is in order to ensure that CBD aligns with Good Manufacturing Practice thereby ensuring that there are no other contaminants in the finished product. According to TNHA (2020), this will be a challenge for small and medium sized businesses who are selling CBD products as they will now be required to regularize their way of business in accordance with these acts. This may propel powerful pharmaceutical businesses to monopolize the industry and outweigh the chance of integration for small businesses. The effect of stringent business protocols will lead to a higher price value for medical, industrial and nutritional products. This will force the cannabis industry into a position of interest based on affordability, whilst neglecting the social responsibility of a multi-applicable plant development industry. This is especially evident in South Africa's circumstances and may pose a threat for the full economic potential of CBD businesses.

Shifting the attention towards the climatic conditions in South Africa, the pervading semi-arid nature of South Africa's landscape is vulnerable to various associated climate change[20] risks. This informs the need for a revitalised approach to renewable energy production whilst mitigating the associated climatic risks of large-scale, monoculture commercial agriculture. The benefits of the innovative hemp industry can be identified in the phytoremediation properties, the prospects for hemp biofuel, hempcrete and other energy related savings with hemp-based products (to be discussed in Chapter 4). Turpie and Visser (2014) suggest that South Africa relies upon productive agricultural systems to support numerous families and economic structures. This positions South Africa as a highly climate-sensitive environment. The effects of climate change are evident not only in the increase of the annual temperature average, but also in more infrequent rainfall patterns with the ominous threat of drought as its manifestation (Turpie and Visser, 2014). Turpie and Visser (2014) indicates that atmospheric weather data from 26 weather stations in South Africa has estimated a temperature increase of 2.4°C by 2050 and a decrease in

[20] Climate change refers to the changes in short term and long term weather patterns directly or indirectly related to anthropogenic activity which alters the composition of the global atmospheric properties (ECA, 2012).

annual rainfall of 6.3% by 2050. These negatively impact the already water scarce resources in which agriculture systems heavily rely upon. South Africa is also reported to have a relatively high evapo-transpiration amoungst agricultural crops, with the highest potential being 1500 mm per year (Turpie and Visser, 2014). The Ricardian Approach[21] can be adopted to integrate data studies on the adaptation methods needed for farmers to ensure sufficient production of agricultural output. Furthermore, these climate associated risks exacerbate poverty in rural communities through the perspective of food security[22]. The importance of addressing associated climate change risks in South Africa is applicable to this study based on the direct impact it has on agriculturally dependant, ecosystem sensitive and geographically exposed rural areas, which is a dominant theme for the majority of the Eastern Cape.

Averchenkova, Gannon and Curran (2019) reveal how South Africa has an existing climate-policy governance structure aimed to address an integrated and coordinated alignment of policy protocols against associated climatic risks. Despite this, there is a reported failure of capacity and implementation of these cross-cutting policy protocols. Averchenkova et al. (2019) explains that the NPC (2013) has integrated climate change as a key element for the overarching strategy for development in the South Africa. Furthermore, DEA (2016), DEA (2017) and Averchenkova et al. (2019) identify that a climate-resilient society must work in alliance with supranational agreements, such as the Paris Treaty, Kyoto Protocol, United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). These international policies addressing the health of the biosphere are enforced through the South Africa's Climate Change Monitoring and Evaluation System. Multiple government policies guide and coerce sustainable development in South Africa (NPC, 2013) (DEA, 2016) (National Treasury, 2013).

"South Africa committed to a medium-term goal of 398–614 MtCO2e between 2025 and 2030" (DEA, 2016:11).

South Africa is required to abide by the National Determined Contribution, Sector Emissions Targets and Desired Emissions Reduction Outcomes (DEA, 2016). The South African Low-Emission Development Strategy 2050 aims to mainstream a reduction in anthropogenic greenhouse gases emissions and provide targets for short, medium and long term emissions for government departments. The hemp industry has the opportunity to

[21] The Ricardian Approach analyses the relationship of farmland value, climate, soil and other variable through an econometric data table (Turpie and Visser, 2014).

[22] Food security is identified as having four dimensions – food systems stability, food availability, food accessibility and food utilisation (Turpie and Visser, 2014).

integrate its industrial applications to contribute towards meeting the protocols within the government's transition to a low carbon economy.

The many high-technical and low-technical applications of hemp allows for substitute manufacturing processes to combat resource intensive, greenhouse gas emitting industries processes (CDCSA, 2020). The low-tech applications can be interpreted as making hempcrete, manufacturing textiles, nutrition and animal bedding and feed, whilst the high-tech applications involve creating hemp bioplastics, biodiesel, medicine and cosmetics. The many applications postulates opportunities for green jobs, green education, green infrastructure, integrated ancillary industries, foreign direct investment and international trade. (New Frontier Data, 2019). National Treasury (2013) and Oke, Aigbavboa and Dlamini (2017), analyse carbon trading as a viable financial tool to ameliorate once unfeasible economic restructuring, whilst supporting local economic development in disparate communities. This can evolve the high carbon emitting industries in a shift towards a low-carbon economy and climate resilient society. In these studies, South Africa can distinguish between the 'cap and trade' programme and the 'baseline and credit' emissions trading scheme[23]. Therefore, South Africa has the opportunity to utilize the hemp industry as a catalyst flagship programme addressing food systems, energy efficiency, carbon capture, renewable energy and a climate resilient environment. These particular aspects of climate resilience foster a stronger recognition for sustainable human settlements (DEA, 2017).

Therefore, the insight into the applicability's of *cannabis* suggest that this innovative and synergistic industry is a multi-sectoral asset for government revenue. The Department of Agriculture, Forestry and Fisheries (DAFF), Department of Environmental Affairs and Tourism (DOEA), Department of Water Affairs (DoWA), Department of Cooperative Governance and Traditional Affairs (COGTA), Department of Energy (DoE) and other cross governmental departments are expected to have an integrated involvement with the hemp industry (DEA, 2016). New

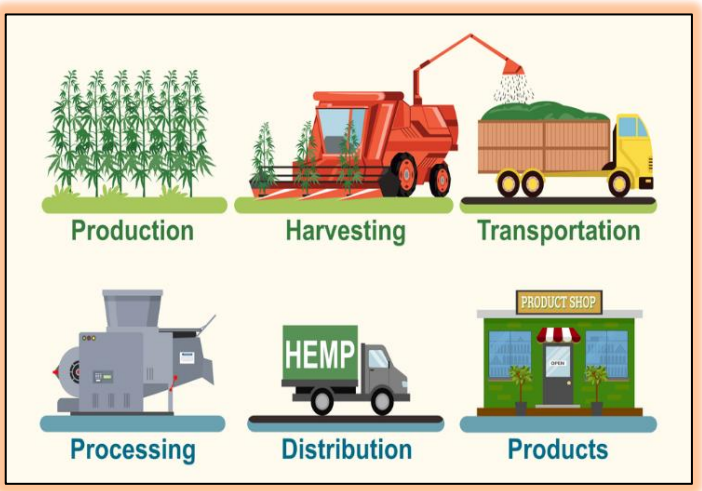


Figure 17: Hemp Industry Value-added supply chain

[23] A 'cap-and-trade system' has an upper limit which determines the amount of emissions allowed under regulation and this is a fixed number. Emission permits are granted based on a specific criteria. Whereas the 'baseline and credit' schemes describe flexible emissions trading designs where a baseline is established and it is used as the measurable point for future and present scenario analyses. Therefore, any polluter whom reduces their emissions below this point earns credits, which can be traded with other polluters in order to fit within regulation. This allows for economic efficiency and is an effective ambassador of the green economy (OECD, 2020).

Frontier Data (2019) exposes the dire need for cross-sectoral coordination and inter-departmental alignment with the advent of a cannabis industry in any country. A relevant introspection of the *cannabis* industry is addressed by Coogan (2016), who fosters the South African perspective of whether hemp will be addressed in its multiplicity or will be perceived as a 'business as usual' crop. Coogan (2016) discusses the distorted historical perception of hemp in South Africa and how this has morphed into a decrepit societal perception which may have the propensity to mitigate the true realization of hemps appropriate product developments.

2.6. Hemp in the Eastern Cape:

Climate change and poverty are inextricably linked (Turpie and Visser, 2014). In the case of the Eastern Cape Province, the need to prioritise sustainable development with rural socio-economic inclusivity is invaluable. The potential of the hemp industry can facilitate a developmental state in which financial investment can materialise in climate combative techniques and agro-rural socio-economic inclusivity. According to the ECPC (2014), the Eastern Cape has an extremely high unemployment rate, requires strategic transformation of the agriculture sector, has a failing public health system and has available arable land for agriculture. Using strategic guidance from the Eastern Cape Vision 2030, the Eastern Cape Agricultural Research Projects and the Eastern Cape Socioeconomic Consultative Council (ECSECC), the research will unpack provincial policy protocols to conceptualise the integration of hemp cultivation in the Eastern Cape (ECPC, 2014) (ECSECC, 2019).

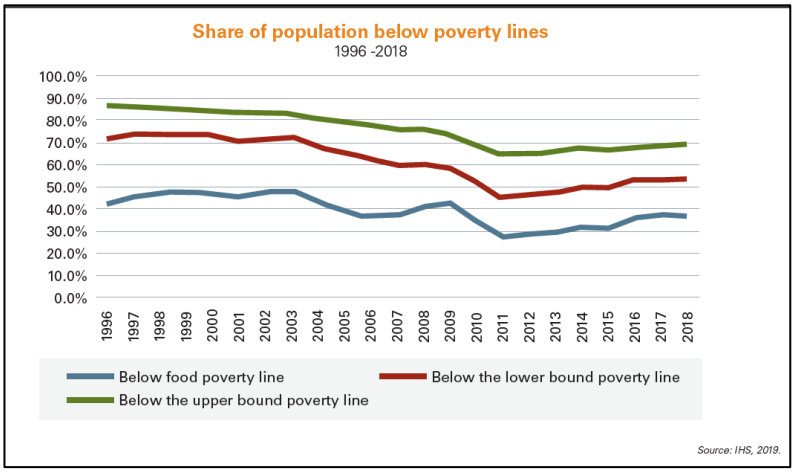


Figure 18: Eastern Cape population poverty levels from 1996-2018

The rooted challenges of the Eastern Cape are primarily due to the Colonial deprivation of education and Apartheid's structural legacy of unequal land distribution. With these impediments against inclusive development and many more past atrocities of the South Africa's previous suppressive states, the Eastern Cape has remained industrially excluded and economically underdeveloped. The relevance of this is that it has curtailed socio-economic progression whilst creating a fortitude of inequality coupled with health and social issues, economic disparities and ecological misuse. According to the ECSECC (2019:22), the Eastern Cape has been seen as "*labour reserves*" which has resulted in an underperforming provincial economy manifesting a high rate of unemployment and

poverty. The ECSECC (2019) highlights that the Eastern Cape has been experiencing an increasing provincial outward migration and evident intra-provincial migration to places of economic agglomeration. This has spatially and economically isolated deep rural areas and led to an increasing demand for essential municipal services in urban areas in the Eastern Cape.

The ECSECC (2019) recognised primary economic factors challenging development in the Eastern Cape, such as; South Africa's weak currency, the impact of the technological age leading the fourth industrial revolution[24] competing with the current nature of the labour market and a lack of access to security of land tenure. These embedded risks require urgent government, private and foreign direct investment in land development opportunities. In addition to these economic challenges, the social challenges highlighted by ECSECC (2019) are the remaining high level of upper bound and lower bound poverty, an expanding youth population unable to be absorbed by the labour market, food insecurity and low nutritional standards, resulting in the prevalence of health issues. The Eastern Cape faces the disease burden of HIV/AIDS, tuberculosis, child mortality and violence. Furthermore, specific environmental conditions, such as a lack of a healthy indoor environment contribute to a defective health status amoungst Eastern Cape citizens.

In the Provincial Investment Conference in February 2019, the ECSECC developed a partnership-based investment council aimed at addressing provincial economic drivers such as the agro-industrial development program. The opportunity to prioritise agro-industrial logistics infrastructure aligns with the ECPC (2014) through the *Ilima Labantu* key stone development program. *Ilima Labantu* is a catalytic flagship agricultural program for the Eastern Cape aimed at addressing humans inter-dependence and cooperation for the benefit of all its' people. It is aimed as a revival strategy for the rural economy whilst developing ancillary industries. This initiative is prioritised due to agricultures labour absorbing potential and cross-sectional, multi-agent mobilisation. The *Ilima Labantu* program aims to:

> *"…address the food security needs of the province, revive the rural economy and increase its value-add to the overall economy"* ECPC (2014:26).

Ilima Labantu is significant for *cannabis* cultivation in the Eastern Cape by providing a strategic vehicle in which hemp farming and investment can be packaged and transformed into a key socio-economic asset. The *Ilima Labantu* program provides short term targets by

[24] Fourth industrial revolution is the new age of accelerated technological innovation driving change in labour and the way humans live.

creating the optimal use of land for families and communities whilst collaborating communal land for productive uses. Through community and small-scale agriculture, sustainable approaches to farming such as restorative agriculture, regenerative agriculture, organic farming, intercropping, agro-forestry and conservation agriculture can be implemented to increase the sustainability of these operations and work in alliance with nature. *Ilima Labantu* intends to provide agro-processing infrastructure to agrarian regions whilst prioritising water irrigation schemes to address the water needs for agriculturally productive land. Furthermore, the notion of capacitating capabilities in agriculture is a key pillar in the *Ilima Labantu* program. The development of skills and integration of best practices for communities is a policy protocol of the agricultural sector in the Eastern Cape Province. These protocols are addressed by the development of education and training programs, institutions and research and development facilities. These protocols aim to harness the knowledge-transfer from subsistence farmers to agricultural development practitioners and vice-versa. The market penetration for Eastern Cape farmers is aimed to stimulate and foster stronger local trading networks through cooperatives and enabling communities to organise and synergise logistics whilst gaining capital through affordable and marketable product development packages.

The *Ilima Labantu* program offers invaluable opportunities to insert small-scale and commercial hemp farming in the Eastern Cape. The agri-entrepreneurship program cultivates a platform for innovative and community-led farming initiatives to propel the value-added employment for the agro-industry via commodity specialisation and multi-commodity products. In addition to these strategies for implementing agricultural economic revenue, the 2025 milestones for the Eastern Cape agricultural sector is set to employ 140 000 citizens in this sector (ECPC, 2014). The integration the hemp industry can be enacted to support these strategic policy protocols.

The ECPC (2014) further affirms the need to integrate the youth into agriculture-led development programs as the drop-out rate in agriculture is partly due to less participation from the youth. The multi-dynamic approach adopted by the ECPC (2014) aimed to revitalise the rural economy and the proposed intervention of the rising *Cannabis* industry can be used to intersect with the challenges and opportunities of sustainable farming in the

Eastern Cape. The attractiveness of *Cannabis* for agri-business is occurring worldwide (New Frontier Data, 2019). And in such fertile districts of the Eastern Cape, *Cannabis* cultivation can become a leading competitive advantage. The alternative hemp industry will provide sustainable employment through a value-added supply chain, investment in the bioeconomy and the circular economy, health and nutritional value and healthy housing in rural socio-economic spaces in the Eastern Cape.

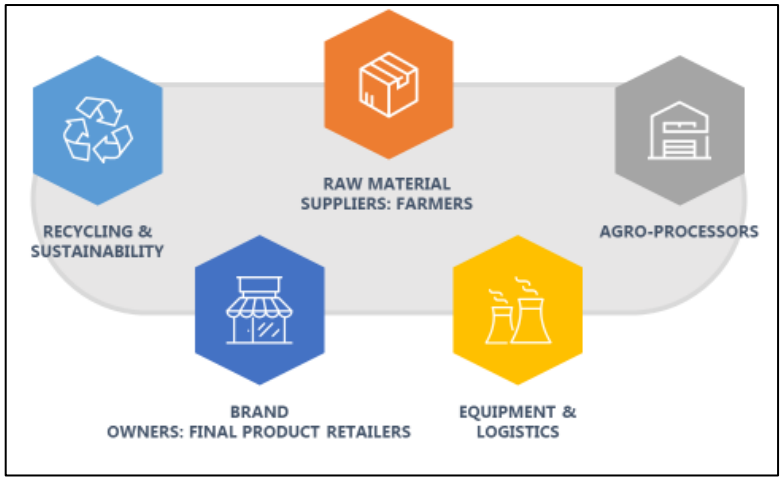


Figure 19: Supply Chain framework and the circular economy

The ECPC (2014:80) supports *"Strategic objective 1.5: Rapid development of high-potential economic sectors*", this identifies an agricultural strategy to address land ownership whilst facilitating water security. These strategies are to be coupled with the creation of complete localised value-addition employment and supply chains. Furthermore, through the guidance of the ECPC (2014), the agricultural sector aims to establish research and development programmes, improve logistics, ensure agricultural expansion is environmentally sustainable and coordinate agro-industrial growth through the Department of Economic Development and Tourism and the Department of Rural Development and Agrarian Reform. The proposed hemp industry has the potential to intersect with the policy protocols for the agricultural growth in the Eastern Cape. The tourism sector seeks to compliment the competitive advantages of ecotourism. This can be guided by the growing worldwide industry for 'cannatourism'. The production and manufacturing of hemp-based products has the potential to foster new skills development in agro-dependent communities. The hemp industry can help address the negative effects of rural poverty and can combat greenhouse effects within existing resource intensive industries in the Eastern Cape.

The spatial concentration of agricultural nodes located in the Chris Hani District, the Wild Coast special economic zone, the Amathole district particularly in Great Kei, Amahlathi, Buffalo City and Mnquma municipality are key development nodes for the hemp industry. The OR Tambo district offers localities in the Nyandeni, Mhlontlo and Mibizana Municipality. A suggestion mentioned by New Frontier Data (2019), is that specialized hemp-based product development programs can identify and create key competitive advantages stimulating the green industrial movement by involving local manufacturing for

international exports. The specialization could include hemp bio-based automotive parts and hemp-based bioplastics for packaging and with different alternative components acting as plastic substitutes. These can harmonize with the automotive manufacturing sectors in the Eastern Cape whilst being a potential opportunity for trade by using the Ngqura shipment port and the Tambo Springs gateway project. Therefore creating an economic identity in the Eastern Cape as forming part of the bioeconomy contributing to sustainable hemp practices.

The Eastern Cape Hemp Pilot Project Initiative (ECHPPI)[25] conducted hemp trials to ascertain whether hemp was a viable crop for agricultural production in the Eastern Cape. The Phase one timeline was from 1999-2005. A total of 15 community farms and 6 research sites were selected for the trial. The pilot project performed in the areas of creating low THC cultivars with a high fibre yield, optimised the cultivation methods, identified strategic agro-ecological areas and guided industrial applications for specific market entry products. Furthermore, the results from the pilot study concluded that hemp is a feasible product for further development. This coerced the National Hemp Foundation to enact commercial research trials for 2010 to 2015 (Sotana, 2013). In order to enable better operations for farmers, specific strategic interventions were identified for hemp farms, such as; funding from government departments for security, labour, and irrigation. In addition, SAHPRA must grant permits before September 2020 in order to allow farmers to sow before the summer season in South Africa. At the time of writing this paper, the legal arm of the government for hemp cultivation has been passed to the DAFF in September 2020. This allows for hemp to be regarded as an agricultural crop for multiple uses rather than as a medicinal product.

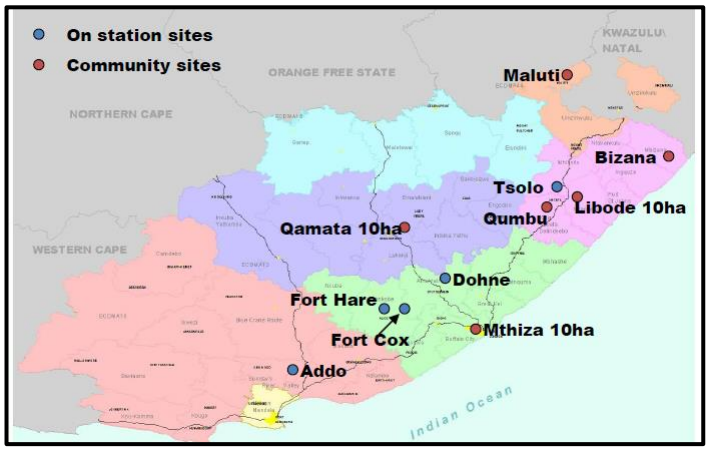


Figure 20: Locations of hemp pilot projects in the Eastern Cape

The advocacy of the CDCSA the CDCEC[26] and the Green Eastern Cape Professional Cannabis and Hemp Consortium supports the opportunity for an educational and hemp developmental program. Matavire (2020) confirms the notion that the Eastern Cape government has commenced with the development and legal aspects involving the development of a potential 'Cannabis College'.

[25] Further information regarding the cultivation practices will be discussed in the contextual analysis.

[26] Cannabis Development Council South Africa and Cannabis Development Council Eastern Cape provides a regulated platform to enact positive and meaningful change for hemps socio-economic, environmental and industrial integration into the formal economy.

3. Contextual analysis of the Eastern Cape Province

The research explores an integrated approach of biophysical, climatic and provincial policy data of the Eastern Cape coupled with scientific journal articles to determine the viability of industrial hemp farming in the Eastern Cape. These will be centred on the demographic analysis, climatic analysis and agro-ecological overview of the landscape to support sustainable commercial and smallholder hemp production.

The Eastern Cape is divided into seven district municipalities which cover an area around 169 000km^2 and is the second largest province in the country. The province is characteristically seen as an area for farming cultivation with large portions of the province holding potential for agricultural investment. The reputable status of the Eastern Cape is the rich biodiversity of fauna and flora and now recent threat of land degradation is impacting the ecosystem.





The features of the Eastern Cape which will highlight the opportunity for hemp agriculture is the high agricultural potential, inter-provincial outward migration, favourable meteorological patterns, industrial local manufacturing and agro-processing centres for an export-orientated and local industry.

The opportunity to integrate hemp agriculture with viable product development can synergise with various inter-sectoral industries to address various over-arching provincial challenges. The challenges pertain to a lack of employment opportunities and localised manufacturing, the need for farmer empowerment, a sub-standard educational performance and a lack of government capacity. The opportunity to integrate hemp as a viable crop will intersect with inter-sectoral government departments such as agriculture, environment, industry, education and health.

3.1. Development indicators

The following analysis contributes to a comprehensive socio-economic model of the Eastern Cape and how it pertains to hemp agriculture. All of the maps below were created using Quantec Easydata as a statistical data source. The maps were configured using QGIS and Python to generate the data layering process.

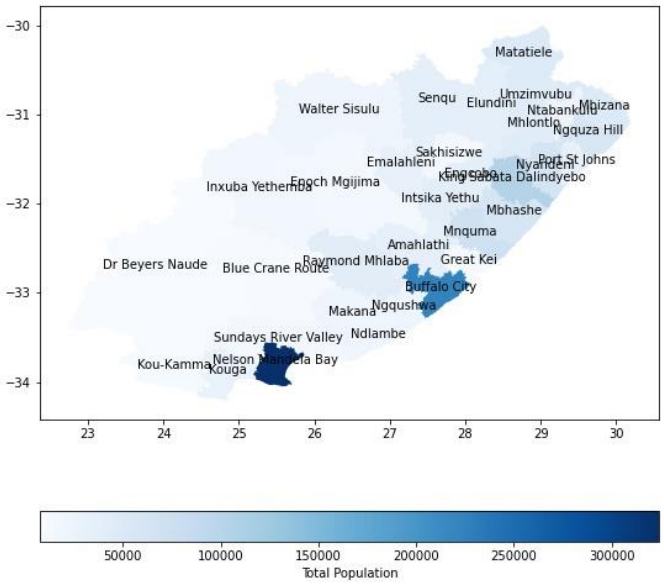


Figure 21: Total population

The map indicates the population density in the Eastern Cape. With the most dense district municipality being Nelson Mandela Bay followed by Buffalo City. The rest of the province has scattered population densities. This displays the intra-provincial migration towards economic agglomeration with better service deliveries, thereby providing an opportunity to develop labour-absorbing industries in these densely populated regions.

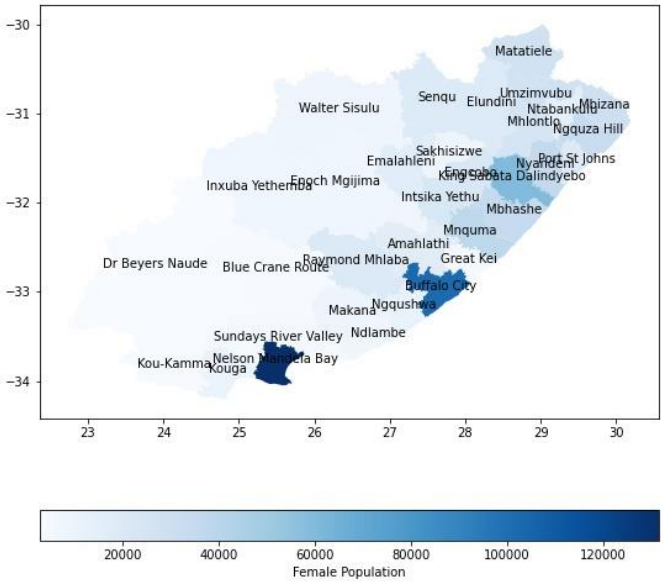


Figure 22: Total female population

The map shows a high number of females reside in Nelson Mandela Bay and Buffalo City with King Sabata Dalindyebo having a fairly dense female population.

These statistics further represent the intra-provincial migration of women from economically and geographically isolated rural areas towards places of economic agglomeration in order to gain employment and achieve a higher quality of life with access to basic services. This supports the need for local regional women empowered hemp value-chain development programs.

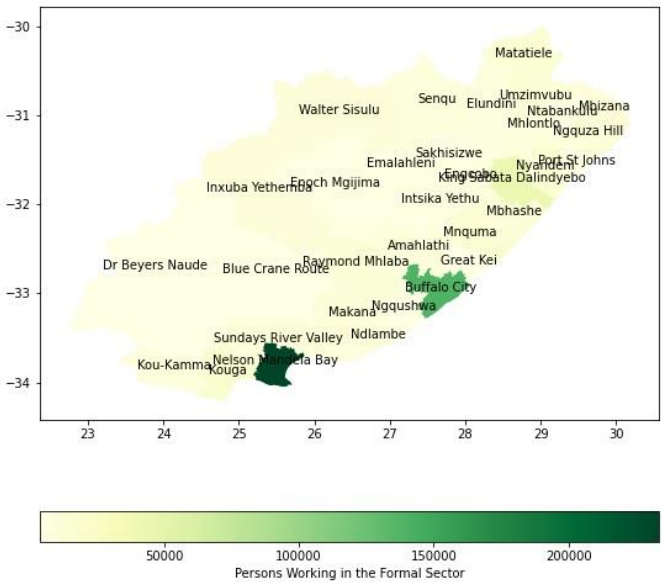


Figure 23: Persons working in the formal sector

The map indicates the concentration of people working in the formal sector in the Eastern Cape. It displays Nelson Mandela Bay and Buffalo City as having the highest and second highest concentration of formally employed citizens.

The map displays the lack of employment in the formal sector outside of Buffalo City and Nelson Mandela Bay. This urges the Eastern Cape to develop an inclusive formal economy which can contribute to the economic rejuvenation of the province.

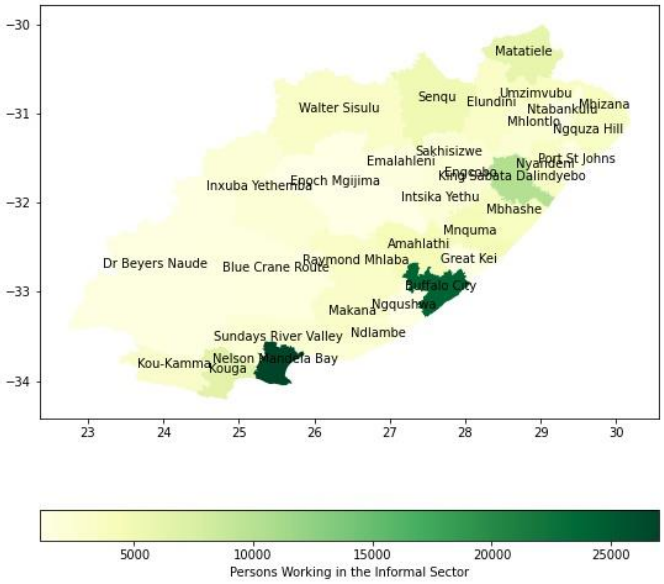


Figure 24: Persons working in the informal sector

This map displays a more dispersed informally engaged citizenry. With the concentration in Nelson Mandela Bay, Buffalo City and King Sabata Dalinyebo municipalities. This suggests the opportunity of attaining economic gain in the most urban municipalities. This further shows the lack of viable economic infrastructure for rural areas. Therefore suggesting an opportunity for agro-rural intervention to invest in the training of skilled labour whilst uplifting various agro-rural communities through hemp agriculture.

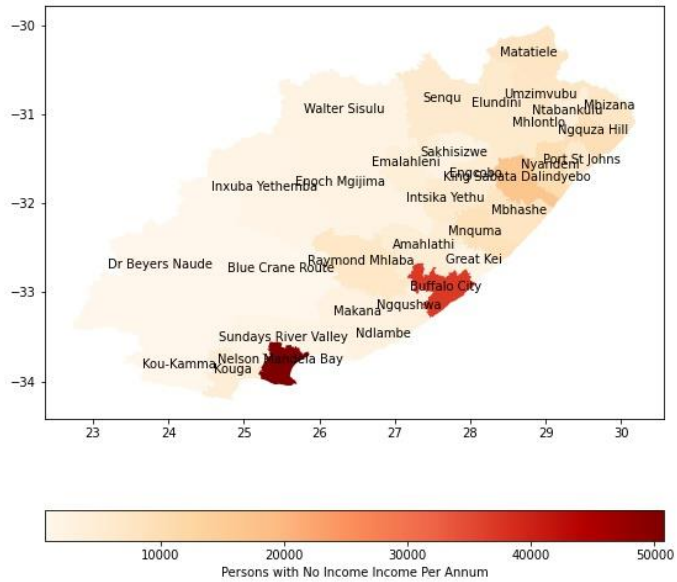


Figure 25: Persons with no income per annum

The following maps indicate the mean annual income for the population within the Eastern Cape.

It indicates that there is a concentration of citizens within Nelson Mandela Bay and Buffalo City, further displaying a fairly evenly spread range towards the North Eastern Coast (Gold Coast) in the Eastern Cape. R This represents the need for strategic intervention in these municipalities.

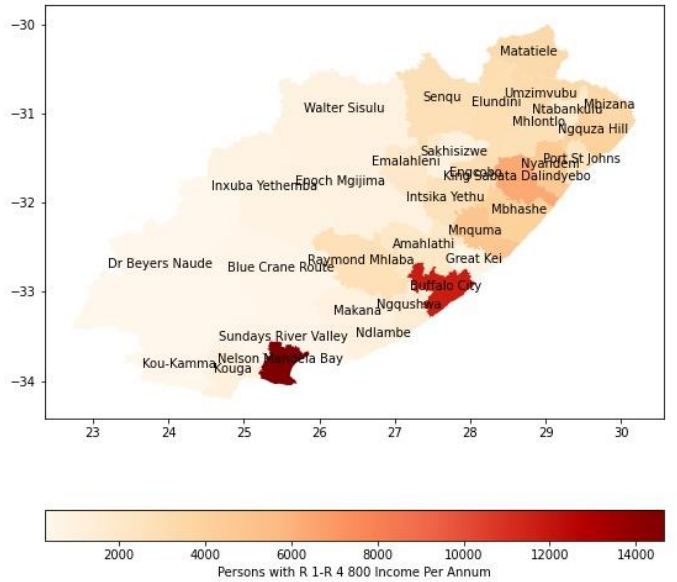


Figure 26: Persons earning R1 – R4 800 income per annum

This displays the lowest bracket of traceable income. The data represents a below the poverty line indicator which is used to gather an interpretation of where the most economically displaced and unequal prioritisation of economic development has occurred within the province. This is analysed in order to align the proposed intervention of agro-rural rejuvenation and hemp agriculture with strategic agro-processing manufacturing infrastructure in specific regions.

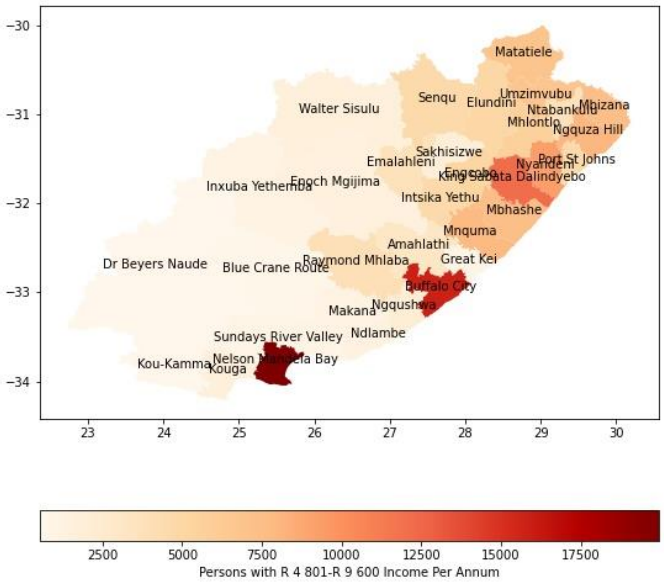


Figure 27: Persons earning R4 801 – R9 600 income per annum

The map further represents the severity of economic deprivation which occurs in the Eastern Cape. The municipalities of:

- Nelson Mandela bay
- Buffalo City
- Mnquma
- Mbhashe
- King Sabata Dalinyebo
- Nyandeni
- Engcobo
- Ngquza Hill
- Mbizane
- Matetiele

require strategic economic intervention and economic opportunities to uplift the income status of the majority of residents whom reside within the municipalities.

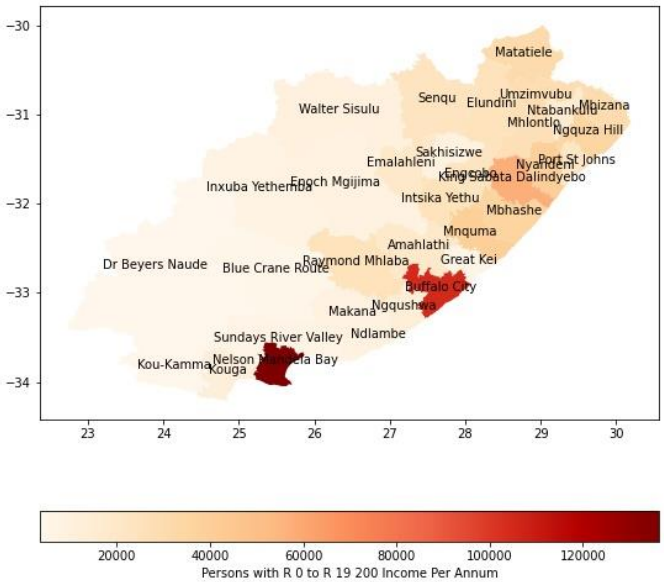


Figure 28: Persons earning between R0 – R19 200

A wider range of income disparity was chosen for this map. Income revenue per annum ranging from R0 to R19 200 is spatialized in this map.

The spread of individuals along the Gold Coast displays the need for strategic economic development within this region of the province.

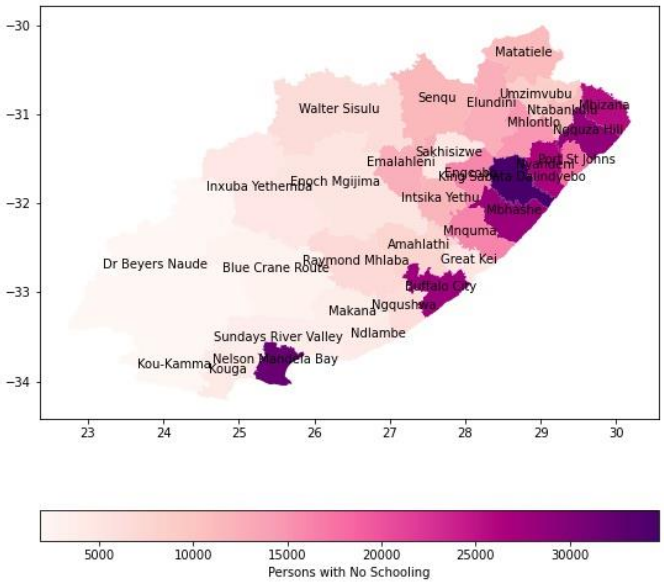


Figure 29: Persons with no schooling

The following maps show the various levels of education within the province. This development indicator was chosen to display the grass roots levels of education and the low standard of education within the Eastern Cape. This can be integrated with the opportunity for agro-rural hemp intervention due to an increase in parent's income from hemp agriculture or any downstream value-addition employment opportunities thereby allowing for enough economic revenue to afford school throughout the child's upbringing.

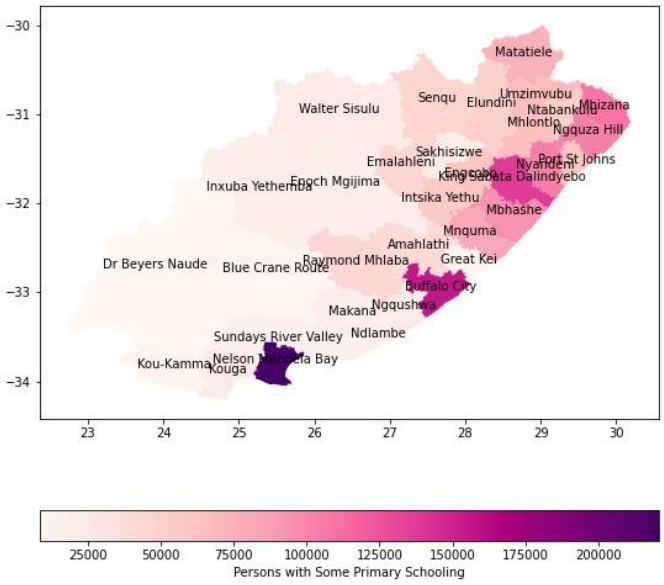


Figure 30: Persons with some primary schooling

The map indicates the range of some primary schooling for individuals in the Eastern Cape and it is important to scrutinise this map in relation to the population densities map. However, this map suggests that some primary schooling ranges predominately along the Gold Coast.

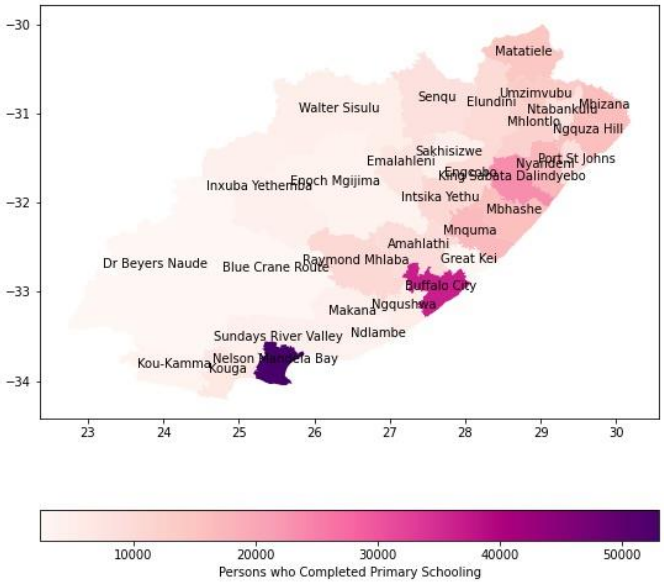


Figure 31: Persons who completed primary schooling

This map forms part of the analysis of the previous educational demographic spatial depiction. The varying degrees of completion of primary school throughout the province is a social challenge for the educational standard within the Eastern Cape.

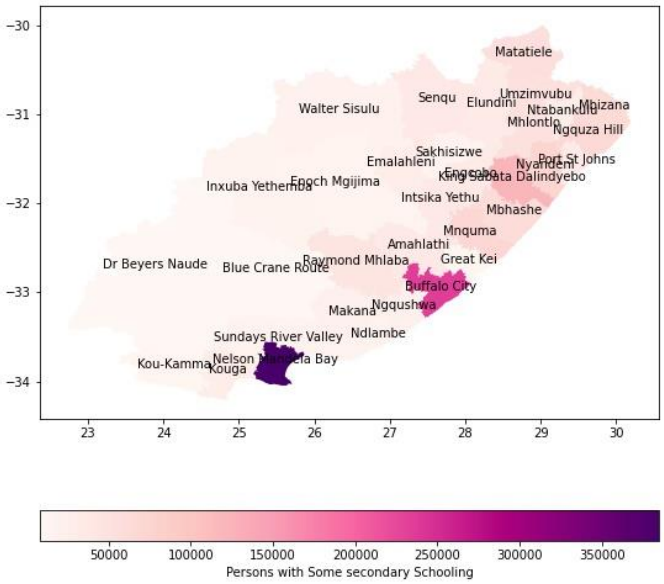


Figure 32: Persons with some secondary schooling

Figure 32 depicts an assessment of the standard of education within the Eastern Cape. The map displays Nelson Mandela Bay and Buffalo City with the highest percentage of citizens with some secondary schooling. This is due to the accessibility of secondary schooling services available within these district municipalities. However, this map infers the need for a strong educational development program.

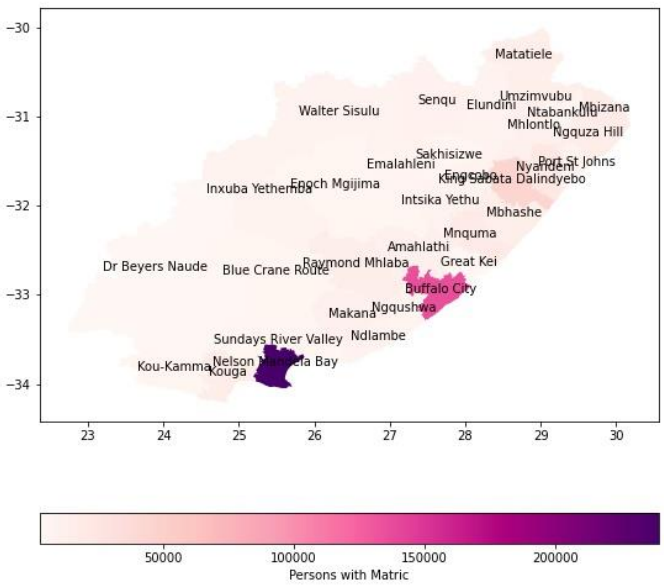


Figure 33: Persons with Matric

The map represents persons within the Eastern Cape who have completed Matric. This spatial depiction aligns with the access to educational facilities which are in Nelson Mandela Bay and Buffalo City. Therefore this postulates that there is a lack of standardized matric facilities and educational programs in the other parts of the Eastern Cape, thereby showing the high unemployment rate within the Eastern Cape and the unusually high availability of unskilled labour as opposed to other provinces.

The specific spatial demographic data above was chosen to display the education standard, gender concentration, annual income and formal versus informal status per municipality. These variables geographically display the areas where the opportunity to intersect the access to opportunity through the hemp value-chain can be targeted. However, this is also dependant on the following the data shown in the next section. The socio-spatial data is indicative of the economic and demographic status of the Eastern Cape and represents the need for transformative and inclusive localised labour-absorbing economies of scale. Industrial hemp cultivation, processing and manufacturing and retail-related market access has the opportunity to provide spatial economic equality of opportunity whilst providing being an enabling industry to provide sustainable generational income for the Eastern Cape.

The two most densely populated municipalities are Buffalo City and Nelson Mandela Bay. Therefore the need for large scale industrial processing and manufacturing of raw hemp biomass should be located within these municipalities. The biophysical data following will indicate the regions which are climatically conducive for the cultivation of industrial hemp.

3.2. Biophysical Properties

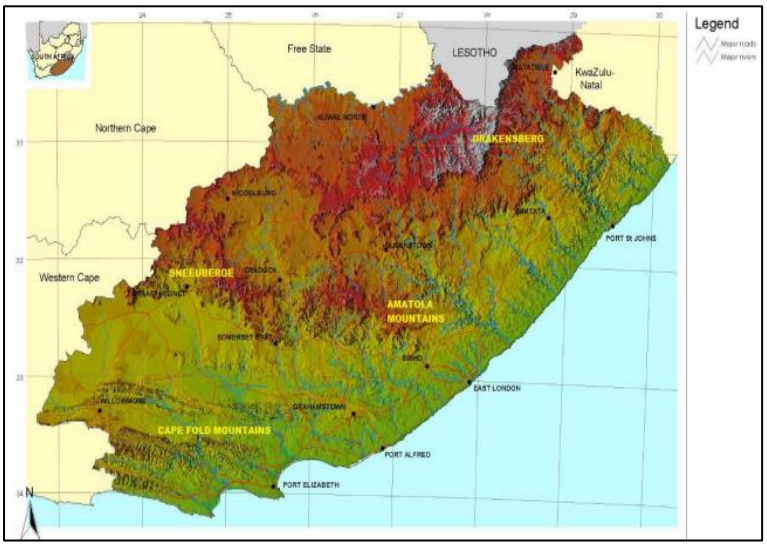


Figure 34: Topography of the Eastern Cape

The northern region of the Eastern Cape is categorised by the mountainous rise of the escarpment whilst the coast predominately consists of steep gorges with river mouths entering the ocean. The shallow plains of the Drakensberg mountain range offer conditions prevalent for hemp agriculture whilst the eastern coastal region consists of a more conducive landscape.

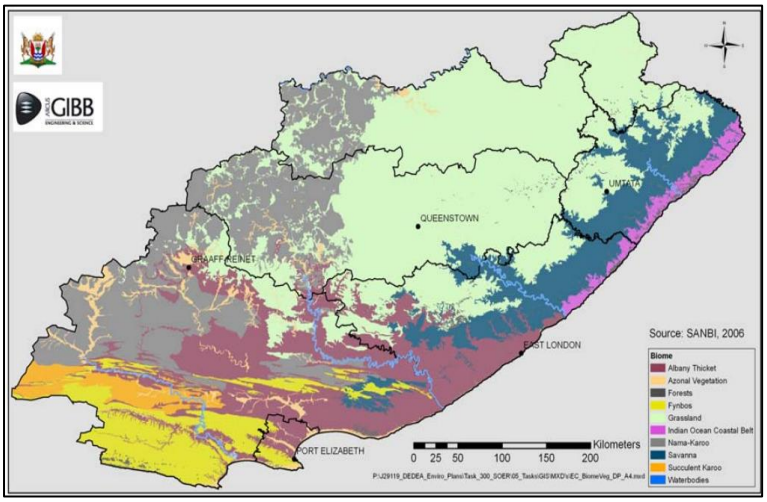


Figure 35: Biomes of the Eastern Cape

The numerous biomes of the Eastern Cape offer a unique opportunity to grow hemp which work with nature and in harmony with the climatic conditions to stimulate viable hemp production.

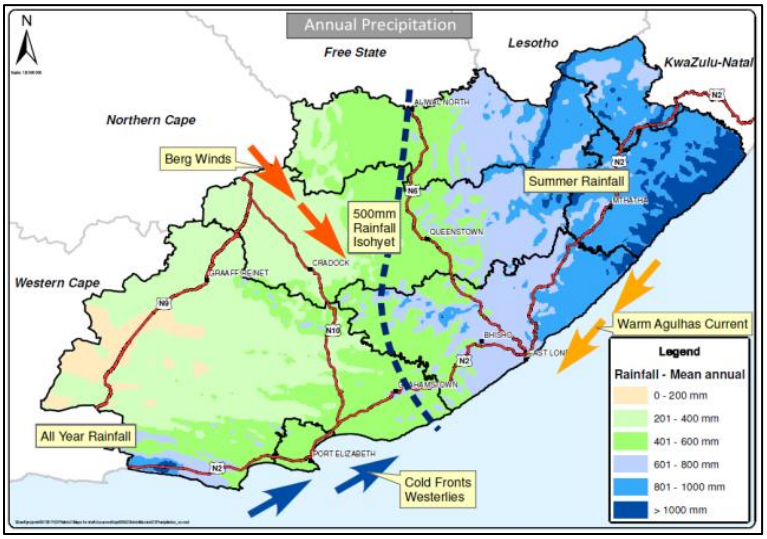


Figure 36: Mean Annual Rainfall

The Eastern Cape has a bimodal rainfall pattern (winter rainfall in the western region and summer rainfall in the east). This impacts the understanding of growing periods for hemp cultivation, thereby favouring the eastern region for hemp cultivation with the summer rainfall pattern. Furthermore, the image below shows the rate of evaporation in the Eastern Cape confirming the least evaporation in the eastern and coastal part of the province.

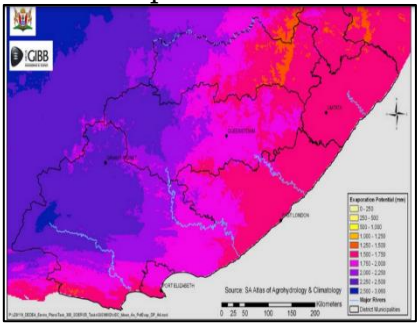
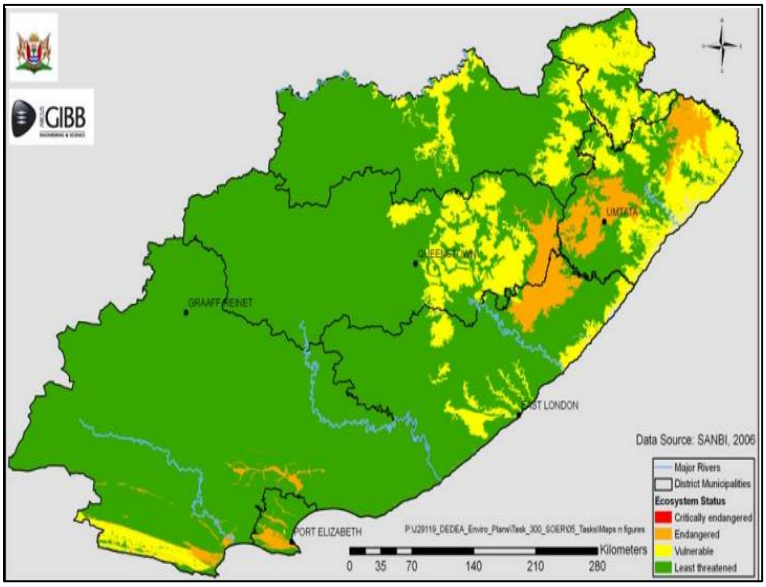
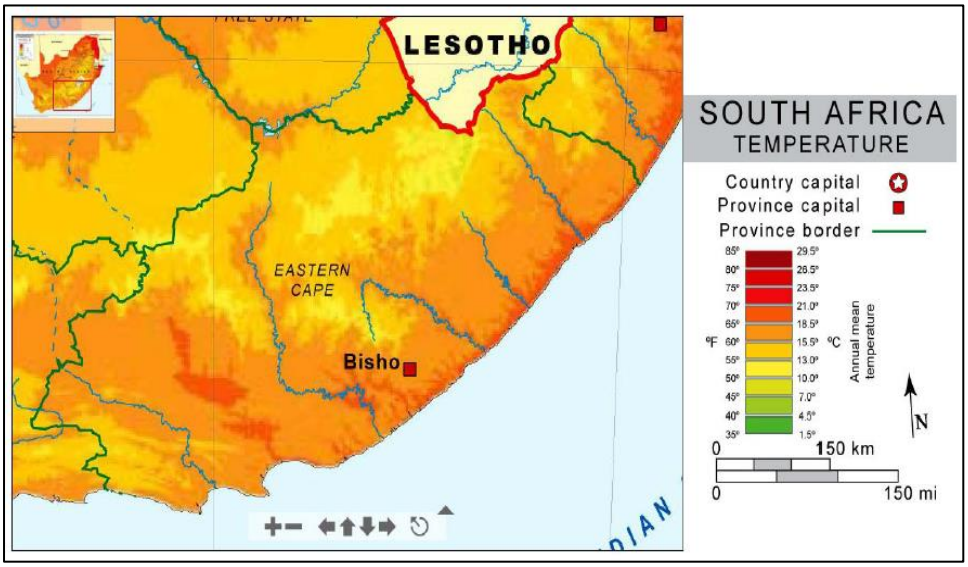


Figure 37: Potential evaporation



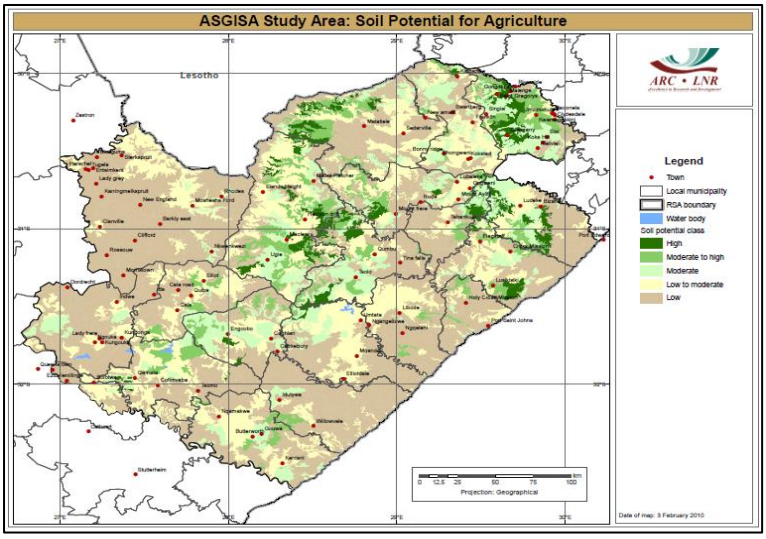
This map highlights the ecosystem sensitivity in the Eastern Cape. It displays the status of the land in terms of its vulnerability and terrestrial ecosystem status. This shows an endangered region encompassing the north eastern region of the province whilst being surrounded by vulnerable land status in the yellow demarcated area. However, the majority of land space is considered least threatened

Figure 38: Ecosystem sensitivity



The provincial temperature ranges display cold interior temperatures progressively increasing towards the coastline. The cold interior coupled with the Nama-Karoo biome may hinder the possibility of viable hemp agriculture in this region. The coastal region bodes well for the integration of hemp agriculture based primarily on the temperature range rates.

Figure 39: Eastern Cape average spatial temperature range



This map indicates the soil potential for agriculture from the perspective of the Agriculture Research Council. This displays the north eastern region and mid-land region as having the highest potential for arable agriculture.

Figure 40: Soil potential for agriculture in the Eastern Cape

3.3. Competitive and Comparative advantages

i) Physical properties

1. Access to ports

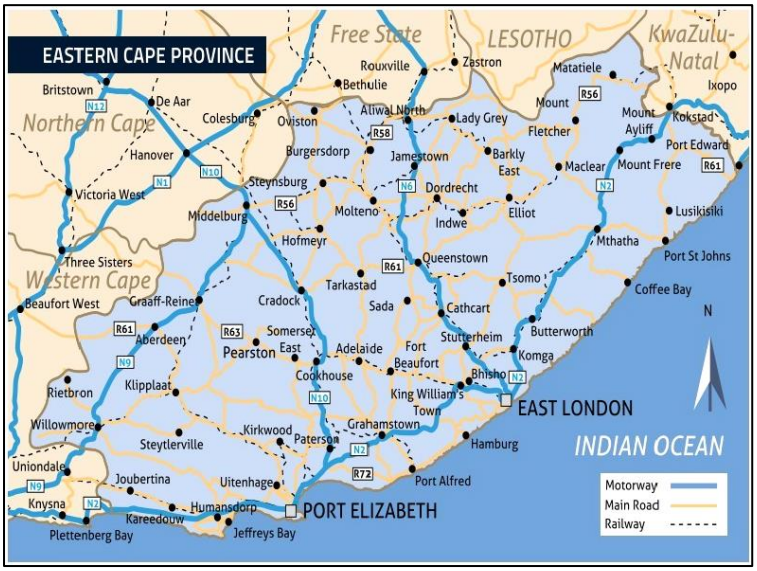


Figure 41: Intra-provincial movement network

The transport network map indicates the importance of the three major ports in the Eastern Cape being Port Elizabeth, East London and Ngqura port. The Eastern Cape Business (2019) earmarked that a provincial economic advantage for the Eastern Cape is the manufacturing and exporting of components in the automotive industry. East London has a competitive advantage of exporting a high number Mercedez-Benz vehicles whilst both manufacturing facilities in Uitenhage (Volkswagen) and East London (Mercedez-Benz) comprise of a vital industrial assets and revenue for provincial economic growth. The foreign direct investment from two Chinese vehicles manufacturers in Coega Industrial Development Zone, First Automotive Works and Beijin Automobile Corporation create a total of R16.1-billion invested into Volkswagen and Mercedez Benz in the Eastern Cape. Eastern Cape Business (2019:36) states that:

"The Eastern Cape manufactures half of the country's passenger vehicles and provides 51% of South Africa's vehicle exports. The sector accounts for over 40 000 formal jobs in the province."

The opportunity to intersect the production of hemp-based biocomposite panels and interior parts for automobiles can provide a sustainable identity for the manufacturing process in the Eastern Cape. Hemp-based biocomposite materials can link with the African Biomass Company which collects agricultural debris and other offcuts and upcycles them into many usable forms (Eastern Cape Business, 2019). Furthermore, the proximity to these ports provides a reduced logistic cost for hemp-based product exports. The opportunity for agro-processing facilities to link logistics costs with farmer cooperatives can enable a sustainable export based economy of final hemp-based products to all viable international markets.

2. Amount of arable land

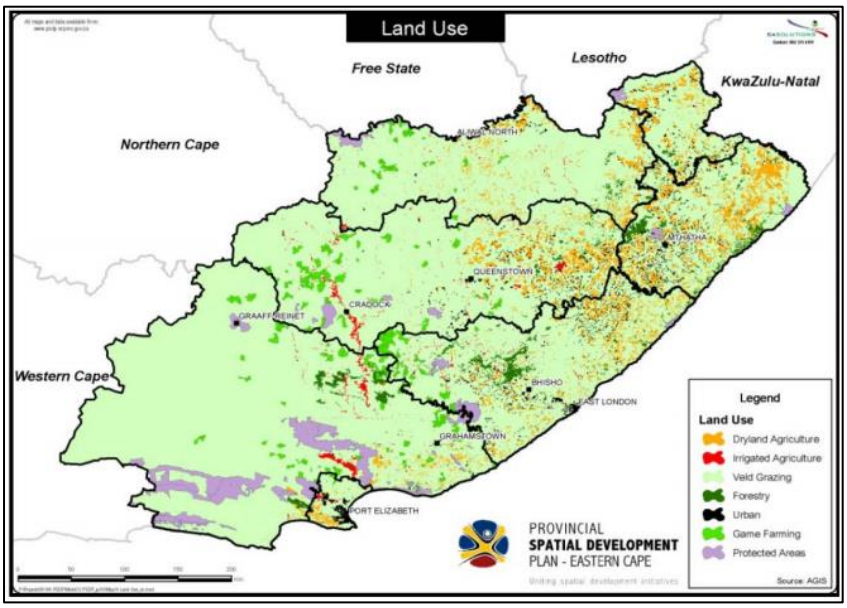


Figure 42: Land Use in the Eastern Cape

The land use map depicts the status of land in the Eastern Cape. This displays dryland agriculture occurring within the north eastern summer rainfall region. This may pose a hindrance for the water requirements needed for hemp farming and livelihood support.

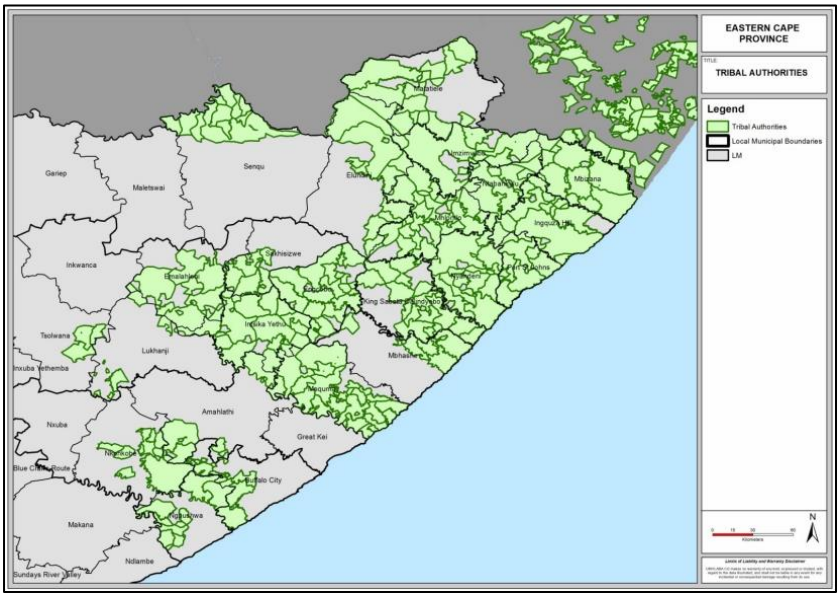


Figure 43: Tribal land in Eastern Cape

The tribal land under consideration further boosts the potential to activate and harness the available arable land. This opportunity can be used to stimulate the viability of the hemp industry to provide enough raw plant matter to establish industrial hemp supply value chains and increase the welfare of the agro-rural communities in the area.

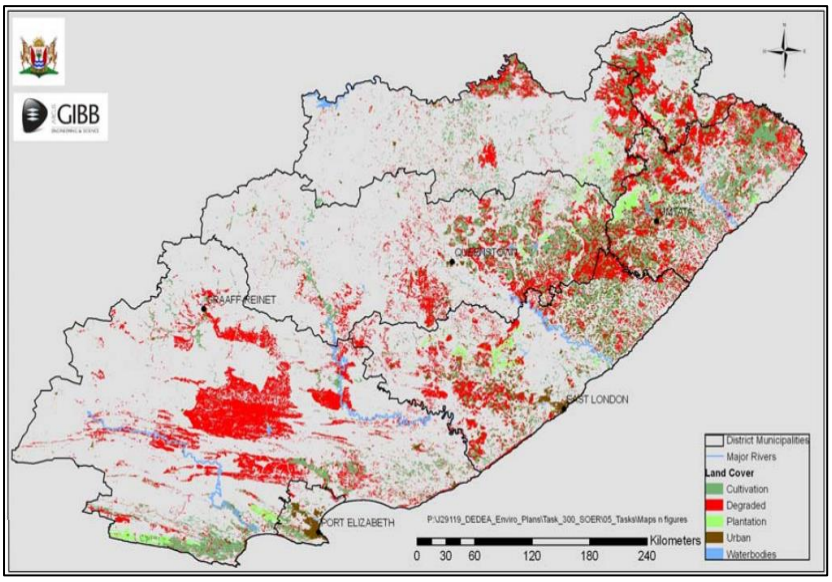


Figure 44: Status of land use in terms of agriculture

The map depicts the farmland status of the Eastern Cape. By integrating the opportunity for hemp agriculture in terms of the data, one can depict the spatial opportunities for hemp agriculture along the coastal zone, yet the need to prioritise hemp farms in terms of their proximity to markets and available logistics infrastructure and agro-processing facilities will be considerable factors when identifying suitable parcels of lands.

3. Spatial concentration of regional economies

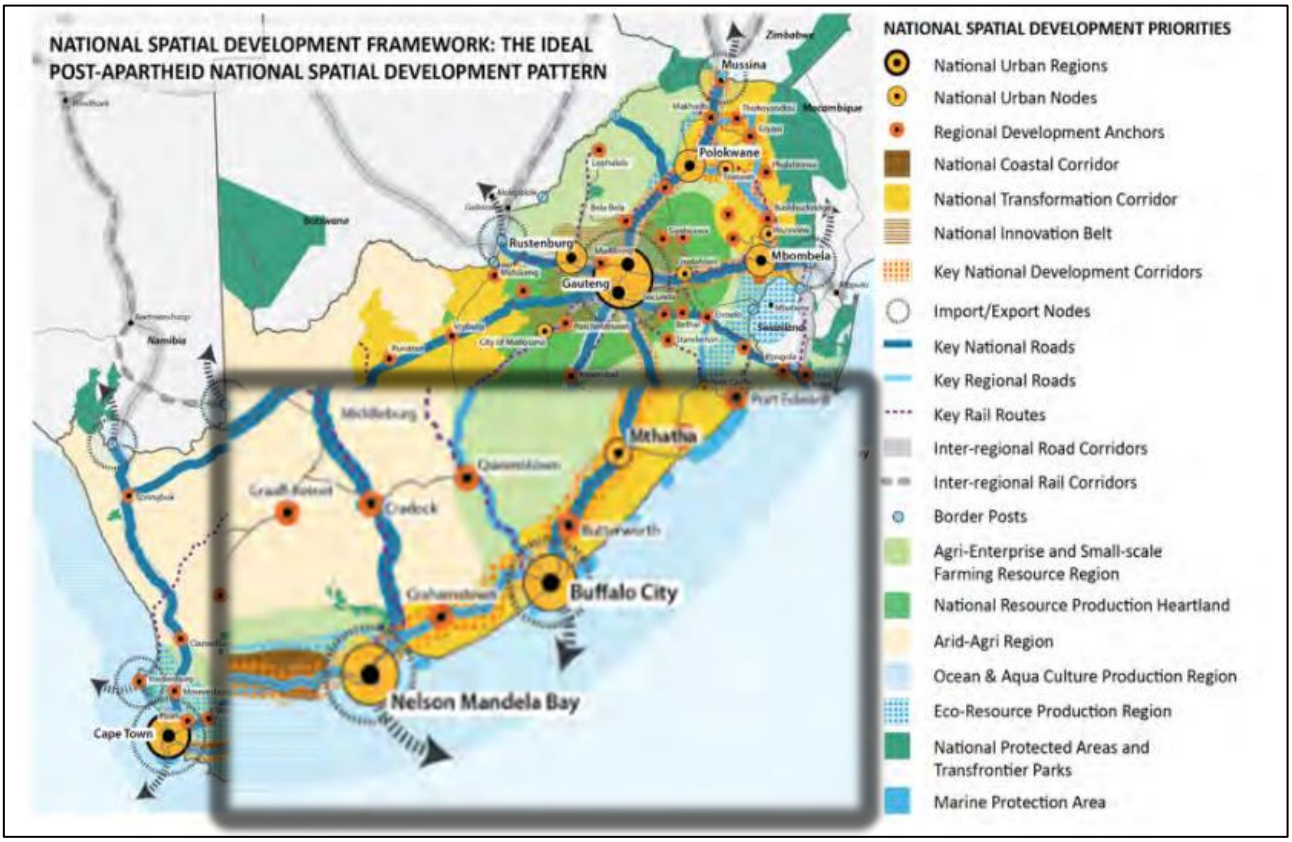


Figure 45: Regional spatial development

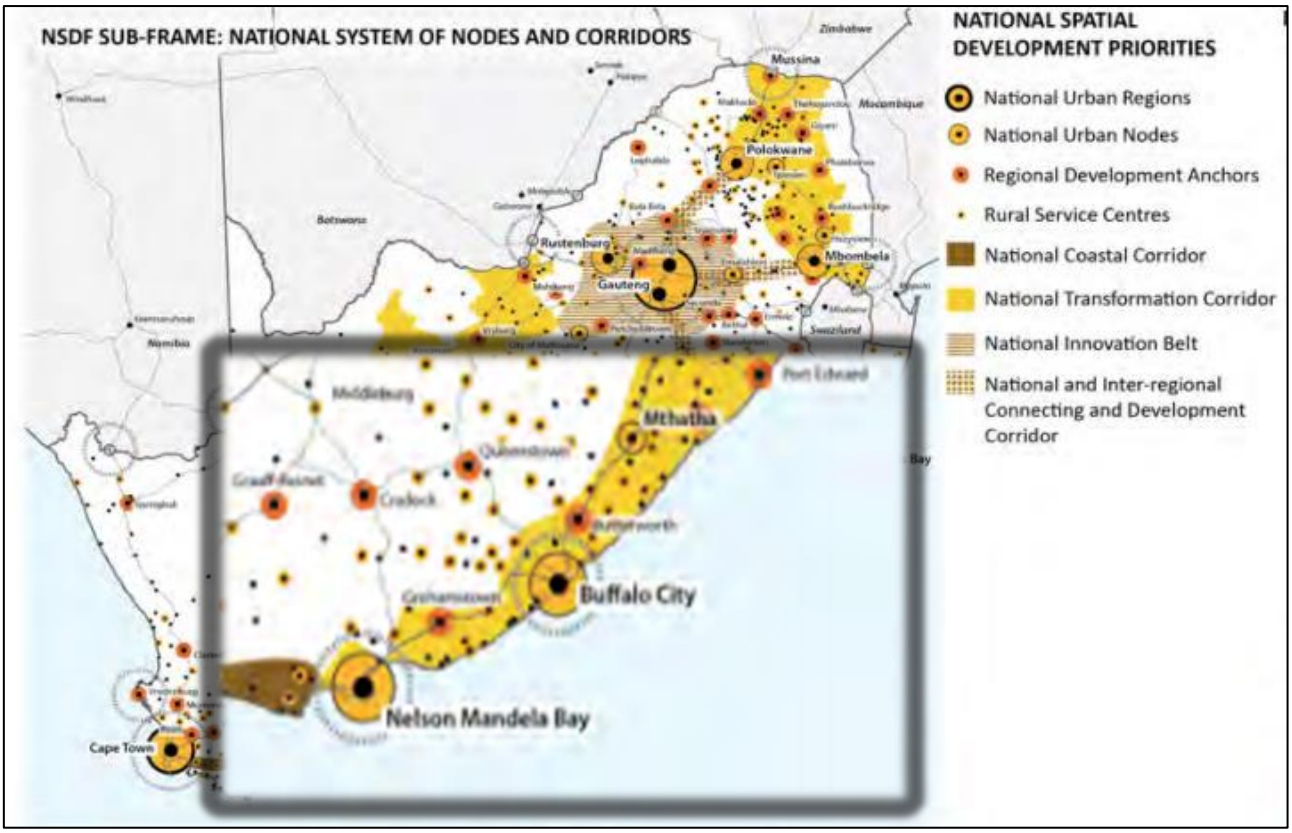


Figure 46: Regional nodal development

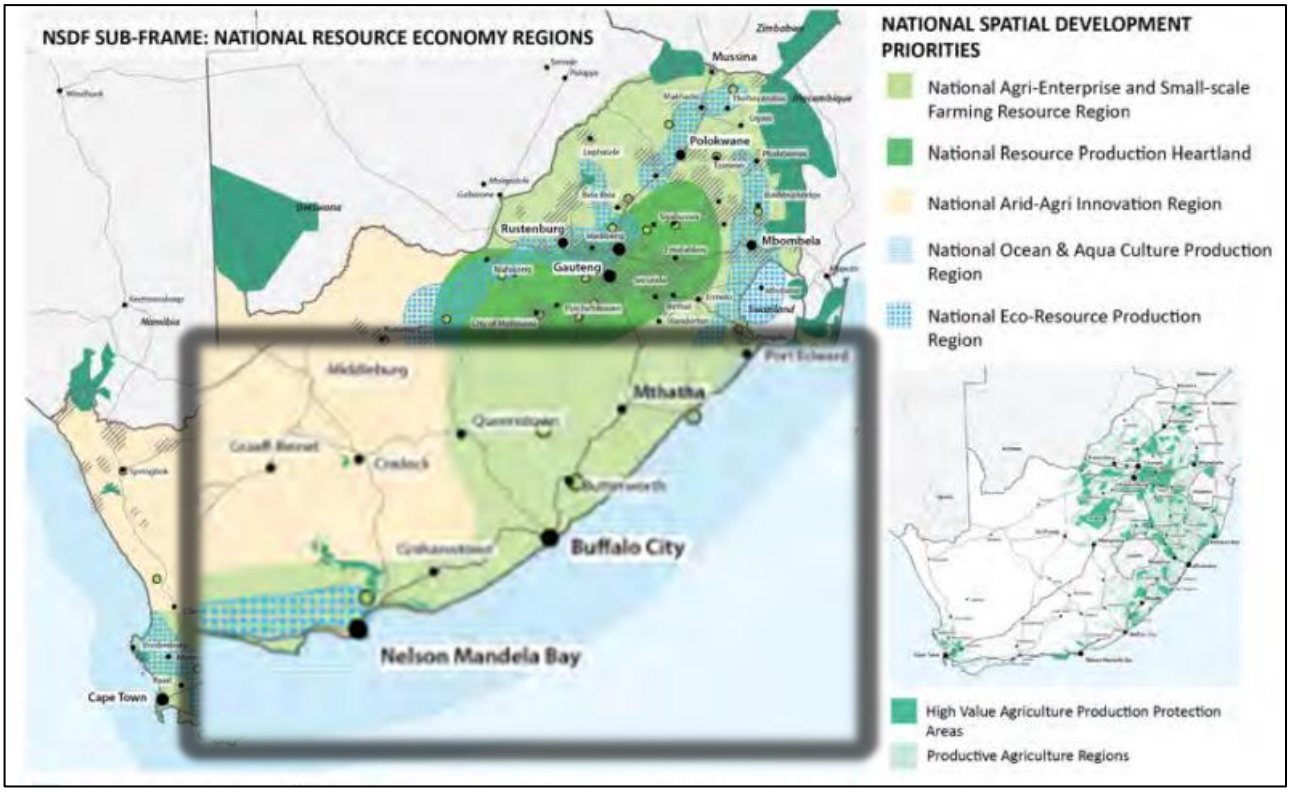


Figure 47: Framing the agricultural land for investment



Figure 48: Policy indicative of potential for agricultural investment

The Coastal Transformation Corridor (CTC) prioritises strategic nodal develop with an integration of agri-enterprise and small-scale farming. The strategic demarcated region for investment aligns with the recent promulgation of industrial hemp and the need to generate revenue within small-scale farming systems. The CTC acts as a vehicle in which hemp agriculture can be packaged from a provincial policy development perspective. Therefore this strategic initiative is a corollary for the implementation of the hemp industry in the Eastern Cape.

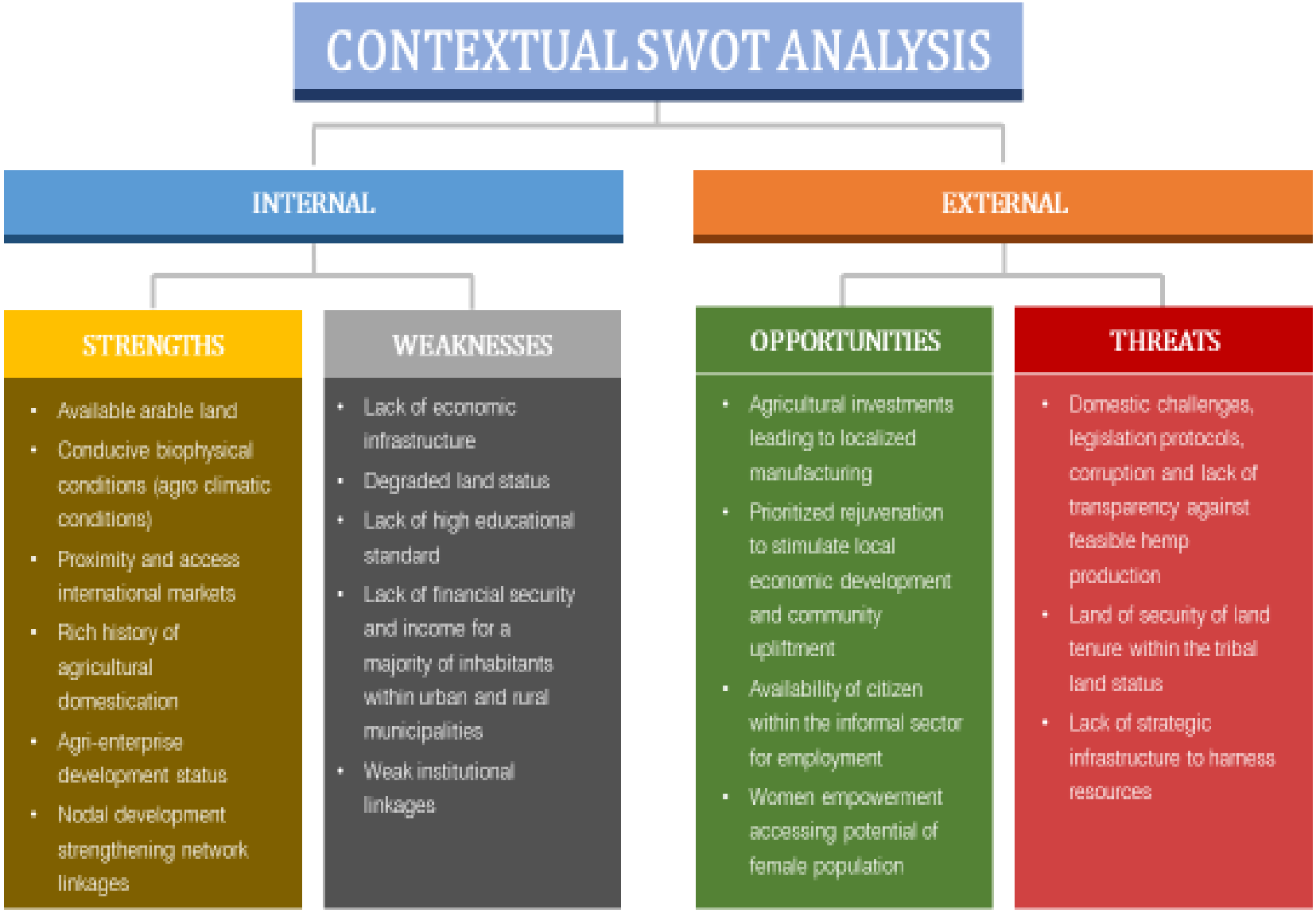


Figure 49: Eastern Cape SWOT analysis based on previous data

ii) Agricultural analysis with a focus on provincial districts and regional communities

The NDP (2011) aims to create labour absorbing employment and economic participation in rural areas with higher agricultural output and support to farmers leading to an 11% increase (1 000 000 jobs) in agricultural related employment by 2030. Reinforcing the need for an expanded and diversified profile of tradeable goods from the agricultural sector. The Eastern Cape Rural Development Agency (ECRDA) (2016) aims to access the dormant potential of the agricultural sector and use it as a vehicle to ignite socio-economic reinvigoration for the rural sector. The ECRDA identified agro-processing as a key asset to increasing the value chain in the agro-rural economy. The key challenges to the implementation and development of these facilities include high mechanisations costs, transport and opportunity costs to markets, low skills base and a lack of access to inputs and support services. However, as a strategic response to the challenges of small-scale farms, the ECRDA established the Rural Enterprise Development (RED) Hubs. The aim is to development primary production and processing whilst partly retaining the circulation of revenue within the community. This strategic agro-rural body prioritises machinery and mechanisation inputs into small-scale farms whilst collaborating with the linkage to market services and the availability of production inputs. The ECRDA RED Hubs have been established in Mqanduli (OR Tambo), Lady Frere (Chris Hani) and Bizana (Alfred Nzo) (ECRDA, 2016).

Sihlobo (2018) identifies five major restrictions against agricultural expansion in the Eastern Cape Province, being climate change, uncertainty of land reform (communal tenure), biosecurity risks, water provisions and inadequate infrastructure development. Sihlobo (2020) identifies some of these challenges as a result of poor alignment between government departments, a misallocation of the budget to agriculture and poor coordination between private sector and government initiatives. Whilst Bennet, Ainsile and Davis (2009) and Davis, Ainsile and Finca (2008)

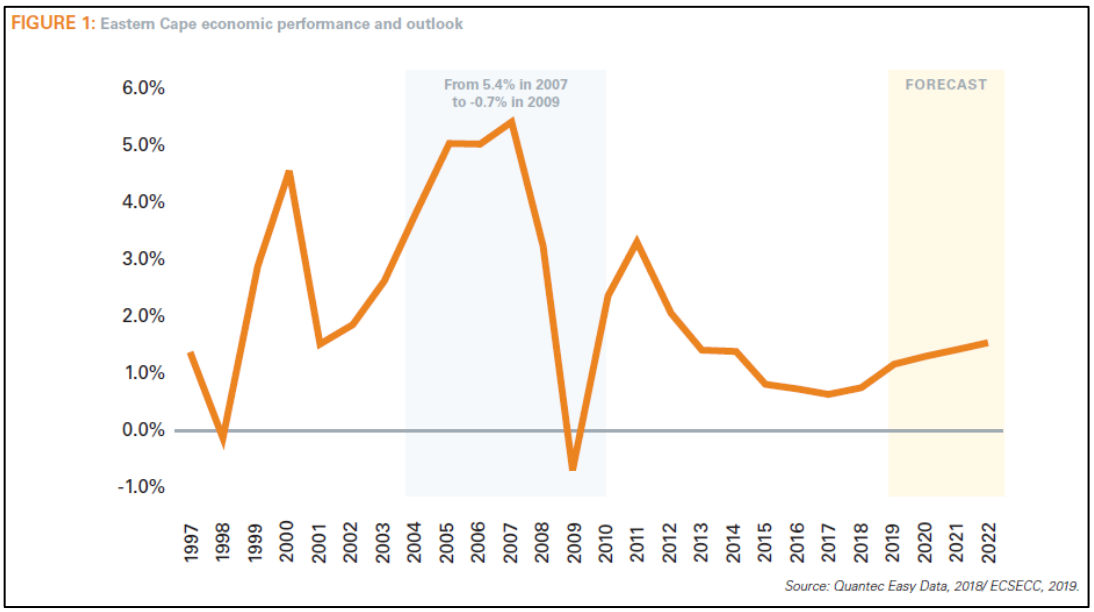


Figure 50: Economic perspective for the Eastern Cape

identify a lack of a guidance and coherence around communal arable lands as a threat to enabling farmer productivity in the Eastern Cape. The Eastern Cape Communal Arable Land Project (ECCALP) aimed to reform and reconnect former communities with their pre-Colonial pastures. Bennet et al. (2009) states that the current restructuring of communal land is due to the Colonial creation of the homelands which enclosed communities and essentially removed them from their farming land. However, poor implementation and complex situations regarding land ownership and allocation is present in agricultural regions in the Eastern Cape. Furthermore, policy certainty for the private sector with regards to land reform will attract investment and boost economic growth through agronomic expansion.

Sihlobo (2020) describes the effects of COVID-19 on the agricultural sector in South Africa. The author emphasises that the agricultural sector has transformative potential if aligned with policy protocols from the NDP (2011). These protocols aim to create stronger infrastructure presence for logistics and agricultural finance. The Land and Agricultural Bank is aimed at cultivating financial security via micro-credit loans to small-scale agriculture through funding from the National treasury and other enterprises. The protocols of the Land and Agriculture Bank are aligned with the targets for the ECCALP, thereby creating a financial and institutional linkage to support and enhance small scale agricultural programs. Kibirige and Obi (2015) mention the Micro Agricultural Financial Institutional Scheme of South Africa (MAFISA) which is aimed at linking farmers with financial aid from banks for increased and improved credit. Furthermore, the Agri-EC is a specific provincial body aimed at agricultural stimulation and policy direction for agriculture in the Eastern Cape. An interesting point mentioned by Sihlobo (2020), states that post-COVID-19 agricultural growth and development will be addressed through the development of under-utilised land in the traditional homelands, boosting export-led product developments and investing in agro-processing value-added supply chains with



Figure 51: Biocomposite textile exports in South Africa

upstream and downstream labour. Furthermore, Tom (2020) investigates the effect of the November 2020 USA Elections on South Africa's credibility within AGOA[27]. The journalist accredits the win of President Biden with a more sympathetic outlook on emerging farmers in South Africa. This correlates with the possibility of strengthening the AGOA trade-deal, however, farmer quality outlook must meet global standards which places the South African industrial hemp industry in a precarious position in terms of its potential economic value.

In the Eastern Cape, various Agri-Park initiatives have been implemented. These are directed in the Butterworth (Amathole), Mtata (OR Tambo District), Matatiele (Alfred Nzo), Lady Grey/Strekspruit (Joe Gqabi) and Cacadu (Sundays River Valley) municipalities (DRDLR, 2015).

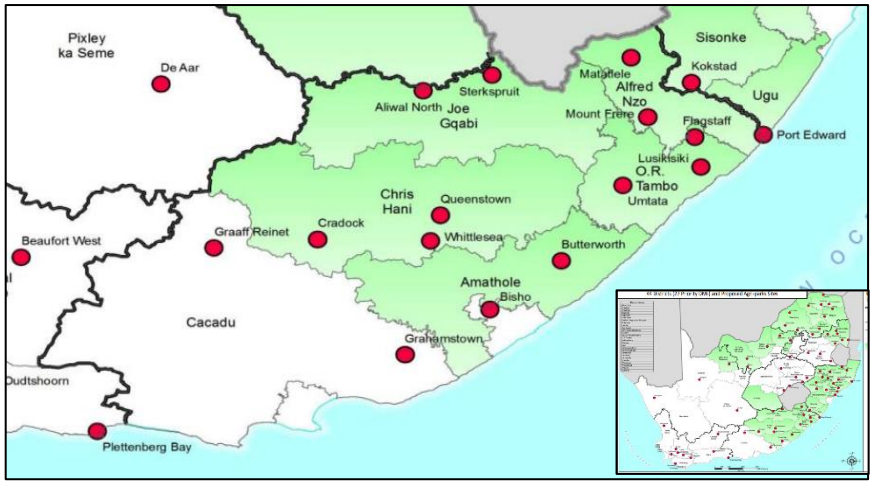


Figure 52: Agri-parks in the Eastern Cape

The physical structure facilitates an Agri-Hub which aims to support rural farmers, develops rural farmer industries operates and act as link for markets with district agricultural production whilst complimenting supply inputs to processing facilities. This coupled with the Farmer Production Support Units (FPSU) which serves as a nodal integration point for rural farmers to remain within a feasible proximity to the commercial hubs, even if geographically disparate. This attempts to distribute the accessibility to markets and counteract the past distortion of unequal productive land distribution. The Rural Urban Marketing Centres (RUMC) aims to connect rural and urban farmers with market intelligence whilst acting as a holding facility for specific products and informing the farmers of feedback from the Agri-hub and FPSU. The diagram beneath illustrates how an Agri-Park can be conceptualised.

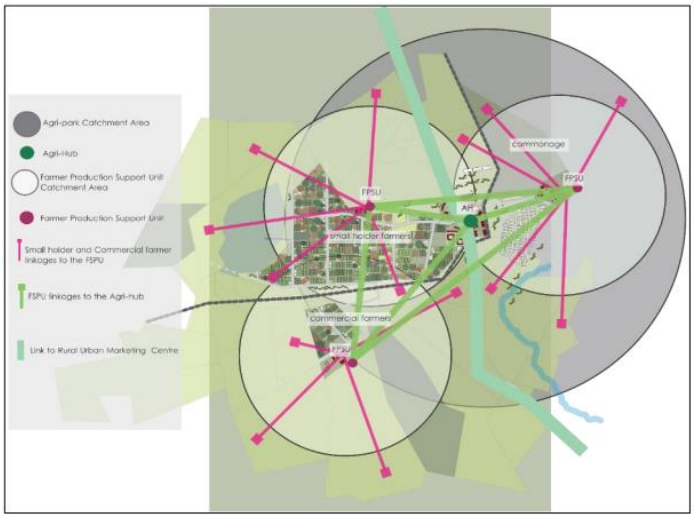


Figure 53: Agri-park design concept

Component	Proposed catchment area in areas of low density population	Proposed catchment area in areas of high density population
FPSU	30km	10km
Agri-Hub	120km	60km
RUMC	250km	150km

The Agri-park concept can be used to develop a model to enable a viable hemp industry.

[27] AGOA (African Growth and Opportunity Act) is design to stimulate stronger relationships and commercial linkages between Sub-Saharan Africa and the United States.

iii) District Municipal agri-analysis

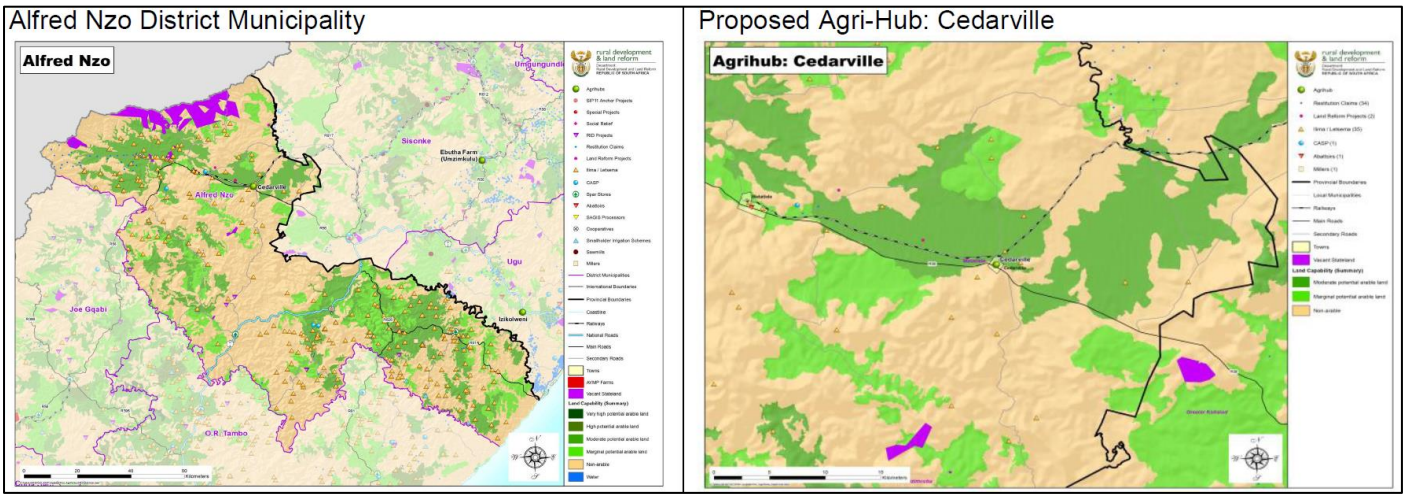


Figure 54: Agriculture contributes 12% to the main economic sectors in the province, with mostly livestock farming. However, the provincial district has high potential arable land for cultivation and has been earmarked for the investment in sorghum, hemp, vegetables and fruit. Therefore the opportunity to synergise investment in hemp agriculture with the proposed alignment of the agri-park and arable land is available (DRDLR, 2019).

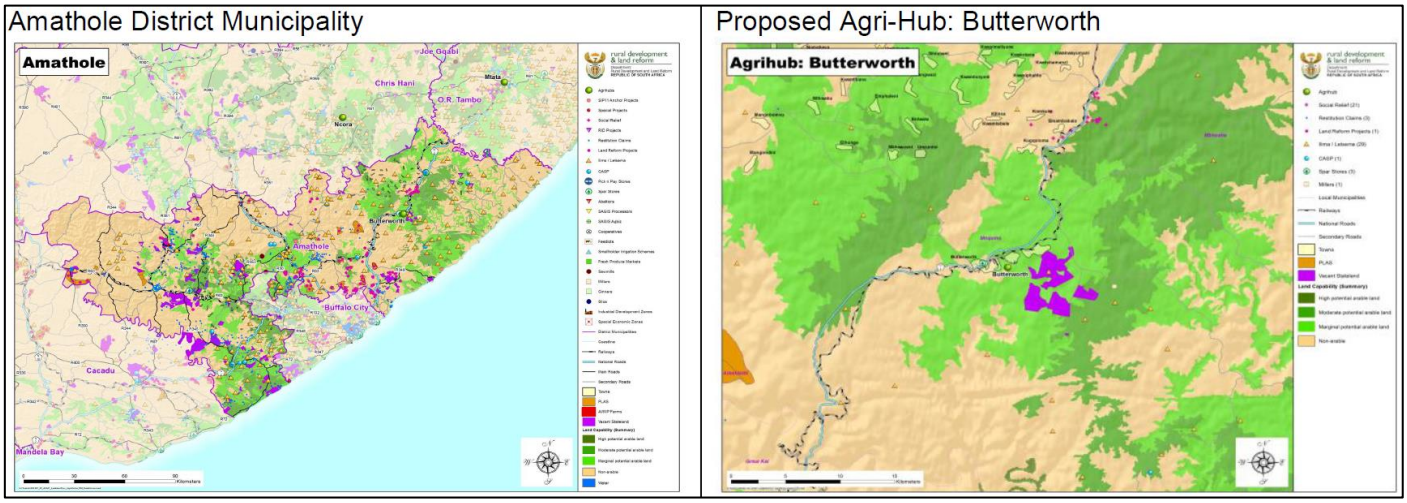


Figure 55: Agriculture contributes 3%, manufacturing 14% and trade 13%. The district province is proposed for an agri-park development in Butterworth due to the close proximity to the N2 National Freeway and the availability of moderate to high potential arable land. Specific challenges such as land of resource input and lack of youth agricultural involvement diminishes investor confidence (DRDLR, 2019).

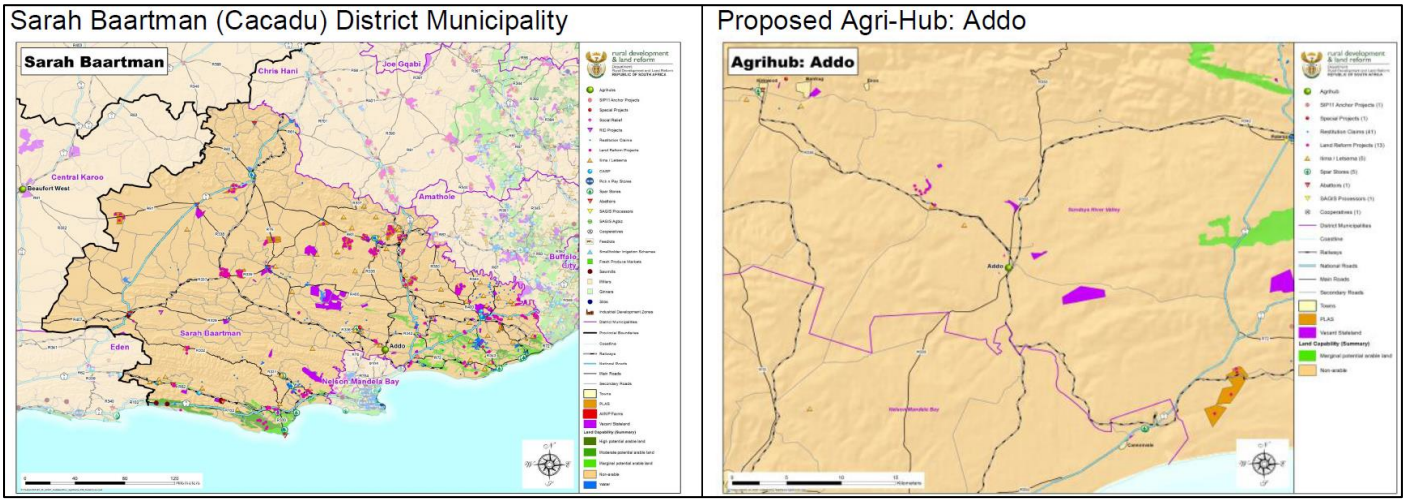


Figure 56: Agriculture contributes 7% of the economic sector. With previous hemp trials occurring in Addo, the region proves its ability to farm hemp for industrial purposes. This can feed into the proposed renewable energy production from biomass in the province (DRDLR, 2019).

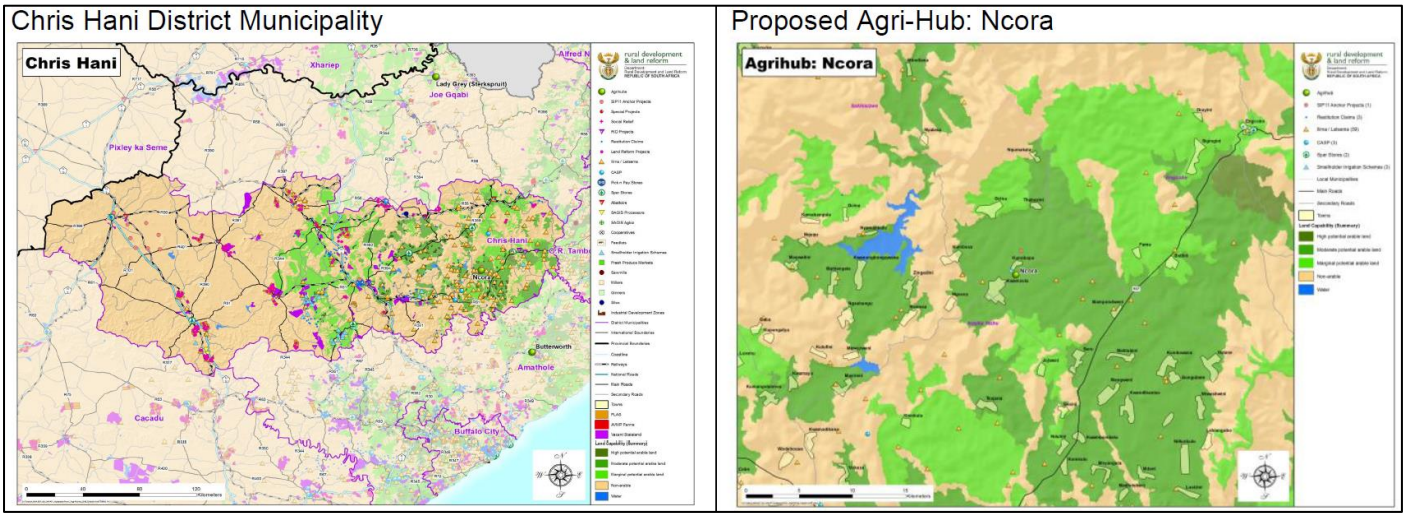


Figure 57: The agricultural sector forms a key potential growth factor the district. However, the sector has received little physical infrastructural investment and therefore there is minimal development for agro-processors in the sector. However, the need to facilitate small-local agricultural growth can be incentivised through collective hemp farming cooperatives in the region (DRDLR, 2019).

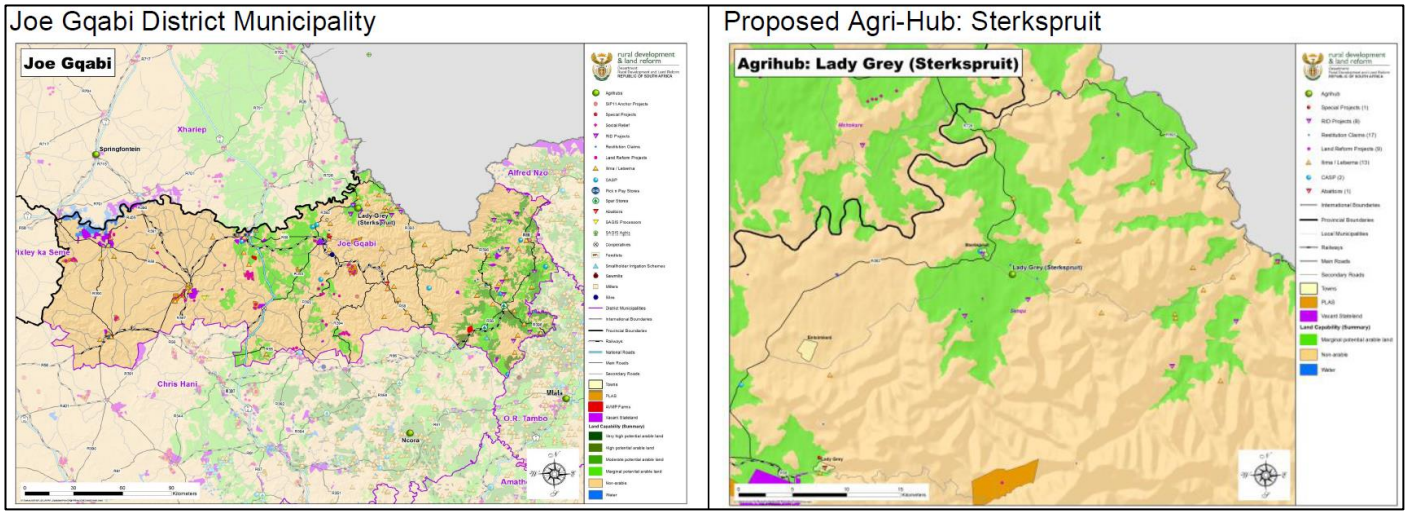


Figure 58: The agricultural sector contributes 6.2% to the district with livestock forming the primary commodity. The availability of arable land, water and transport connectivity propose the investment of hemp agriculture as animal feed thereby increasing the health of livestock. A challenge is to protect arable land from over-grazing, stock theft and encroachment into natural biodiverse hotspots (DRDLR, 2019).

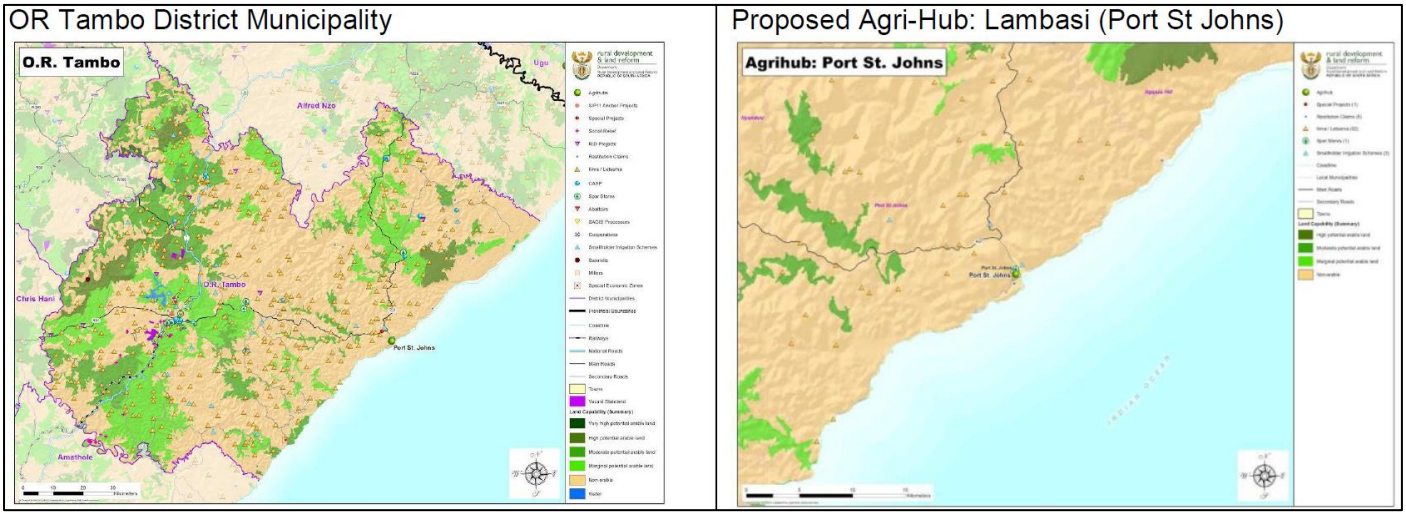


Figure 59: The agricultural sector contributes 3.5% with trade contributing 18.5%. Port St. Johns is earmarked for the development of a district agro-processor. However, land capability with the region is poor and surface conditions of roads limits travel (DRDLR, 2019).

iv) Small-scale agriculture analysis

The shift to small scale agriculture in the Eastern Cape was analysed by Kibirige and Obi (2015) who focus on the efficiency of small holder farmers in the Eastern Cape, conducting methodological studies on the agricultural efficiency of small holder farmers using the Cobb-Douglas production function[28]. The recommendations from this study found that the government needs to address youth employment programs which aim to upskill and development youth economic empowerment in the Eastern Cape. Small holder farmers must utilize cheaper fertilizers and increase the use of improved seed genetics, herbicides and pesticides which allow for an increase in efficiency of farmer output whilst specific small-scale agro-industries should be formed in order to fully optimize the value-addition of an agriculturally active region. Lastly, the alignment of investments from government in agro-industries must be aimed to diversify downstream employment options for rural communities whilst providing a mutually reinforcing increase in the efficiency of farm output compared to the input supplies from targeted government investment (Kiribige and Obi, 2015).

Manyevere, Muchaonyerwa, Mnkeni and Dhau (2017) studied selected soils in the Zanyokwe region[29] in the Eastern Cape to understand what the best management practices would be for smallholder crop management. The study aimed to address yield gaps[30] in smallholder farms. Due to smallholder farmers lacking resources and having poor access to services, the addition of organic and inorganic fertilizers and management of crop residues are inconsistent. Many biophysical constraints affect micronutrient availability in soils, such as topography, climate and parent material yet anthropogenic actions were also found to deter the health of the soil for crop growth. The study aimed to identify the levels of Zinc, Manganese, Iron and Copper in the region which is under the influence of the Zanyokwe Irrigation Scheme. Manyevere, Muchaonyerwa, Mnkeni and Dhau (2017) found that the soil nutrient status under the irrigation scheme lacked zinc which led to inconsistent yield gaps. Whilst the Water Research Commission (2010) identified socio-economic constraints such as a lack of capital and unstable markets which hinder the yield of small-scale farmers in the Zanyokwe region. Furthermore, the constraints relating to agronomic management such as; weed control, plant population management, water management, correct planting time and choice of cultivars were seen as a lack of technical know-how of some small-scale farmers in this region.

[28] The Cobb-Douglas production function measures technical and allocative efficiency using input costs and variables amoungst other data to formulate the efficiency of a farms productivity (Kibirige and Obi, 2015).
[29] In the Amahlati Local Municipality consisting of six villages being Zingcuka, Kamma-Furrow, Lenye, Burnsill, Ngqumeya and Zanyokwe.
[30] Difference between yield potential and long term yield averages

In another study conducted by Ntsonto (2005) focusing on the economic performance of the Zanyokwe Irrigation Scheme, the evidence revealed that weak government institutions and poor extension services of ward members was a major constraint in allowing for the successful progress of small holder farmers in the Zanyokwe region.

Fanadzo, Chiduza and Mnkeni, (2010) discuss smallholder irrigation schemes and the relationship between the performance of these systems and farmer crop management.

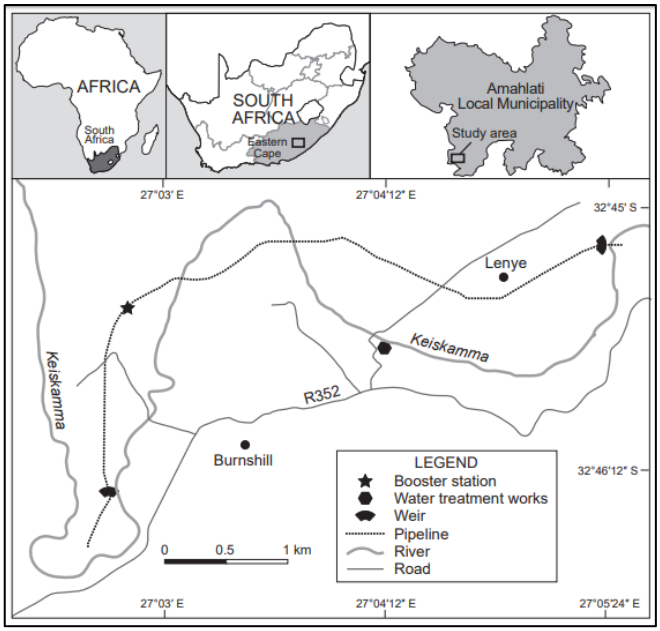


Figure 60: Zanyokwe study region

Figure 61: The capacity of irrigation systems in the surrounding regions

Irrigation scheme	Irrigated area (ha)	Area per farmer (ha)	Number of farmers	Irrigation system	Year of establishment
Zanyokwe	439	4.2	61	Sprinkler	1984
Tyefu	641	0.4	1678	Sprinkler/drag	1983
Keiskammahoek	744	5.1	147	Sprinkler	1976
Shiloh	455	1.6	278	Centre pivot/sprinkler	1970
Qamata	1959	2.0	1000	Flood	1968
Ncora	2490	9.2	272	Sprinkler/drag	1976

Fanadzo, Chiduza and Mnkeni, (2010)found that planting density and crop mix, nutrient management, crop protection, water use and management and crop cultivars and yields and land use intensity are the key crop production practices for farmers. However, in the Eastern Cape, Fanadzo, Chiduza and Mnkeni, (2010) explains the lack of synergistic and comprehensive farmer crop production practices negatively impact the optimum use and sequential productivity of smallholder farms. Smallholder[31] farmers in a South African context have been classified within certain criteria such as; land size, income level, purpose of production and racial grouping (historically disadvantaged) (Pienaar and Traub).

[31] Many interpretations of smallholder farmers are analysed in a South African context (Pienaar and Traub, 2015).

v) Hemp trial analysis

The Eastern Cape Hemp Pilot Project Initiative (ECHPPI) established a three phase[32] rollout scheme for hemp agriculture. The map beneath illustrates the specific sites which were selected for the hemp cultivation processes. These were industrial hemp trial tests to determine whether the Eastern Cape can support hemp crop development.

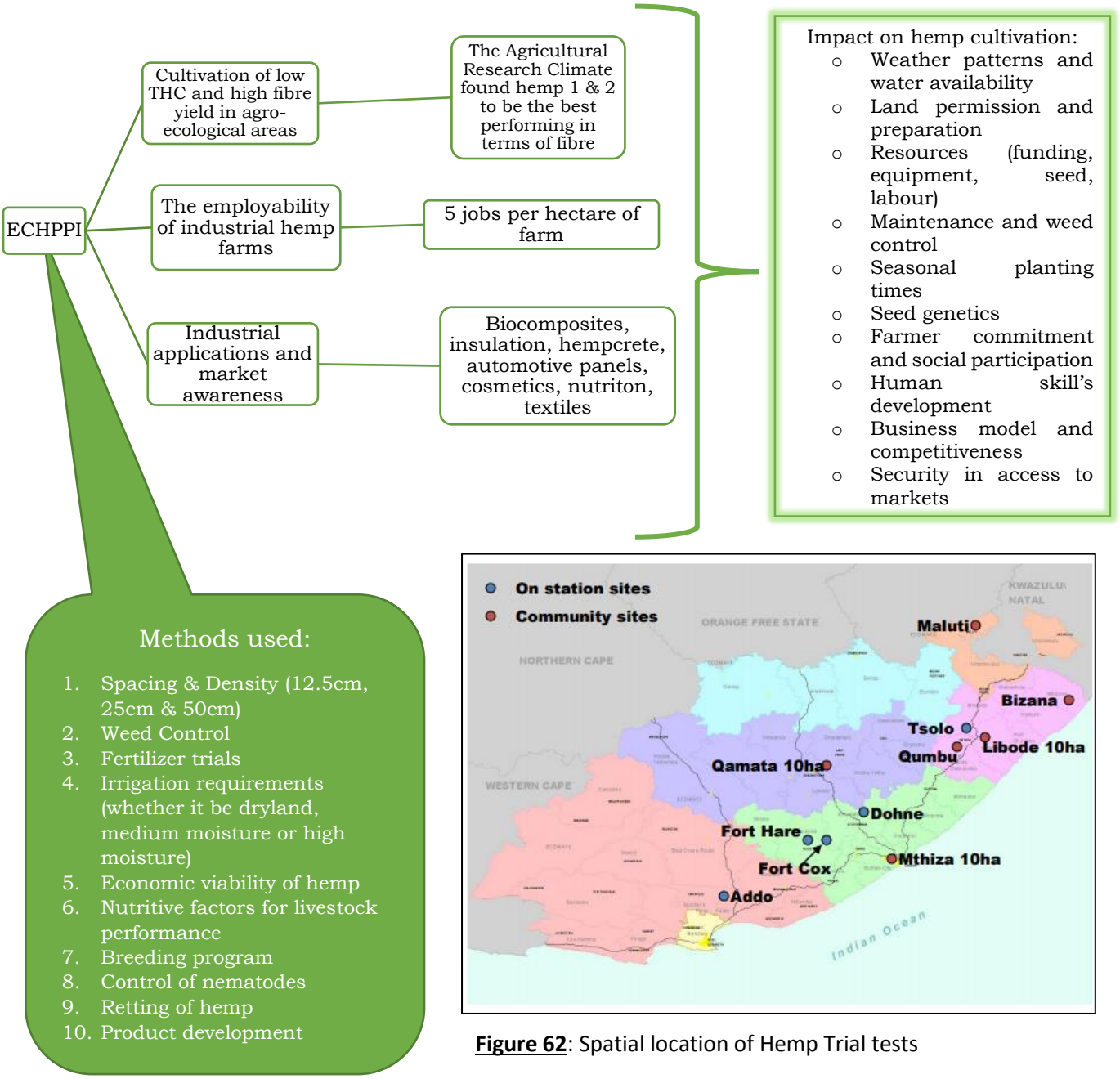


Figure 62: Spatial location of Hemp Trial tests

[32] Phase 1 from 1999-2005, Phase 2 from 2007-2015 and Phase 3 from 2016-2020.

The ECHPPI investigated the employability factor of each different production line involved in the experiment of hemp farming. The number indicated in the figure on the right represents the employability of (3 777) multiple hemp product development avenues. This figure was done during trial tests and possibly was limited by the nature of a sustainable value-added supply chain. Therefore, the scalability of farms may increase the amount of people employed whilst adding ancillary employability through logistics, retail and manufacturing.

Plus 3,777 Agro-processing jobs

Fibre based industry	No of jobs	Seed based industry	No of jobs	Medicine based industry	No of jobs
SFS fibre extraction and cottonisation	160	Oil pressing facility	90	Medicine extraction facility	70
Spinning facility	90	Cosmetics	90	Analytical lab facility	10
Weaving	90	Protein powder Milling Facility	70	CBD medicines	10
Zelfo boards	100	Feed production	200	THC medicines	10
Insulation	100	Snacks	100	Roots and tonics	50
Hemp crete production	100	Bath and Massage oils	90	Vapourisers	50
Happy Homes	1000	Ointments	90	Waste management	90
Non wovens	100	Biodiesel	180	Security	90
Pellets for biofuels	20	marketing	90	Training	50
Bio-composites	540	NHF & industry association	36	Accounting	11
Total number	**2300**		**1036**		**441**

Figure 63: Potential labour absorption of hemp value-added employment

Blouw and Sotana (2005) investigated agronomic data pertaining to four different European hemp cultivars planted in the Eastern Cape. The experiment conducted field test trials to determine the suitability of the Eastern Cape for hemp fibre production and the adaptability of European strains. The four different hemp cultivars[33] were guided by different agronomic parameters on two agricultural research sites, Addo (Sarah Baartman District, Sundays River Valley municipality) and Dohne (Amathole District), in collaboration with the Agricultural Research Council – Institute for Industrial Crops in the Eastern Cape (see map below).



Figure 64: The Eastern Cape showing Addo and Dohne

The parameters were different row spacing, seeding rate and population density of hemp whilst also determining the suitable weedicide control for hemp. These studies were conducted in 2000 and 2001 with the results concluding that the optimum row spacing for the same cultivar is 12.5cm and 50kg of the seeding rate. The results also proved that the range of hemp yield (19.5%-23.65%) with different row spacing was marginal. The treatment of weedicide marginally affected the hemp yield

[33] Novodsaska (Previous Yugoslavia), Kompolti (Hungary), Felina - 34 and Futura - 77 (France).

from Novosadska (20.7%-25.2%), Felina-34 (19.9% - 22.6%) and Futura – 77 (20.3% - 23.1%). It was concluded that there was no significant different of percentage fibre yield between chemically treated cultivars and non-treated cultivars. The final remarks made by Blouw and Sotana (2005) was that the hemp fibre yield in the Eastern Cape is comparable to other hemp growing countries with the most appropriate time for seeding in October and November.

Lewis (2020) discusses the policy status on cannabis and hemp in the Eastern Cape. To this extent, the author addresses the opportunity to stimulate a national inclusive *cannabis* economy through various national and provincial implementations. Specific prospects such as a provincial cannabis economic plan and investing in former homelands of the Eastern Cape are aligned to foster a sustainable agricultural, industrial and social growth path for the province. Furthermore, Lewis (2020:5) postulates the need to prioritise traditional growers with the Mpondoland region which forms part of a "dagga belt" from the Eastern Cape to Kwa-Zulu Natal. This suggestion is due to the historical culture of *cannabis* cultivation for the past 100 years. Specific indigenous knowledge systems have been in practice for generations which have harvested unique cultivars of landrace strains in the Eastern Cape[34]. The significance of this is that the farmers in the region are using intergenerational farming methods to cultivate cannabis which can be directed adopted into hemp farming. Providing a rich diversity and supply of industrial hemp from rural farmers. Lewis (2020) explains the indigenous methods of small-scale hemp cultivation which are used in the Ingquza Hill Municipality (Mantlaneni village) which irrigates their land using pumped river water. Various methods are sequentially adopted by other cultivators which provides a viable small-scale hemp farmers market that can supply agro-processing facilities.

It must be emphasised that although the synergistic opportunities to integrate hemp agriculture into agro-developments exists, there remains hindrances for the economic sustainability of small-scale farmers with the Eastern Cape. Therefore, the heavily awaited National Cannabis and Hemp Master Plan will be used to develop the provincial cannabis development plan that may enable the local growers to have market accessibility into the economic framework. Various recommendations are mentioned by Lewis (2020) which propose a stronger political, economic and social integration for hemp cultivation. The author suggests better public education around hemp, technical support programs for rural farmers, investment promotion into sub-regional farm lands, market accessibility, investing in the Lusikisiki research hub, municipal support and public sector monitoring. The feasibility of the hemp industry relies on the harmonious coordination and mutual

[34] Internationally identified cultivars of 'Swazi Gold', 'Malawi Gold' and 'Durban Poison' (Lewis, 2020)

reinforcing nature of government departments whilst using policies and development strategies to harness the hemp industry so that there can be a viable economic base in which farmers are insert their lands potential for biocomposite materials and CBD oils.

The Statement of the status of the Eastern Cape Cannabis Project was released on the 14th October 2020 (Sotana, 2020). This document revised the technicalities and methodology used in the experimental trials in the Eastern Cape. These elements addressed the agronomic practices needed for hemp cultivation and the various findings from the trial tests (as previously mentioned). Furthermore, hemp permit conditions and requirements were established[35]. These gave regulations for establishing hemp farms and specific protocols to abide by if you have applied for a permit. Sotana (2020) revealed the most current challenges facing hemp farmers in the Eastern Cape. These included the need to evolve the permit from research status to commercialisation, the revival of the Hemp SA trust, hemp permit application must be governed by the Project Manager, the need for product development, allowing hemp seed breeder to continue, the infrastructure needed for security fences must be provided through government subsidies whilst contributing towards the input costs per hectare for small-scale farmers and lastly, the need to pursue investment for farmers to be able to cultivate standardized hemp crops.

In a statement of the Status of the EC Cannabis Project, Sotana (2020) alluded to the construction of business model needed to harness the full capability of the cannabis and hemp farms. The Community Public Private Partnership (CPPP) is geared for a revival. However, the model consisted of:

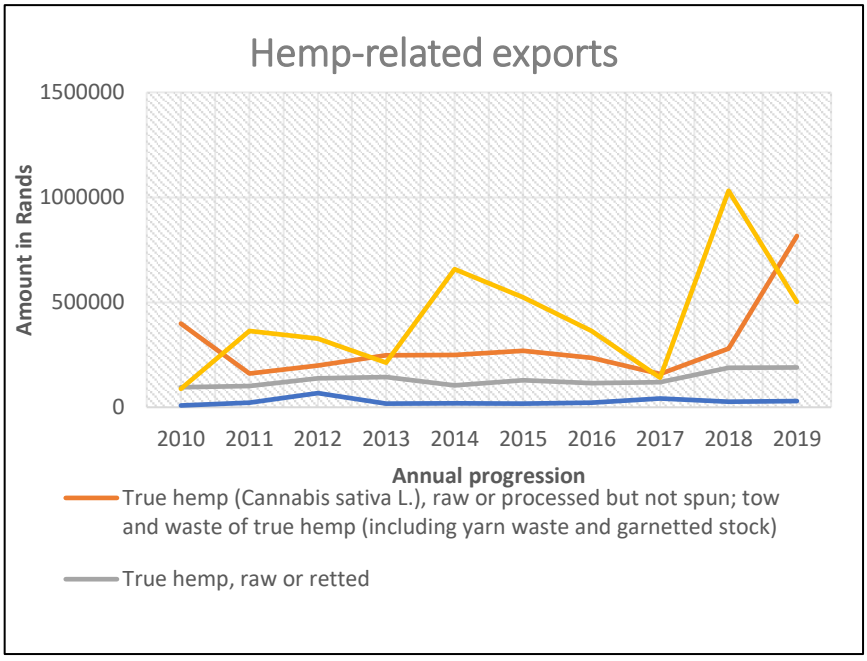


Figure 65: Hemp-related export graph

- Farmers/community in ownership of private or communal land and tribal land in the six kingdoms of the Eastern Cape to be engaged.
- The private sector to initiate off-take agreements, skills training, knowledge transfer, education, investment and management.

[35] The hemp research and development permit conditions and requirements for farmers will be discussed in the annexure.

- Public sector to provide funding for resources and infrastructure whilst complimenting production and marketability through exports.

Furthermore, according to NAMC (2017), the below table surmises the viability of developing hemp field trials in South Africa in 2014/2015 if the tests were to become an internationally competitive industry. The information displays the balance of total income minus expenses. The value is in proportion to a 1 Ha facility. The total income according to the NAMC (2017) was calculated to be R 5 500 per hectare. The strategy and specific agronomic practices were concluded to be inconsistent and there were reported internal challenges within the hemp farm trials. A key point of observation is the relative increase in price of demand for hemp products and hemp raw materials since the field trials were conducted. This will prove to be a significant factor in conducting hemp field trials and commercial hemp farming in 2021.

Projected Income statement for SA's hemp trials if they are capacitated to reach ideal international yields

Model for farming hemp		
Statement	1 ha	
Income		
	Seed	R 50,000.00
	Stalks	R 30,000.00
	Leaves	R 18,000.00
Total Income		R 98,000.00
Expenditure		
	Soil test	R 500.00
	Soil preparation and planting	R 6,000.00
	Seed	R 6,000.00
	Fertilizer	R 7,000.00
	Labour	R 50,000.00
	Water	R 7,000.00
	Electricity	R 7,000.00
Total Expenditure		R 83,500.00
Gross Profit / Loss		R 14,500.00
Other expenses		
	THC test	R 5,000.00
	ARC workshop	R 3,000.00
	permit costs	R 1,000.00
total other expenses		R 9,000.00
Total loss / profit		R 5,500.00

Figure 66: Project revenue statement

4. The Viability of alternative hemp-based products

4.1. Applications of industrial hemp

Industrial grade hemp is a versatile and multi-applicable plant material which can be used as seed, oil and fibre. Hemp is an appropriate crop for industrial applications as every part of the plant can be used and the many applications are derived from different anatomical structures of the plant. The focus of this section is to investigate hemp as a bioaggregate building material (hempcrete, hemp insulation panels), hemp fibres for the production of bioplastics (biodegradable composite materials), hemp as a biofuel (renewable source of biomass for electricity and heat generation) and hemp as a textile substitute (apparel, fibre boards and rope).

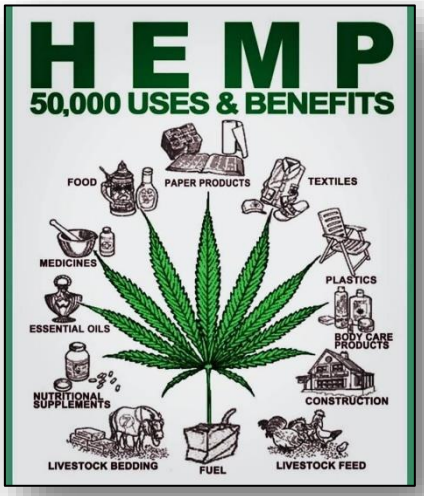


Figure 67: Hemp product potential

The following subsections will aim to clarify the composition of the materials, the viability of production of these materials based on the net energy yielding rate and performance as an energy efficient product whilst attempting to extrapolate the economic perspective of industrial hemp production for sustainable product development. Due to a lack of accessible South African scientific data into viable hemp-based products, the following subsections utilise international best case studies. However, where applicable, South African hemp-based product development information will be analysed. This poses a limit to the research as the various meteorological conditions, agronomic practices and soil properties in South Africa differ as compared to those abroad. These climatic conditions may affect the composition of lignocellulosic properties within the industrial hemp plant. There may be a locked landrace strain in South Africa which may further support a high-yielding, drought resistant, fast-growing and synergistic component for research.

The economics of production and scalability factors regarding industrial hemp farming has various controls which pose a stringent analysis in order to correctly determine the viability. These controls are the:

- location of farms,
- use of the crop,
- average dry yield per hectare in kilograms,
- average price per kilogram
- costs of production
- gross profit margins

Due to the restricted timeframe, lack of accessible feasible data and undetermined average costs of production regarding South African hemp farms coupled with the COVID-19 travel restrictions, this sections analysis attempts to extract foreign price ratios whilst using existing data from a South African perspective.

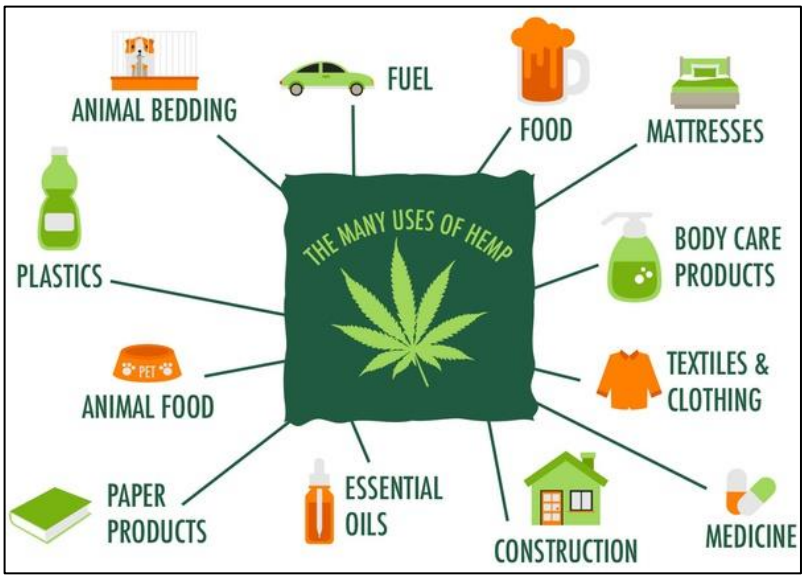


Figure 68: Some of the potential uses of hemp

4.1.1. Building applications: Hempcrete

a. What is it?

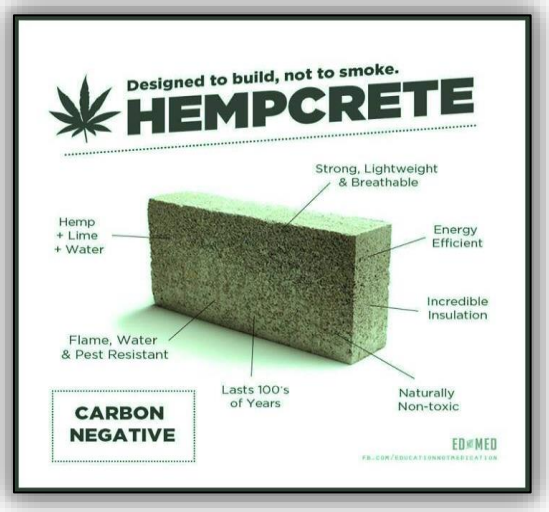


Figure 69: Hempcrete benefits

The construction industry is a large emitter of carbon dioxide in South Africa whilst continually consuming non-renewable energy in the operational stage. The notion of geoengineering is a deliberate endeavour by humanity to manipulate the environment by implementing carbon dioxide reduction (CDR) methods coupled with bioenergy for carbon capture and storage (BECCS) (Monika (undated)). Therefore, introducing hemp as fast growing crop for building materials is considered a viable solution for reducing the carbon emissions in the construction industry. Hemp hurd's are used as the raw material with added hydraulic-lime as a binder and water to create a paste-like composition, this can be used as a green building material in the construction industry. The use of hemp as a bioaggregate building material reduces the embodied energy of the building throughout the life-cycle analysis. Lime-hemp-based concrete (hempcrete) is also known as a cellulose-aggregate concrete, agro-concrete or vegetal concrete. When hemp is applied as a building material for construction its energy performance throughout the pre-construction phase, operational stage and post-construction stage displays hempcrete as a carbon negative

building material. This is due to the carbon sequestration of the plant during growth phase, the minimal carbon dioxide emissions during manufacturing, the storing of carbon when performing in the building and the ability to reuse the material after construction for multiple different purposes thereby integrating it as a renewable material within the circular economy. The behaviour of hempcrete differs in comparison to conventional construction materials (red clay bricks, cement blocks). The benchmark characteristics of this versatile composite are that it is lightweight, has good moisture buffer capability, low thermal conductivity and very good acoustic insulation (Jami et al. 2019).

b. The types of applications and energy efficiency

The rise of energy efficient and eco-designs in construction represents the need for new building materials and specific technologies which can lead to a decrease in the consumption of energy with a reduced embodied energy of materials used.

Hemp concrete insulation panels comprise of:

- Wall insulation
- Roof insulation
- Sub-slab insulation
- Window insulation

According to Jami et al. (2019), the performance of the *Cannabis Sativa L.* plant as a building material can be grouped into eleven different subsections:

- Binder Characteristics: The binding component of hempcrete is a lime-based binder. This binder is primarily used due to its large abundance and distinctly low emission when in the manufacturing stage. Another essential reason for lime being the primary binding composite is due to the high compatibility with hemp hurds and its' property of low elasticity modulus (malleable material). Furthermore, hydraulic lime and water is the preferred binding agent with hemp hurds. When hydraulic lime mixes with water it rapidly increases in strength and water resistance throughout substrate aging. Hydraulic lime has pozzolans[36] which mix with the hemp hurds and then petrification occurs, this describes the hardening of the mixed material to fossilization (Novakova, 2018).
- Density: The density of the hempcrete is much lighter than that of the cement based concrete. This is due to the aggregate of the concrete being made of hemp shivs/hurds, which is far lighter than the aggregate used in cement concrete, which is rock/sandstone. Various researchers have investigated the density of hempcrete with

[36] Pozzolans are a silicate composition which react with calcium hydroxide within hydrating cement which allows for the development of a more cementitious final composition.

conclusive data showing that recent advances in the manufacturing process and the use of different binders for mix have allowed for varying densities and a mixture of quantities to optimise the specific quality of final material to match the environment in which the mix will be used. This is due to each plant having different textural strengths with regards to the amount of hurds within the plant, how it grew and other agronomic variables. Therefore the density of the material does vary more frequently than conventional building materials. Although this occurs in manufacturing, it confirms that there is a link between the density of the materials and its thermal performance. According to Jami et al. (2019:5); "…*the thermal conductivity of lime-hempcrete increases by 0.005W/m.k (watts per metre kelvin)*[37] *for every 50 kg/m*^{3} *gained*" thereby displaying a high thermal capacity.

- Compressive strength: This aspect in a building material is of utmost importance. It is indicative of the amount of resistance of a material, without changing shape or breaking against weight or force. The compressive strength of hempcrete is much smaller than that of cement. A higher compressive strength factor can be ascertained when cement is added to the lime-hempcrete. The material performs intrinsically well in earthquake prone areas, due to its low-density and resistance to bend or break (Jami et al., 2019).
- Flexural strength: The flexural strength of a building material represents the ability of a material to resist bending. With regards to hempcrete, the stiffness of the material is determined by the type of binder used. However, due to the increased carbonation over time, specifically for hempcrete, the stiffness increases over time (Jami et al. (2019).
- Shear Behaviours: A test performed by Chabannes et al. (2017), confirms that hemp concrete has a strength of 0.36MPa[38]. This value is proposed as a safe and appropriate shear strength for the purpose of building design.
- Thermal properties: Hempcrete is examined to have a high thermal capacity as opposed to the standardized cement-based concrete. According to Novakova (2018), the R-value[39] of hempcrete is determined by the thickness of hemp mixture. However, an interesting note is that there is a 45% reduction in the amount of energy consumed used when hempcrete is used, as opposed to concrete (being 0.18 k^2 /W). In terms of the U-value[40], the thermal transmittance of heat is primarily based on the density of the composite and the thickness of the wall in conversation. A study conducted by Sutton, Black and

[37] Watts per meter Kelvin addresses the thermal conductivity by implicating 'K' as the specific rate of heat transfer in a homogenous material.

[38] A Megapascal (Mpa) is indicative of the compressive strength of a material. This explains the amount of pressure (weight load and bearing) which can be applied before a breakage in the material. The higher the MPa, the stronger the material.

[39] The R-value measures the thermal resistance properties of a material used in construction. It can be shown to represent the heat transfer per unit of an area.

[40] The U-value is a measures of heat or energy lost through the transmittance

Walker (2011), found the U-value of hempcrete to be in between 0.08 and 0.13W/m^{2}K[41]. According to Evrard et al. (2006), hempcrete is found to have a heat capacity 1500J/kg.K in a non-moist state. This value can increase as the relative humidity of the air increases. This value for hempcrete is much higher than the conventional cement concrete used in buildings all around the world. This is due to the reduced energy consumption and healthy microclimatic conditions of hempcrete in building environments.

- Hygrothermal behaviour: this component of a building materials' performance indicates the physical changes exhibited by the material when in contact with differing levels of heat and moisture. Indicative of the materials ability to absorb, store and release heat and moisture. Hempcrete displays a high performing moisture buffer value. This indicator reveals the materials performance with regards to its ability to take-in or release moisture at different levels of relative humidity (Hussain et al. 2019). The concluding remarks of the moisture buffer value signify that the higher the value, the better the ability of the materials performance with regards to regulating humidity. It is important to consider the coating of the exterior wall in terms of its ability to absorb moisture and thermal conductivity. These variables of the coating affect the performance of the hempcrete and may leave it susceptible to the growth of mould. A point to consider is the performance of mortar joints between bricks. This performance indicator does affect the heat fluctuation of the building material.
- Acoustic properties: The acoustic properties of hempcrete have been identified to have a good level of acoustic insulation. Jami et al. (2019) is that the density and porosity of the material does not determine the absorption of acoustics of hempcrete. It was found that the major constituents of this property is determined by the chemical composition of the binder.
- Reaction to fire: This component determines the buildings safety and can be on the determining factors that ensures this sustainable building material can be issued with a safety permit for a building. With not many studies being done about the fire safety of hempcrete, there is more research and avenues of testing to perform before the data can be organised into a building safety parameter.
- Durability: This determining factor of a buildings performance guide developers, architects and other construction team members of the materials ability to be resistant to freezing and thawing, to salt-exposure and to biological deterioration. With past archaeological findings showing that hemp used in construction still remains intact, after thousands of years of exposure to harsh climatic conditions, indicates the ability of the material to endure extremities with structural integrity. However, the ancient composition of the materials do not align with recent scientific investigations of

[41] The number of watts per square metre directly per degree of temperature difference between the two sides of a material.

hempcrete. Hempcrete was found to have a weak-resistance to freezing. Due to the reduction in mass from the freezing and thawing of the product, thereby reducing the compressive strength of the material. Hempcrete has a good resistance to salinity, due to the large pores in the product not allowing for the crystallization of the sodium chloride. There was no biological deterioration found in hempcrete, due to the lack of nutrient based composites which allow for microbial growth in the material. More studies are being conducted on the ability of the material to perform better under freezing conditions.

- Environmental credential: Hempcrete is considered to be carbon negative. This is due to the plants ability to absorb carbon dioxide and release oxygen in the growing phase of the organic matter. Carbon dioxide is then released in the manufacturing process of the material through the carbonation process in the drying stage. Afterwards, during the performance of the hempcrete, carbon dioxide is stored by the product.

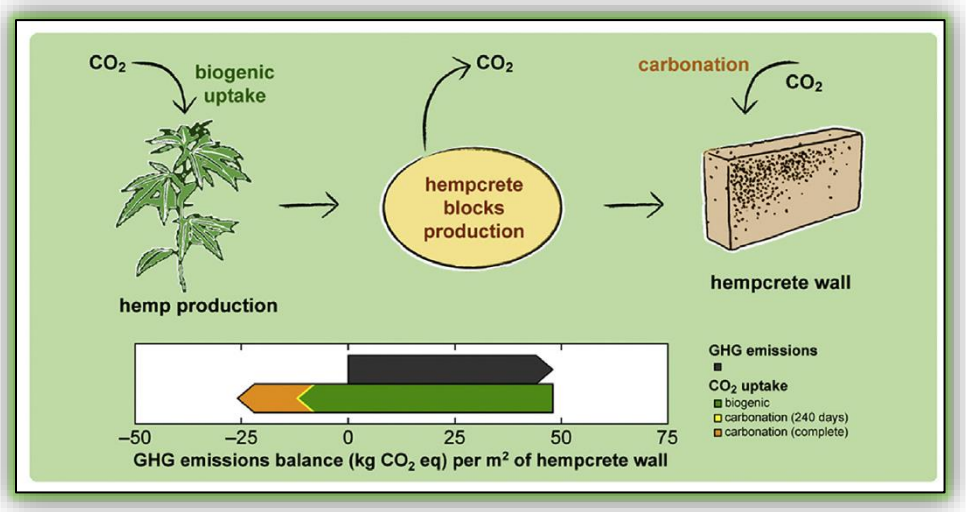


Figure 70: Life-cycle assessment of hempcrete in terms of carbon sequestration

Hemp insulation panels provides a well-balanced, microclimatic feature by having a natural protection against mould, pests and decay whilst creating a healthy indoor environment for its occupants. Hemp reinforced concrete is a composite material which uses hydraulic cement mix reinforced with discrete hemp fibres. Furthermore, an analysis conducted by Ghalieh, Awwad, Saad, Khatib and Mabsout (2017) investigated the use of hemp fibre reinforced polymers (FRP) as a structural contingency to support concrete columns. This investigation found that various stress strain curves[42] and axial stresses could be addressed by a hemp fibre polymer with a bidirectional hemp epoxy. The results found that the hemp FRP has a high ductility[43] when used as structural reinforcement. It is proposed that these applications can be used for bridge

[42] Stress strain curves describes the relationship of a materials stress and strain.

[43] Ductility is the ability of a structural design or part of the structure to experience inelastic deformation prior to collapse without a substantial loss in the resistance factor. The ductility is affected by the slenderness of the column ratio (Scrucca et al. 2017)

reinforcements and roads strengthening designs. This advances the applicability of hemp as a fibre concrete reinforcement for a worthy investment consideration.

c. Financial viability

Scrucca et al. (2020) investigated the financial market analysis of hemp exports from France in 2016. The data found that the various applicable parts of the hemp plant were sold at different rates for export based on their market value in the year 2016:

- Seeds (growing 9088 tons/year)
- Fibres (growing 20 005 tons/year)
- Hurds (34 080 tons/year) will be the focus in this specific section.
- Dust (11 212 tons/year)

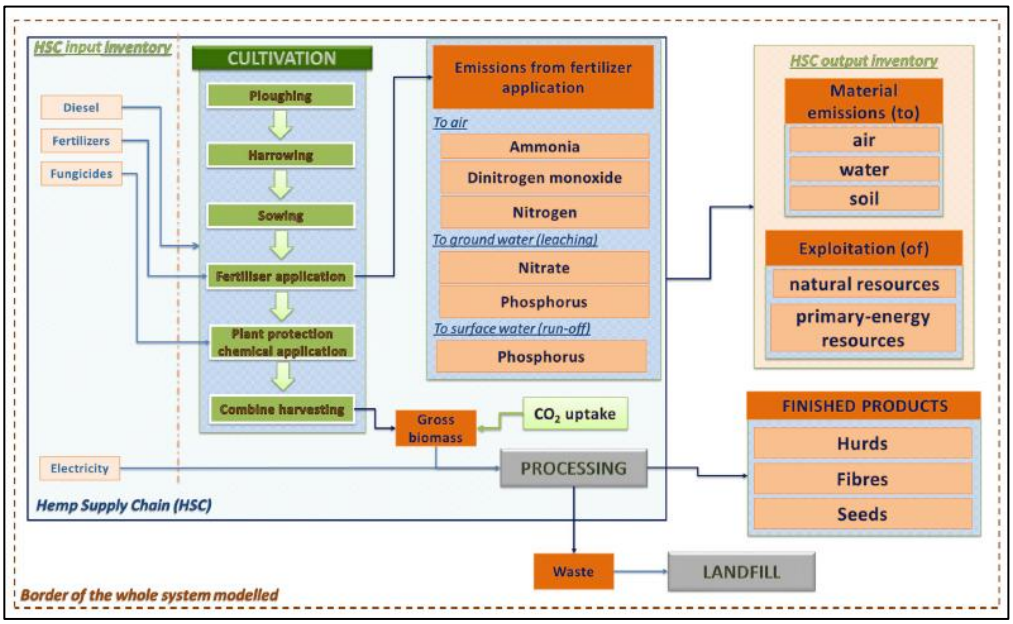


Figure 71: Production assessment of hemp in a study conducted in France.

The hemp hurd's represented two-thirds of the market volume for France which entailed a 50% turnover rate. The average sales of products were estimated to be between 200 to 300 Euros per ton. However, as a product of a competitive market in Europe, the quality of the hemp hurd's reflected the price of export. Therefore, the higher the quality of hemp hurd's, the higher the market price was for specific industrial related companies. Scrucca et al. (2020) indicates that the cost of the raw material represents a 20% to 30% value of the selling price if the final product were to be locally manufactured. Therefore, this represents a significant opportunity to align local manufacturing agro-processing facilities and production lines with the creation of value-added products in the Eastern Cape which can offer high-quality hemp bio-based concrete with multiple avenues into various hemp structural reinforcing products. However, the opportunity to offer hemp hurd's as raw material for export still remains viable within the context of biocomposite export related market analysis (refer to **Figure 51:** Biocomposite hemp export related graph in contextual analysis section).

According to Novakova (2018:5), the specific amount of raw material required for various applications is tabulated below:

Amount of material per 1 m^3 of hemp concrete according to use			
	Shive (kg)	Binder (kg)	Density (kg/m^3)
Roof	110	110	220
Walls	110	220	330
Floor	100	275	375
Plaster	200 - 250	500 - 700	700 - 950

Figure 72: Volume of biomass required for hempcrete

This displays the large volume of shives required for the production of different building applications. This understanding demonstrates the challenge for farmers to produce large quantities of hemp.

4.1.2. Hemp-fibre reinforced polymer structures

a. What is it?

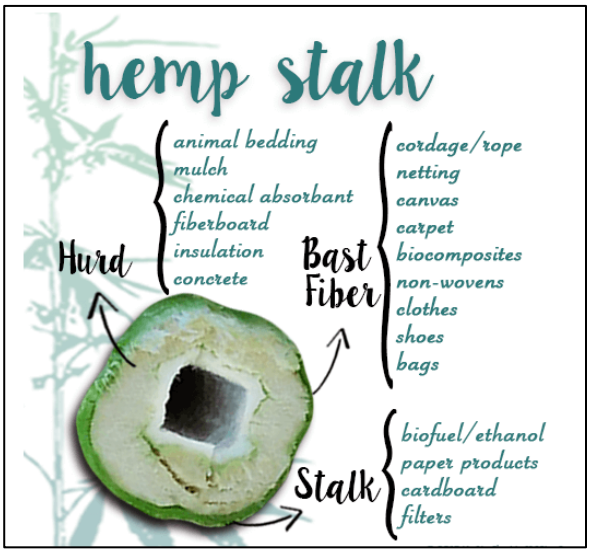


Figure 73: Applicable anatomical parts of plant for production

The interest in natural fibres is increasing worldwide. Natural fibres offer good mechanical properties, low initial cost and an ability to be reinforced with composites to substitute conventional synthetic fibres. Natural fibre reinforced plastic as a hemp bioproduct can be developed into many different applications. With the introduction of hemp thermoplastic polymers, the potential for low density, increased energy recovery, recyclability and a high strength to mass ratio proves that hemp-fibre integration offers a sustainable and viable alternative for synthetic plastic components. The manufacturing of this composite can be adopted into existing petroleum-based plastic manufacturing facilities (Wu, Xia, Cai, Chi, and Cheng, 2018). Hemp-based bioplastics[44] could synergise with other plant matter that contains a high lignocellulosic derivative to increase the financial feasibility of the project thereby combining hemp with other vegetable derivatives[45]. Dhakal, Ismail, Zhang, Barber, Welsh, Maigret and Beaugrand (2018) explain that banana contains an excellent mechanical property relative to tensile and flexural strength, thereby impacting the direct, indirect and operational energy consumption of products. The selection of cultivars[46] with specific performance of high fibre yielding

[44] Hemp-based plastics can be suitably manufactured to have specific mechanical and chemical properties to suit a purchaser. Therefore hemp can be a bio-based ethylene, a compostable polymer, in an HDPE matric and as an acrylonitrile butadiene styrene (ABS) which is used for injection moulding.

[45] Flax, Jute and Sorghum.

[46] Clarke and Merlin (2017) mention the use of a strain called Kompolti TC.

properties increases the amount of usable properties for biopolymer composites. Bioengineering the landscape to provide optimum hemp growing conditions can produce texturally strong hemp for bioplastic components. Hemp fibres strains are domesticated to produce mostly unbranched, tall stalks, therefore the production of seed and flower are not amplified. The farming method is done by increasing the plant density when sowing seeds. This agronomic consideration allows for an overall increase in dryweight stem after cropping. The crops bunch together which reduce seed generation and increases the height of the plant (up to six metres) therefore increasing the fibre availability. According to Dhakal et al. (2018), after harvesting industrial hemp, it will be 70% cellulose dryweight, 22% hemicellulose dryweight and 6% lignin dryweight stem (with the remaining 2% falling into either one of these categories). Therefore providing clean and safe alternatives for communities whilst providing a market for new tradeable goods (cups, bottle and containers), further decreasing waste pollution in landfills[47]. Hemp biocomposite plastic derivatives can offer packaging for manufacturing and transportation industries which would increase the demand for more material, thereby increasing the economic value of hemp bio-materials.

b. <u>The types of applications and energy efficiency</u>

Hemp offers a sustainable lignocellulosic fibre which is a renewable energy source versus conventional synthetic petroleum-based substitutes. Petroleum-based synthetics are becoming less attractive due to their negative environmental effects such as non-biodegradability and carbon-intensity in the extraction and manufacturing processes. These aspects increase the polluting effects of products by increasing the amount of non-biodegradable waste in landfills and in the ocean further harming terrestrial biodiversity and marine life. Hemp-based plastics are sustainable. For example, they do not emit harmful phthalates[48] and do not cause allergic reactions. Hemp fibres are classified as a natural resource and can be used to develop high-performance materials with environmental and energy efficiency benefits. Hemp as an abundant source of raw material which is renewable, biodegradable, low weight, high tensile strength and firmness is becoming an attractive feature worldwide for carbon intensive industries. Hemp biocomposites offer higher values for eco-compatibility, economical value and versatile industrial availability which appeals to the construction, automotive, aeronautical and manufacturing industries (Dhakal et al. 2018).

[47] It must be noted that hemp bio-plastic will still contain some form of petroleum based derivative and therefore will need to be disposed of in a commercially compost facility which is not available to all citizens.

[48] Used as plasticizers which add flexibility, durability and longevity to plastic whilst being a softening agent for polyvinyl chloride (PVC). This group of industrial chemicals causes damage to the human body when micro-biodegradation forms and is consumed or inhaled (CDCP, 2017).

The integration of hemp fibre as a reinforcement for a polymer matrix composite still has various limitations. These can be defined as the complexity surrounding the morphological structure and the chemical composition in each individual plant, the thermo-mechanical properties, moisture absorption rate, surface abrasion and crystallinity[49]. The process of transforming raw hemp into a bioplastic is through the use of a microbial process that exposes hemp to oxygen and sodium hydroxide (NaOH). Sullins, Pillay, Komus and Ning (2017) examined the effects of material treatment on hemp fibre reinforced polypropylene[50] composites. The studies suggested that by adding a substance called maleic anhydride grafted polypropylene (MAPP), it supports better interfacial compatibility with hemp fibres which reduces the water absorption of the final composite. This coupling agent further increases the hardness and strength of the composite. This finally deduces that the compatibility of hemp fibre with MAPP coincided with increased mechanical properties.

Miritoiu, Stanescu, Burada, Bolcu, Padeanu and Bolcu (2019) conducted studies testing the Young Modulas[51] and tensile strength of hemp fibres. These mechanical properties performed extremely well. Dhakal et al. (2018) conducted studies[52] on the different aspect ratios of hemp fibres in relation to the amount of polycaprolactone[53](PCL). The concluding results from this experiment found that when hemp has a 26 aspect ratio with the PCL, the hydrophilic component of the fibre-reinforced biocomposite has an enhanced mechanical property thereby confirming the synergistic relationship of hemp with PCL to provide substitutes for light-weight applications.

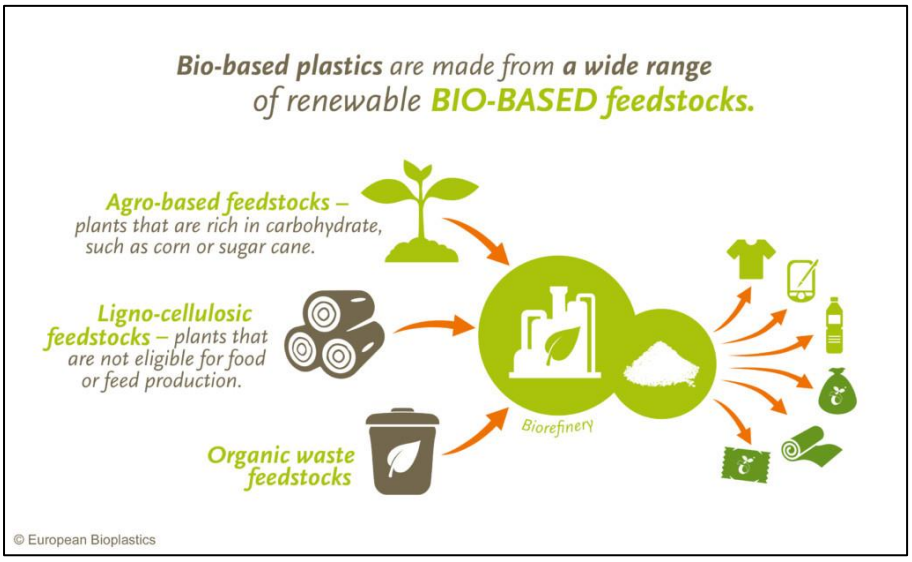


Figure 74: Agro-based product development

The applications for hemp biocomposites include using hemp-based polymer substitutes for light weight applications in the transportation industry, being dashboards, interior features and stress dependant

[49] Crystallinity with regards to hemp fibre implies the ability of molecules to be structured in a degree of structural order. This aspect influences the density and hardness of a material (Sullins et al. 2017).
[50] Also known as polypropene, it is a thermoplastic polymeric structure which is partially crystalline. However, it is measured to take 20-30 years to biodegrade as opposed to 500-1000 years for other plastic derivatives.
[51] Young Modulas testing measures the ability of change in a material under lengthwise tension (Miritoiu et al., 2019).
[52] This study used the Hemp strain called Fedora-17.
[53] Biodegradable polyester (Dhakal et al., 2018).

components. Hemp-based thermoplastic injection moulding can provide non-toxic structural support for many mechanical technologies. Hemp fibres used for biocomposite materials offer biodegradable recycling packages, fibre reinforced panels, boards and many other electronical component material. Furthermore, Miritoiu et al. (2019) found that hemp fibres have a high vibrational resonance and can be used for musical instruments. This offers a new integration for various hemp-derived musical instruments for development in the Eastern Cape.

c. Financial viability

Hemp-based bioplastics leads to a decrease in the impacts of acidification in waste environment whilst ensuring non-renewable energy consumption decreases. Hemp fibres were found to be 40% cheaper than other materials such as glass fibres (Miritoiu et al., 2019).

Prade (2011) states that hemp fibre boards need a large amount of cultivated space and would require a high volume of biomass. This can be converted into a single production line of fibre boards needing 1 hectare of hemp biomass. The viability involving the growing, harvesting, processing, manufacturing and distribution costs are incurred when deciding which final product or biocomposite output ratio is required. Therefore, by synergising the cellulosic hemp biocomposite with existing factories and biopolymer factories, it will reduce the total cost of production.

Due to the recent investigation in South Africa of hemp as a raw material for bioplastic production, the viability of specific product development involves costs relating to efficiency of technology, efficiency of hemp stalk decortication, agro-processing costs, second tier manufacturing processes and economies of scale (these suggestions are recognised as being infant industry challenges). Therefore, in order to develop cost-benefit ratios for hemp bioplastic production, there must be a strategic hemp biocomposite integration model to determine the financial viability of producing hemp for bioplastics. This proposed model can aim to position hemp farms in close proximity to biocomposite refineries, thereby synergising logistics, whilst developing energy efficient technologies to reduce waste and optimise bast fibre use[54]. An investigation conducted by the National Agricultural Marketing Council (2017) attempted to quantify an agricultural model for hemp if it were to reach international standards and yields. This table is represented below:

[54] The adoption of the proposed Eastern Cape Agri-park logistics structure may serve as a vital tool to integrate collective hemp farming within financially viable distances from agri-hubs.

Model for farming hemp		
Statement	1 ha	
Income		
	Seed	R 50,000.00
	Stalks	R 30,000.00
	Leaves	R 18,000.00
Total Income		R 98,000.00
Expenditure		
	Soil test	R 500.0
	Soil preparation and planting	R 6,000.00
	Seed	R 6,000.00
	Fertilizer	R 7,000.00
	Labour	R 50,000.00
	Water	R 7,000.00
	Electricity	R 7,000.00
Total Expenditure		R 83,500.00
Gross Profit / Loss		R 14,500.00
Other expenses		
	THC test	R 5,000.00
	ARC workshop	R 3,000.00
	permit costs	R 1,000.00
total other expenses		R 9,000.00
Total loss / profit		R 5,500.00

Figure 75: Field trial test finances

However, suggestions involving this financial feasibility study were limited due to various field trial tests which had delays in planting time, bad soil preparation, capacity issues (poor management) and incorrect harvesting time. Therefore, in order to reflect an accurate assessment of the financial viability involving the production of hemp bast fibre for biocomposite production, a market entry product must be developed to reach the consumer to produce a model for bast fibre production.

Sullins, Pillay, Komus and Ning (2017) and Ziner (2020) propose hemp fibre as being a stable product for commodity development. The authors aim to incentivise farmers for strict production of hemp-fibre stalks which would prioritise the growth of high quality fibre. This would increase the conversion ratio of raw material into viable composite structures. The cost ratio calculations depends on dry matter yield of fibre. Furthermore, Sotana (2013), NAMC (2017) and CALM (2019) state different hemp stalk prices for one hectare of stalk production. Using the basis of one hectare of hemp producing 10 tons of biomass,

- Sotana (2013) states that a hemp farm can generate R25 000 per hectare,
- NAMC (2017) found that the income for hemp stalk would be R30 000 and
- CALM (2019) found one hectare could generate R50 000 worth of hemp stalk biomass.



Figure 76: Figures proposed for value of hemp

These conflicting industry income statements invite a possibility of stable market prices for hemp primary and secondary fibre production. These would provide financial surety from investors and government to finance and fast-track hemp fibre production.

4.1.3. Bioenergy

a. What is it?

Bioenergy[55] is one of the fastest growing industrial energy sources worldwide in terms of renewable energy. According to Anwar, Gulfraz and Irshad (2014), agro-industrial biomass which comprises of lignocellulosic properties provides an inexpensive, renewable and largely abundant naturally occurring resource which can be used for cost-effective bioenergy. Gulfraz and Irshad (2014) explains the need to development green biotechnology to increase the conversion rates and lower the conversion costs of a specific crop yield, in this case, industrial hemp. The lignocellulosic composition of various high yielding energy plants allows for the sustainable production for vehicle biofuels with an ability for combined heat and power (CHP) production from a fast-growing biomass with a high conversion rate. This investigation of industrial hemp biomass will focus on the energy production of industrial hemp cultivated for commercial production.

Countries such as China, Ireland, USA and Germany have investigated hemp as a source of energy. Hemp as an energy crop can be defined as short-cycle rotation crop, with low input fertilizer and high carbon sequestration which can be used for liquid bioethanol or solid biofuel (Styles and Jones, 2007). The notion of industrial hemp as an energy crop is seen holistically by identifying the relative low input costs and high output conversion rate of the crop in terms of its energy carriers. In order to be a viable energy crop, the plant must be area-efficient. This describes that the crop must produce a high yield per space used. Industrial hemp has an opportunity to be an energy crop due to its ability to grow 10 – 15 tons per hectare in 100 -120 days, thereby proving that it is area-efficient (Kolarikova, Ivanova, Hutla and Havrland, 2015). Kolarikova et al. (2015) investigated industrial hemp grown for briquettes energy purposes in Czech Republic, concluding that the hemp briquettes were not financially viable if sold at the same price as wood. Prade (2011) further investigated the net energy balance/yield (input and output) of industrial hemp whilst focusing on the biomass energy yields, being hemp as a biogas substrate and as a solid biofuel.

b. The types of applications and energy efficiency

The stalk of hemp contains pulp, this is suitable for the production of biofuel. By using the woody masses of hemp shiv for energy use in the form of bio-pellets or bio-briquettes, hemp has a heating value of 9% at a humidity of 16.5-18 MJ/Kg[56]. Hemp seed derived oil can be used for the development of biodiesel, with a conversation rate of 97% with remediated soil for further

[55] Bioenergy is a derivative from a biomass which can be described as the biological material from a recently alive or living organism (Prade, 2011).

[56] In comparison to conventional substances such as petrol (gasoline), crude oil and diesel, the heating value (calorific) varies from 42-47 MJ/Kg. This is a measurement of a fuels energy density.

cultivation. Prade (2011) reported that hemp grown in Sweden in 2007 which was used for direct combustion in a cultivated area of 829 hectares had an average yield of dry matter being 5.6Mg[57]/Ha. These were used and sold as briquettes for warming houses, similar to the study conducted by Kolarikova et al. (2015).

The biomass conversion techniques influence the properties of the hemp biofuel substrate or the use of hemp for CHP. These techniques could be anaerobic digestion[58], combustion, fermentation[59] and various other techniques (Prade, 2011). The by-products of these methods of conversion can be used for fertilizer. Finnan and Styles (2013) summarise the bioenergy energy chain analysis of hemp conversions, this article will be used to explicate industrial hemp applications in terms of biogas, bioethanol and biofuel. Contrary[60] to Kolarikova et al. (2015), results from Finnan and Styles (2013) report hemps yield range from 8 to 14 tons per hectare per year which has a mitigating greenhouse gas factor of 8.7 to 16.1 tons of CO_2. These results conclude a high greenhouse gas mitigation factor in comparison to other renewable and non-renewable petroleum based resources It is reported by Finnan and Styles (2013) that hemp cultivation has an annual greenhouse gas emissions estimate of 3 tons of CO_2 per hectare. These factors consider the upstream and downstream energy usage (whether it be diesel or electricity conversions) which creates a life-cycle analysis of the product.

When hemp is converted into industrial products, the energy balance[61] has a net energy yield of 156 GJ[62] per hectare per year with the average yield factor considered. With these multiple energy performing factors considered, industrial hemp yields a high conversion rate per hectare harvested and thereby confirms the applicability of this plant as a viable energy crop for mitigating greenhouse gases[63] whilst providing a reliable source of energy for electricity, CHP and biofuel use. Prade (2011) comments that hemp is a relatively new crop in the energy space and there is potential for yield improvements that harness agronomic practices and more efficient technologies.

c. Financial Viability

The optimal economic prospect for bioenergy production when sowing seeds is a lower plant density than required for fibres. This should allow for 20kg of seeds per hectare, according to

[57] Milligrams
[58] Uses a digester (fermenter) in an oxygen-free environment (using methane) that utilizes microbial degrading of a biomass source.
[59] Microbial conversion of biomass when oxygen is present.
[60] This may be due to the different agronomic cultivation practices, input variables, pedological variables, seed strains and meteorological factors.
[61] Energy input minus energy output. Considering fertilizers, manufacturing, packaging and transport (Finnan and Styles, 2013).
[62] Where one gigajoule is equal to 277.8 killowatt hours (kWh)
[63] The greenhouse mitigating factors are dependent on the final end-use product (Fike, 2016).

Prade (2011). Energy conversion yield estimates that industrial hemp would allow for viable economies of scale for both small-scale and commercial farmers. Converting hemp into biofuel and other energy-purposes can be used a first-step implementation factor to establish industrial hemp agriculture as a viable crop for investment and harvesting (Prade, 2011). The different energy conversion methods mentioned previously can be installed in a biorefinery[64] which can create energy efficient products and improve the overall return of a farmer's revenue support stream. The high biomass yield of industrial hemp can integrate production methods into low-value and high-value end-use products whilst providing a high fibre content and oil-rich seeds for diverse product profile for agro-rural and commercial farmers.

Hemp biomass has high combustion rates and can be used to generate electricity or heat as opposed to other agro-waste combustion properties. The field in which hemp is grown and harvested, can be reused after each crop cycles due to the phytoremediation properties of hemp. This saves the farm owner from re-fertilization of inorganic compounds. Industrial hemp cultivation can further make use of most cultivars and therefore most Cannabis Sativa subspecies Sativa can yield high biomass properties. An important consideration mentioned by Finnan and Styles (2013) is the notion of intercropping hemp with food as the nutrient balance in the soil allows for companion planting which provides viable alternative edible produce to be grown amoungst the hemp plantation. Schluttenhofer and Yuan (2017) mention the use of genetic engineering to increase the strong-walled abscission zone which reduces the hemp seed to shattering. This would allow for maximum yield of hemp seed out of maturity. Hemp farmers mitigate the problem by collecting seed at 70% maturity. The low pesticide requirements and the ability to out-compete weed growth provides another agro-ecologically significant attribute for this crop, thereby increasing the financial viability of industrial hemp for multiple harvesting seasons.

Baldini et al. (2020) investigates two different hemp cultivars grown for dual-purpose produce, being fibre and seed. Whilst Garcia-Tejero, Duran Zuazo, Sanchez-Carnenero and Hernandez[65] (2019) reveal the challenges of growing hemp in the form of agronomic practices. The different agronomic conditions consist of plant densities, irrigation doses, cropping systems and sowing times. These factors affected the yield parameters. Furthermore, certain meteorological conditions such as high air temperatures (above 30 degrees Celsius) and the long photoperiods affected dual-purpose hemp. These two factors affected a dual-purpose industrial hemp crop due to the misalignment of seed harvesting and fibre. Therefore, these two studies concluded that dual-purpose crops needed different conditions and harvesting time to optimise their yield intensities.

[64] A biorefinery converts raw biomass sources into a conversion process with specific equipment that either produces power, fuel or other value-added products.

[65] A brief mention that this study was conducted for biomedical secondary metabolites of hemp (cannabinoids) using two industrial hemp cultivars being Carma and Ermes (Garcia-Tejero et al., 2019).

Finnan and Styles (2013) found that in order to cover expenses of hemp production and harvesting, the price of the biomass was €98.1/DM tons when specific mineral fertilizers were used as opposed to €61.6/DM tons when organic fertilizers were used. This converts to R1 901.50 and R1 194.0.1 (respectively), based on the current exchange rate when writing this report. These compare as being less expensive to other energy-purpose crops. Another advantage mentioned by Finnan and Styles (2013), is the immediacy of supply offered by industrial hemp. This implies that industrial hemp has responsivity and complements a bioenergy strategic analysis for farmers in order to create a consistent revenue stream or consistent supply of high-grade biomass derivative products. These factors identify hemp as a valuable biomass resource for production.

Das, Liu, Saeed, Williams, Hu, Li, Ray and Shi (2017) conducted an analysis of industrial hemp as a biomass feedstock. This study considered the pre-treatment method[66] in terms of the biomass, technology of biomass decomposition and sugar release. The strain 'Futura-75' was used in this experiment and yielded a 5347kg/ha of cellulosic biomass with a yield of grain of 1230 kg/ha. The experiment evaluated the economic feasibility of hemp in comparison to other crops[67]. The method considered biomass yields, growing costs, corresponding ethanol yield, grain yield and prices. The final conclusion of the inquiry found that hemp can be grown as a dual-purpose crop.

The ECHPPI conducted hemp field trial tests in the Eastern Cape. The farms were identified in Libode and Qamata. These farms yielded 4 tons of DM/Ha and 1 ton of DM/Ha, respectively (Sotana, 2013). These results are based on agronomic practices mentioned in the Eastern Cape socio-economic analysis. Sotana (2013:36) tabulates a financial analysis of the revenue stream generated by hemp oil and hemp dry stalks.

Income	Unit	Cost / unit	Quantity/ha	Value / ha
Hemp dry stalks	Tonnes	R2,500	10.00	R25,000
Hemp oil	Litres	R100	150.00	R15,000
Gross income				**R40,000**

Figure 77: Income for different products of hemp

These results indicated to the IDC that the hemp is a financially viable crop for production with the biggest expense being the security fence and wages for workers. These results expressed in Figure 77 reveal the ability of hemp to diversify its production profile and be resilient to shocks in the market, thereby proving hemp elasticities in the form of tradeable goods (Sotana, 2013).

[66] For the purposes of this study, the pre-treatment methods and the technicalities fall out of the field of inquiry due to word restriction limits.
[67] Kenaf, switchgrass and sorghum.

Fike (2016) adds that the value of these oils for industrial bioenergy systems are crippled by the lack of systems capability. Therefore this points to the need to provide large-scale production technologies which can provide the appropriate economies of scale which can lower the cost of this mode of production. Lastly, the net energy yield per hectare of industrial hemp is greater than other energy crops with the output-to-input ratio performs significantly more efficiently than average energy crops.

4.1.4. Textiles

a. What is it?

Hemp textiles serve as a multi-functional fabric for weaving, rope, string and clothing applications with more versatile applications. Hemp contains bast fibres which comprise of short and long fibres which can be seen as the technical hemp application part of the plant. These are along the outer side and length of the stem. Primary fibres are recorded as being longer and larger than secondary fibres[68] which are thinner and shorter whilst containing lignified cellular walls. This comparative understanding indicates that primary fibres are the ideal fibre needed for textile applications. An important analysis made by Schumacher, Pequito and Pazour (2020) emphasises that the secondary fibre content increases with plant age. Therefore the harvesting time for hemp fibre crops is vitally important in order to optimise the amount of primary fibres available in the plant. Furthermore, Schumacher, Pequito and Pazour (2020) explains that in order to extract a high dry matter yield with a proportionally higher content of primary to secondary fibres, the timing of harvesting is important yet this factor is determined by the specific agronomic conditions, meteorological conditions and the geographic location indicative of the climatic circumstances. Bengtsson (2009) identifies multiple harvesting practices determined to optimise the primary fibre extraction from industrial hemp. These practices include assessing the colour of the stem, internode dropping stages, pre-identified calendar cycles or just before flowering. Bengtsson (2009) also indicates that harvesting when seed maturity is forming allows for the optimal moisture retting process due to the correlated maturity of the stem epidermis which is then easily separated from the shives.

One of the pertinent factors when considering hemp for textile applications is due to the intensive carbon footprint of the textile industry. The current cotton based textile industry is considered to be one of the most polluting industries worldwide (Schumacher, Pequito and Pazour, 2020). The emergence of natural-based fibre for clothing apparel has been on the rise since the 1990's and is coupled with the rise of climate awareness and the progressive change in carbon intensive industries globally. The important advantages of natural fibres consist of:

[68] These fibres are considered important for different applications such as corkage, recycling and pulp purposes.

- Hygroscopicity
- Air permeability
- No harmful substance emissions
- No electrostatic charge accumulation (wool excluded)
- Biodegradability
- Renewability
- Some contain medicinal properties (Muzyczek, 2020).

According to Horne (2020:168), the chemical composition of hemp fibre contain "*60%-70% cellulose, 15%-20% hemicellulose, 2%-4% lignin, 2%-4% pectin and 1%-2% fat and wax".* These factors are considered important due to the processing and weaving needed for fine textile applications such as linen and casual leisure wear. Muzyczek (2020) emphasises that specific characteristics of hemp fibres are considered to be unfavourable for textiles, such as the thickness, stiffness and a low elongation. However, in Xishuangbanna, Yunnan Province, China, the first commercial hemp processing mill has been developed. This will be able to cottonize hemp fibre with a reduced lignin rate of 0.2% at a rate of 50 000 tonnes hemp fibres per year. Furthermore, the distinct advantage of utilizing hemp as sport, leisure and other apparel can be described by having:

- Quick moisture absorption and hygroscopicity
- Breathability allowing for an adaptable high heat absorption. This also pertains to cool climate due to the air-trapped bubbles amoungst the fibre which are warmed up by the thermoregulating properties of the human body.
- Ultra violet protection.
- Absorbability.
- Naturally resistant to mould.
- High value of strength which decreases any stretching factor considered with conventional apparel.
- No collection of electrostatic charges (Muzyczek, 2020).

Hemp fabrics do not use polluting substances such as dye and chemical detergents. This positions the multi-use crop to be able to perform with less harmful additives. The need to eradicate chemical preservatives and supply healthy and renewable textile fabric to the population can be delivered through the investment in hemp-derived textiles and clothing apparel.

b. Types of applications and energy efficiency

The use of hemp fibres for apparel can address a multitude of resilient ecological and industrial factors which outcompete the conventional cotton-based thread used for different apparel. A comparative study of industrial hemp grown for fibre versus the conventional cotton fabric was conducted by Schumacher et al. (2020). Schumacher et al. (2020) concluded that 1kg of useable hemp fibres accounted for 2041-3401 litres of water versus the same weight for cotton which used 9788-9958 litres of water. This confirms that hemp is three times less water intensive than the conventional clothing-base material being cotton. Furthermore, the carbon footprint analysis of hemp versus cotton in terms of its space (hectares) per yield amount compares such that hemp uses 1.46-2.01 gha versus cotton which uses 2.17-3.57 gha[69]. Schumacher et al. (2020) investigate the overall energy usage of one metric ton of spun hemp fibre which ranges from 15, 009 MJ[70] to 32, 622 MJ versus the one metric ton of cotton using 11, 711 MJ to 25, 591 MJ. This value is higher for hemp due to the extraction and fibre formation stages having little to no investment in energy efficient technologies in comparison to cotton-based products which have has considerable investment and timely technologies decreasing the energy usage. Therefore, with further investments in sustainable and energy efficient technologies in hemp extraction processes, the overall energy usage of industrial hemp spun for textile fibre will be reduced.

Corbin, Soulat, Ferreira, Labanieh, Gabrion, Malecot and Placet (2020) investigated the influence of weave patterns in high-performing hemp composites. This explored the length of plant fibres and the optimum weaving patterns to create products at different scales. The study concluded that hemp fabrics contained competitive tensile properties when woven using low-twisted rovings[71]. The study further extrapolates the optimum weaving styles for different product

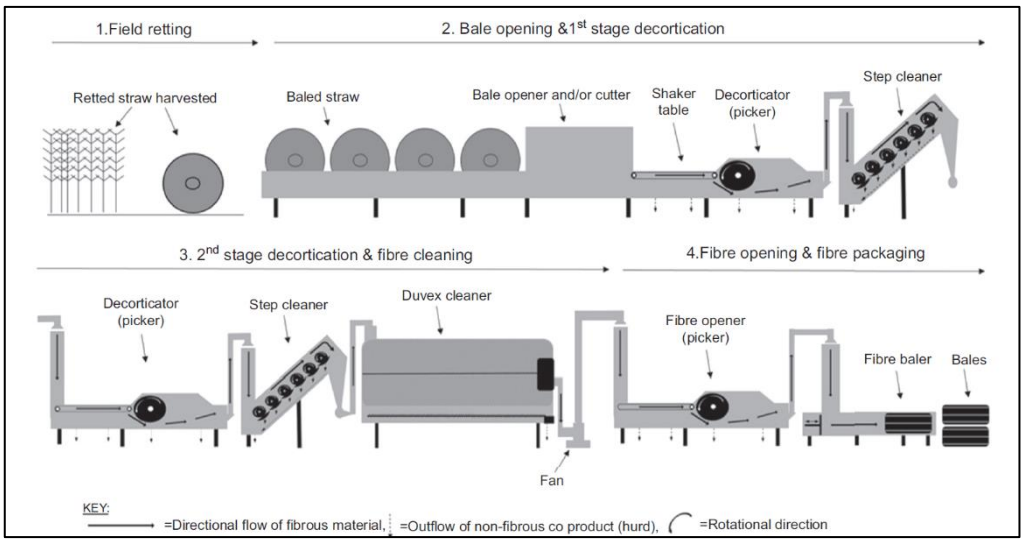


Figure 78: Hemp fibre processing

[69] This metric measures the demand of land in comparison to the available arable land supply on Earth, measuring a world average productive hectare (Schumacher et al. 2020)
[70] Megajoules
[71] Lower twisted roving provides better draft performance in terms of creating less fibre-to-fibre friction.

developments and thereby decreasing wastage and optimizing efficiency in the hemp textile industry.

Baldini et al. (2020) examined the suitability of different genotypes of *Cannabis sativa L.* for their stem yield in North-East Italy. These results concluded that different genotypes of industrial hemp affect variables of the total stem yield in the crop. However, specific factors such as weather conditions had the most effect on the crop health. Temperatures over 30°C were seen to affect specific seed oil extraction but no noticeable difference with fibre yield. Horne (2020) mentions the need for more refined processing machinery to spin long and short fibres for textiles applications. Horne (2020) explains that many other research methods of processing for other fibre extracts can be implemented into the hemp fibre strain processing systems thereby reducing the energy demand for advanced machinery. Specific retting methods of hemp can be used for different applications whilst mechanical processing is likely to extract efficient hemp fibres.

c. Financial viability

Schumacher, Pequito and Pazout (2020) emphasised costing industrial hemp farming for textile extraction. Their economic methodology took into consideration four major input variables in order to generate a feasible input-to-output ration. These factors were the fertilization costs (also referring to the preparation for agricultural activities), genetic cultivar accessibility, irrigation costs referring to either under rain-fed[72] or irrigation scheme monitoring and pest control (cost of field operations). Benelli, Pavela, Petrelli, Cappellacci, Satini, Fiorini, Sut, Dall'Acqua, Canale and Maggi (2018) investigated the use of essential secondary metabolites from industrial hemp as a natural insecticide. The results concluded that a specific composition of A-pinene, (E)-caryophyllene and Myrcene as the main terpenoids components from the strain CV Felina 32 can be used as a natural and green Integrated Pest Management Control against pests[73]. These pests included a specie of Aphid (*Myzus perisicae*) (Green peach aphid) and the tobacco cutworm (*Spodoptera littoralis*) (Egyptian cotton leafworm). The isolation and combination of these terpenoids do not have a negative effect on specific vertebrate animals whilst proving to be non-harmful to other essential predators and necessary insects such as the Asian Lady Beetle (*Harmonia axyridis)* and the *Eisenia fetida* (various types of worms) (Bellini et al. 2018). Therefore, the use of these terpenoids and the creation of a sustainable extraction process may prove to decrease the overall costs of industrial hemp fibre grown for textile application by extending the

[72] Rain-fed conditions in this instance refers to mitigating fresh water usage by allowing the hemp to be grown primarily with rain waterhowever when the farm is parched or in a dire moisture lacking conditions, irrigation water would be used.
[73] The process of terpenoids extraction involved steam-distillation, gas chromatography and gas-chromatography- mass spectrometry.

commercialisation factor and financial viability of industrial hemp farms by providing natural botanical insecticide.



Figure 79: Hemp fabric

Ranalli and Venturi (2004) investigated the viability of hemp as a textile in the European market and found that a major challenge to securing financial investments for hemp was due to the high labour costs. A proposition set forth by Horne (2012) was that by developing high-value added hemp textile products, the financial barrier of high labour costs can be offset. Corbin et al. (2020) mentioned that a shortcoming of industrial hemp for fibre extraction is its' competition against other natural fibres such as flax. The competition changes depending on country-specific scenarios. However, when seen as a viable co-crop for natural fibre, meaning that it can be integrated with other natural fibres to co-exist within the textile community, this induces a strong edge towards reducing the textile industry carbon footprint whilst investing in a different industry. Ranalli and Venturi (2004) mention the need for government subsidies in Italy when processing hemp for fibre extraction. This key element of financial support from government contributed to research and development around harvesting processes, agronomic conditions needed, phenotypic relationships with specific pedological studies[74], these contributed to a sustainable financial input-to-output ratio of hemp fibres which are now self-supporting economic revenue streams. This suggests a feasibility behind hemp when exposed to government fiscal policy assistance. Hemp proves to be eco-compatible when compared against conventional non-fibrous material used for apparel.

[74] Bengtsson (2009) investigated specific textile fibre quality parameters and quality guidelines for organic cultivation of hemp for maximum fibre yield such as climate, temperature water, light intensity (photoperiod), growth cycles and nutrients in extensive analysis. However, for the purposes of this research paper, it will not be explored due to word count restrictions.

5. Interview synthesis and analysis

Throughout the course of my research, I conducted 12 interviews with academics, experts, industry experts and associated hemp professionals[75]. To this extent, I have unpacked the contents of the interviews results which pertain to my research objectives and aims. Furthermore, thematically collating the interview data from the contextual analysis and product development chapters. Therefore, the results section connects information from each interview with contextual data form the Eastern Cape and hemp-based product development evidence to provide an analysis of conclusive information around the viability of hemp agriculture in the Eastern Cape.

5.1. Summary of respondent interviews

The table below represents the role of each respective respondent and their relationship to the objectives of this research (please refer to annexures for full interview analysis):

No.	Respondent and Role	Relationship
1	Forestry South Africa	Biomass availability in South Africa. Affordability and cost-benefit analysis of hemp as a sustainable biomass supply. Relevance of hemp as a biocomposite for industrial applications.
2	Fields of Green for All	Challenges facing the hemp industry from a socio-political perspective. Perspectives regarding hemp regulations for trade and industry growth whilst including small-scale farmers.
3	Agr8	Geospatial data layering of farming communities. Capacitating small-scale farmers with technical know-how of integrating hemp crops into their farms. Collaborating a hemp ecosystem to optimize a farm specialization in the hemp supply chain.
4	Medical Cannabis cultivator	Cannabinoid research and applications.
5	Cheeba Africa	First educational platform for Cannabis and Hemp in South Africa. Significance of hemp education. Creating an awareness of the possibilities of hemp agriculture.

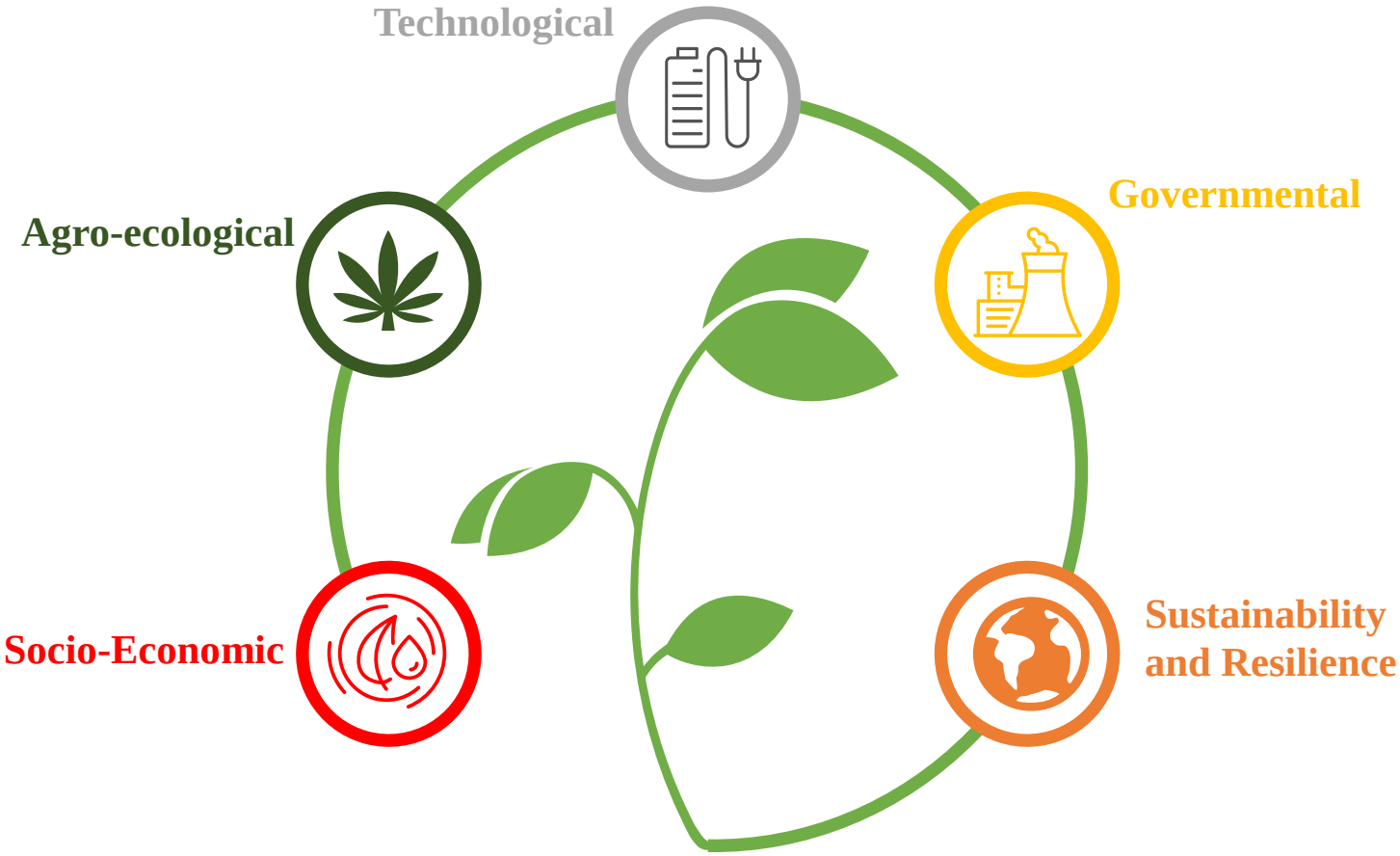
[75] Refer to annexures to see the tabulated analysis of the interview findings.

		Accessibility of hemp and cannabis education to the citizens of South Africa.
6	Hemporium: sustainable applications of hemp	Focuses on applications of hemp specifically cosmetics and hemp-based construction.
7	African Cannabis Advisory group (ACA)	Cannabis financial advisory group providing an investment platform to develop start-up ideas and strategic financial know-how of operating hemp businesses.
8	Eastern Cape Professional Cannabis and Hemp Consortium Official	Represents the perspective of small-holder and traditional farmers in the Eastern Cape with regards to hemp and cannabis cultivation.
9	Leading expert apiarist in South Africa	The integration of Honey Bees in agri-ecosystems to support a healthy agricultural landscape. Currently working with hemp and cannabis farmers to create sustainable Honey Bee farms within the hemp agricultural zone.
10	Canada's Industrial Hemp Corporation Official	Recently patented a disruptive technology which uses artificial intelligence, machine-learning technology for hemp decortication for biocomposite industrial fibres and polymer matrixes in Canada. Focusing on the primary and secondary processing of hemp fibre for bio-pellets (thermoplastics), hemp fibre reinforced polymer matrixes, textiles and nano-materials (aimed to replace graphene).
11	Original Cape Town Hemp Growing OG's Cannabis Industrial Development Cooperative of the Western Cape (DCWC)	Original Cape Town hemp develops hemp apparel and a CBD isolate range thereby exhibiting the viability of hemp to develop products. Growing OG's is a non-profit organization aimed at providing an opportunity for youth engagement through musical talents. This was developed by constructing a musical studio made from hemp, using hempcrete and hemp insulation panels. This displays the versatility of hemp to develop acoustically appropriate music studios whilst stimulating rural youth engagement. The DCWC is a delegated provincial representative to government on behalf of hemp and cannabis-experts. This body aims to be the interface of the Western Cape's hemp and cannabis experts with government in order to

		disseminate accurate information about cannabis and hemp in terms of cultivation and industrial growth.
12	Crafted Hemp Farms official	A Research and Development permit aimed to develop a multi-purpose hemp crop for genetic seed harvesting, seeds and biomass. Aims to develop agro-rural socio-economic inclusion on the farm to stimulate women-empowerment programs and providing local employment opportunities to the surrounding communities.

The participants above were chosen based on their expertise and relevance in the cannabis and hemp industry. Various relevant officials in the Eastern Cape provincial government were contacted with no success on return of emails and phone calls. Due to COVID restrictions and the need for expertise opinion in this research topic, the elected participants were selected whom were available and had relevance.

5.2. Thematic results findings and synthesis of data addressing the opportunity for sustainable hemp agriculture in the Eastern Cape



a) Socio-economic

- Sustainable financial support for agro-rural communities

The socio-economic dimension regarding hemp agriculture was reported to be the most important potential in the current economic climate in South Africa and the Eastern Cape. Respondent 1 refers to the strategic role of the Department of Trade and Industry to facilitate the economic drive needed to expand hemp as a raw material for industrial products. This correlates with the cross-sectoral department involvement in the hemp industry and the National Hemp and Cannabis Masterplan formed by the inter-sectoral government departments aimed to expand and assimilate hemp as a multi-beneficial crop for many industries. The impact would be a policy driven strategic framework which demarcates specific roles and responsibilities to government departments within the hemp ecosystem. The framework would identify strategic parcels of land for investment, how to support supply chains and develop a timeframe the action for specific implementable

projects within South Africa. This would stimulate investor confidence and promote the integration of hemp as a sustainable crop for cultivation.

It is important to note that the within the proposed hemp masterplan, the opportunity to increase employment and stimulate industries can be urged through the development of low-tech, mid-tech and high-tech applications therefore applying the appropriate development applications within areas that need employment. The suggestions regarding the Eastern Cape is to stimulate the available arable land through the demarcated Coastal Transformation Corridor to provide labour absorbing employment for actively-seeking-employment citizens. The more farms which generate employment, the larger the multiplier effect of that farmer workers income to support a family structure or meet their needs to increase their quality of life.

Historical employment data

	2008 Q4	2013 Q4	2020	2025	2030
Total employment	1.3 million	1.3 million	1.6 million	1.9 million	2.2 million
Labour supply	1.8 million	1.9 million	2.0 million	2.2 million	2.4 million
Unemployment rate	25.2%	27.8%	20%	14%	8%
Poverty rate					
Gini coefficient	0.63	0.64	0.62	0.60	0.58
Agriculture employment	80 000	67 000	90 000	140 000	180 000
Manufacturing employment	203 000	134 000	180 000	250 000	300 000
Construction employment	111 000	151 000	200 000	250 000	300 000
Tourism employment		40 000	70 000	130 000	200 000
Social economy employment (estimate)		150 000	180 000	220 000	250 000
Knowledge-based services employment (estimate)		40 000	80 000	120 000	180 000

Figure 80: The goal for labour absorption in the agricultural, manufacturing construction and tourism industry in the Eastern Cape thereby aligning with the potential of the hemp industry

The Eastern Cape has structural challenges such as large unemployment, youth migration and women-unemployment. Therefore, by integrating women empowerment programs to foster employment which harnesses the indigenous skills and abilities of the women in the community to provide sustainable income. The use of training facilities to develop skills for women in planting and pruning, administrative capabilities and low-tech hemp textile product development would provide technical know-how of farm management. Textile applications imply using hemp for baskets, hats, table cloths and other products which integrate with existing dexterity skills in agro-rural communities. Respondent 12 stimulates the engagement with women-led employment plans through Crafted Hemp Farms in the Eastern Cape. Respondent 12 explains women-based employment is more trustworthy and they demonstrate better care and attention to the crop. The field visit to a farm in the

Eastern Cape used primarily women-empowerment employment activities such as pruning, packaging, maintenance and cultivating practices.

A lack of youth engagement in agriculture can be addressed via education and training facilities for hemp workshops within the community. These could be through the proposed Cannabis College in the Eastern Cape and the training and education workshops from various hemp farms in the Eastern Cape. The appeal of hemp sustainability and hemps' association as a legal crop is spurring interest in many ages of life. Through the advocacy from the private sector and marketing campaigns, the perspective of the youth on engaging will be attracted to an evolving industry.

The Land and Agricultural Bank from the National Treasury and the Micro Agricultural Financial Institutional Scheme of South Africa (MAFISA) mentioned in Chapter 3 provides the platform to enable financial support systems to local and sub-regional farming enterprises.

- Capital investment

Respondent 5 divulges the effects of intense capital investment needed for start-up hemp industries. The high costs of upfront capital pose a challenge for growing small-scale farmers, especially in the Eastern Cape. Respondent 5 suggests the need to establish collaborative, long-term sustainable businesses to develop hemp agriculture as a catalyst to stimulate industries in South Africa.

The evidence relating to cost of fencing, cost of equipment and wages addressed by the Eastern Cape Hemp Pilot Project Initiative depicts a high up-front capital cost. Sotana (2020) mentioned a strategic business model for integration into hemp farm projects. This is the Community Public Private Partnership (CPPP) which delegates funding from government, private sector international off-take agreements and communal owned land within tribal kingdoms. The suggestion here is to address the upfront capital costs of hemp farms whilst stimulating industry by harnessing the potential of arable land. In order to meet these goals, the legislation must enable growth and tribal authorities must be transparently communicated with to foster sustainable partnerships.

Furthermore, Respondent 1 and Respondent 5 confirm the need for a transparent trickle-down effect from foreign direct investment and capital investments into a social leadership program in hemp agriculture. By developing employment opportunities and active participation for social welfare programs, valuable change in agro-rural communities and farming landscapes can be created., Respondent 1 alluded to the challenges, such as the costs of production, which pose a challenge for the infant hemp industry. Some of the challenges are growing enough hemp as a raw material for consistent input into industrial

manufacturing sectors, the integration of hemp into industries, logistics and cost of logistics for farmers and market accessibility and receptiveness. Respondent 1 elaborated on the financial and structural challenge of logistics for hemp. The logistics includes the delivery of input materials and farm equipment to geographically disparate farmlands and the delivery of the raw material to agro-processing facilities. In addition to this, respondent 3 explains that the hemp market needs coherent logistics and timely exposure of products in order to become financially feasible for potential hemp farmers.

- COVID-19 pandemic

The COVID-19 pandemic has created economic contraction in many worldwide economies. The commensurate rise in climate change and the emergence of the COVID-19 pandemic has called for more urgent action to develop climate combating industries whilst creating sustainable labour markets. The potential of the hemp industry to address these two challenges deserves careful attention and robust investment in the Eastern Cape. The commercialisation of hemp licenses for farms in the Eastern Cape would promote increased employment for agro-rural farm workers in the region whilst stimulating industries for local and international trade.

Respondents 1, 6, 7 and 8 confirm the economic starvation experienced in South Africa caused by the effects of the COVID-19 pandemic. Respondents 6 and 7 support the need to integrate hemp into the growing, processing, manufacturing and retail stage in our economy. Both interviewee's agree that hemp could serve as a vital tool to stimulate local economic empowerment and contribute to the greater quality of life for farmers and residents within communities. Respondent 8 advocates that hemp must be used as an asset to form part of the South African Economic Reconstruction and Recovery Plan within South Africa and for the Eastern Cape specifically. Respondents 2 and 8 mention the perspective on the possibility of monopolization of the hemp industry coincides with respondent 1 and 5's viewpoints on the fear of an isolated hemp industry. Respondent 2 explains that the values and key principles of what the plant represents is being over shadowed by the 'Green Gold Rush' of chasing CBD products. Respondent 8 explains the challenges of distributing revenue within the hemp ecosystem if there is no economic prowess in facilitating development opportunities for local communities.

- Social responsibility, community, culture and history

The historical significance of industrial hemp and its cultural value within communities in the Eastern Cape contribute to its viability within the social and environmental landscape. In the Eastern Cape, the development benefits surrounding the plant contribute to the esoteric philosophies of connecting people and creating community via its psychotropic

effects. However, the stimulation of hemp as an industry will diminish the stigma surrounding the 'weed' and suggest a valuable cultural significance within the *cannabis* paradigm. Therefore, by understanding the cultural significance of hemp within the Eastern Cape and its ability to impact agro-rural farmers will instigate social responsibility and greater awareness around the potential use of the plant as a viable crop through it ability to gain revenue. Hemp and its mistaken relationship with THC-producing marijuana, can be used as a symbolic representation of the economically viable attributes of the crop therefore contributing to the notion of 'Topophilia'[76], which amplifies the identity of a culture through its physical environment. Therefore, by harnessing the potential of the Xhosa Kingdoms tribal authorities to farm hemp in the Eastern Cape, the ability to foster a greater sense of belonging and mutual cohesiveness will intersect with the potential of social responsibility within the community.

The suggestion coincides with Respondents 11's findings through the need to develop tribal land for hemp agriculture which can aim to address sustainable housing in the Eastern Cape further promoting industry development, downstream employment opportunities and a healthier population via the environmental properties industrial potential of hempcrete. According to the socio-economic findings, biophysical studies and policy evidence[77], the tribal authority land over-laps with the agri-enterprise and small-scale farming resource region, the available arable soil potential and the Ncora agri-hub (and the logistics infrastructure) is in the local municipalities of:

- Port St. Johns
- Nguza Hill
- Mbizane
- Matatiele
- Elundini
- Buffalo City
- Mnquma
- King Sabata Dalindyebo
- Raymond Mhlana
- Ntabankulu
- Umzimvubu
- Mbashe

[76] Topophilia describes having a sense of place and belonging which further enhances cultural identity and value within a geographic space.
[77] Chapter 3's analytical data.

The increase in welfare will contribute to a greater quality of life in terms of the ability to afford healthcare services, educational fees and basic necessary goods.

The use of hemp as a sustainable biomass for product development can create a strong product brand emerging from the Eastern Cape. This can drive the transformative potential of hemp as a crop in the Eastern Cape which enhances the social collective attitude towards hemp and suggests more corporate and industrial co-operation.

The interview process expressed a multitude of overlapping comments. Respondents 2 and 8 agree that the plant has historical and intrinsic significance within South Africa, and the cultural value is being disregarded by government and investors. However, Respondent 3 affirms that hemp is now forming part of the green industrialisation movement occurring throughout industries worldwide. Therefore the respondent hopes hemp will be managed holistically by the public and private sector in order to allow for collaboration and local-community involvement and beneficiation.

- Cannatourism

The industrial significance of tourism in the Eastern Cape provides income for many indigenous communities due to the global attraction of the Eastern Capes richness in indigenous fauna and flora and beautiful beach fronts. Therefore by developing Cannatourism within hemp and cannabis farms in the Eastern Cape, the increase in attraction from global citizens and local residents would boost the growth of the industry. The boost would allow for the development of ancillary retail outlets on the farms such as farm stalls, coffee shops and small holder goods. This form of ecotourism provides a farm experiences with added benefits such as farm excursions, educational pamphlets, phenotype hunting and possible seedlings for the participants in the activity. The opportunity to develop Cannatourism as a form of sustainable non-invasive touristic methods could stimulate more investor confidence and other forms of social upliftment for the region.

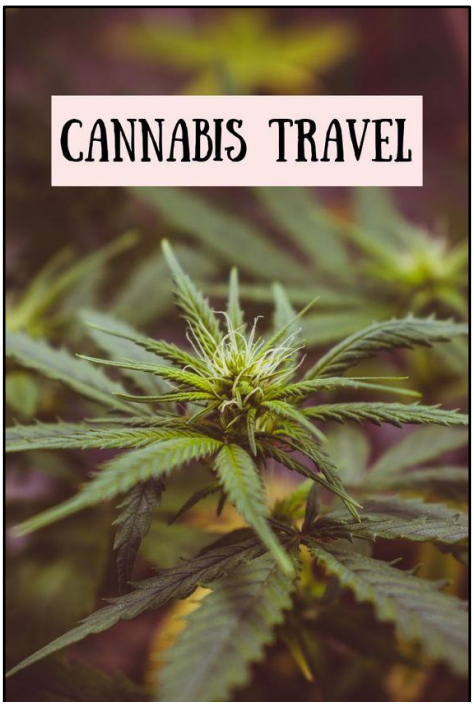


Figure 81: Cannatourism as a viable economic asset in the Eastern Cape

- Agro-rural farmer co-operatives

The transformative potential of inclusive agricultural farmer co-operatives provides mechanism for industry growth, employment and an increase in quality of life. The development of an agro-rural farmers' co-operative model would integrate intelligent systems to link farmers remotely with information-sharing platforms.

The farmer co-operative alludes to the notion of farmer protection, ensuring there is an understanding of soil, crop health, yield management and training. Furthermore supported by a risk and data platform giving the farmer the idea of market demand for price discovery and specific agronomic practices to follow. Following this, the grouping of third party services contributing for micro-credit loans, banking and trade finance, crop verification and certificates and marketing schemes would ensure market security, thereby all culminating in the marketplace, allowing for the retail of processed and unprocessed crop, international trading of crop and logistics organization.

Systems thinking around agro-rural communities for small-scale agriculture:

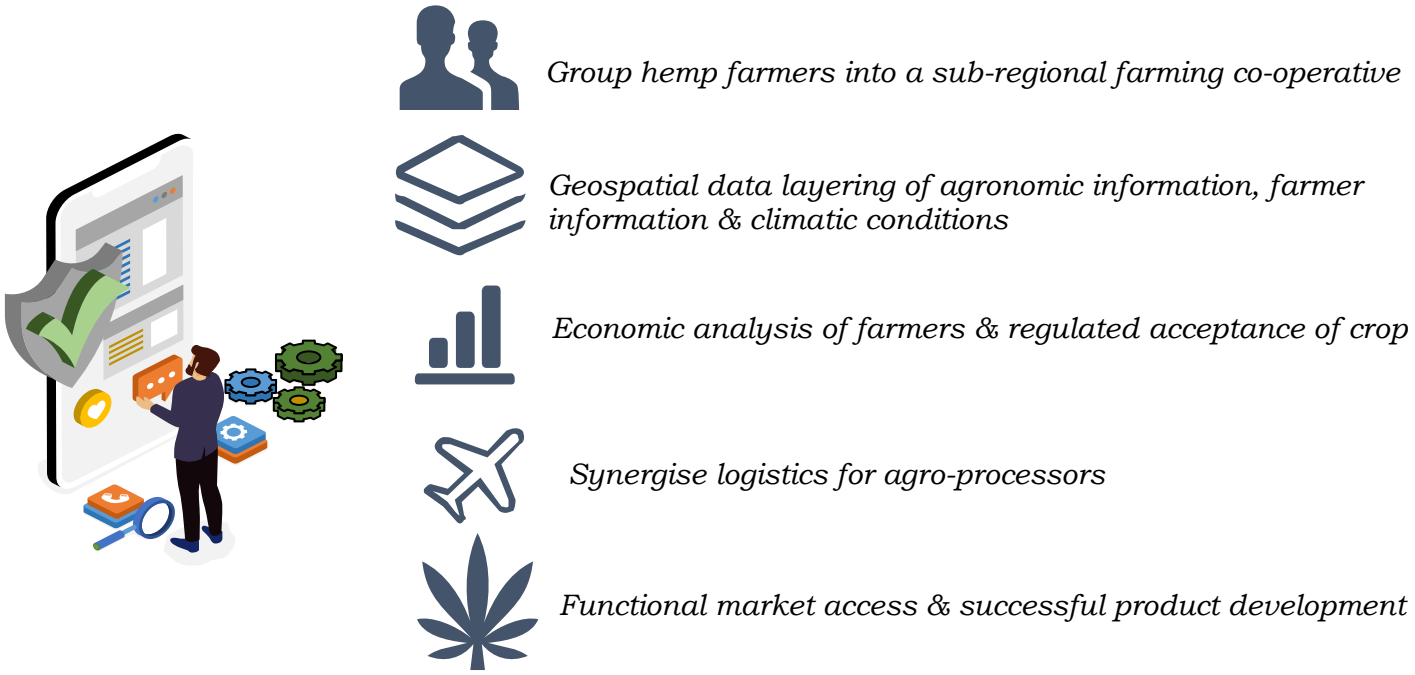


Figure 82: Infographic showing the concept behind the farmer integration model

The idea of integrating systems sharing platforms for the better overall management of farmer financial security and market entry would allow for a sustainable and resilient sub-regional farming community within the hemp ecosystem.

- Viable energy efficient hemp-based product development

Due to the infant stages of hemp-based product development in South Africa, the primary need is to develop enough biomass and dry yield per hectare to provide quality supply for industrial applications on feasible economies of scale. Therefore the growing hemp industry will require more commercially licensed hemp farms to deliver specific agronomic practices for plant growth in order to specialize in applicable product development. The need for government funding to develop industries which process hemp into a sustainable products will be an integral factor when kick-starting the industry. The cultivation of South African

grown hemp will decrease the selling price of hemp-based products and therefore lead to a more accessible product for lower income citizens.

It is important to note the energy efficiency and renewable nature of hemp as a green building material. Hempcrete can contribute towards social housing schemes and healthy housing options in the Eastern Cape. This notion of sustainable development can synergise with the Chatten Agri Mine in Humansdorp which extracts lime and limestone thereby providing an intra-provincial source of binder for hempcrete (Department of Mineral Resources and Energy, 2021). Hempcrete provides a carbon neutral building material for sustainable housing. Hempcrete has the potential to address a multitude of housing related issues such as the sick house syndrome[78], community, sense of security, government social housing challenges, transformative rural development, sustainable and energy efficient infrastructure. The development of a hempcrete industry provides labour absorbing employment options and synergises with combating the resource intensive construction industry. The opportunity to integrate hempcrete as a sustainable green building material into the Green Building Council of South Africa could provide a unique building material for healthy and sustainable housing in South Africa.

The investment in the automotive industrial sector within East London can synergise with the production of bioplastic integration which reduces the overall carbon footprint of the industrial mechanisation process whilst stimulating the hemp industry for investment. The use of hemp-based thermoplastic and biocomposite polymer matrixes can provide structurally resilient motor vehicle parts for the Mercedez Benz and Volkswagen investment in Coega Industrial Development Zone[79]. Due to hemp-based polymer structures having good mechanical properties and better performing energy efficiency, the opportunity to integrate hemp-derived polymer structures into mainstream industries can combat the petroleum-based plastic industry and thereby provide sustainably produced and biodegradable plastic substitutes.

The suggestion of using hemp as fuel or to provide a carrier for combined heat power would need commercial equipment, investor buy-in and large quantities of biomass with seed for extraction. Therefore, the reliance upon existing systems of technology do not meet the requirement of advanced biorefineries whilst the challenge of generating large quantities of hemp for fuel still exist in the early stages of the hemp industry. Prade (2011) investigated the net energy yield per hectare of hemp (input and output) and found that hemp has a high output-

[78] Sick House Syndrome pertains to specific diseases and symptoms of illness inhabitants experience in a building due to a low level of health standards.

[79] This is further elaborated on in the government section within this chapter.

input ratio than other renewable forms of energy. The fast-growing ability of hemp supports the demand of the supply chain further promoting hemp as sustainable energy crop.

The viability of industrial hemp as a bioenergy crop is supported by the high conversion rate per hectare and whilst storing carbon in the growth stage thereby providing a sustainable source of energy for biogas, bioethanol and biofuel.

The opportunity for hemp fibre development can help stimulate local manufacturing and generate Eastern Cape textile brands. The advantage of using hemp for textiles is the lower carbon footprint than conventional cotton material. Furthermore, the development of hemp fibres for household textiles, working garments, sport apparel or leisure wear has benefits for breathability, hygroscopicity and Ultra Violet protection with many other benefits. Hemp is a renewable resource and provides a natural fibre that proves to have the mechanical factors worthy of market demand. When in the final product, hemp still has the potential to biodegrade. These factors can align with addressing healthy clothing for the population of South Africa and international markets whilst generating local value-added supply chains for employment absorbing potential in the agro-rural communities of the Eastern Cape. According to Ranalli and Venturi (2004), the need for government funding to invest in refined processing and weaving equipment is necessary for the initial development of hemp textiles. This aligns with Respondent 10's innovative Artificially Intelligent fibre processing equipment which generates high quality fibre processing based on market demand.

b) <u>Agro-ecological</u>

- <u>Sustainable Agricultural Practices[80]</u>

In the environmental realm, restorative and regenerative agriculture contribute to a healthy soil status through the different nutrient demands from the crops. Therefore it mitigates soil sterility whilst contributing to less surface runoff of water and soil erosion due to the requirement of minimum soil disturbance (zero tillage). Water scarcity in the Eastern Cape is a reality. However, with the implementation of permaculture, restorative and regenerative agriculture, the conserving of water in the root system is more prevalent due to the mix of roots systems which deter surface run off and allow for more absorption within the soil network. Regenerative, restorative and permaculture farming techniques rely upon the natural mix of plant diversity amoungst the farm to provide a sustainable method for cultivating product. The insertion of the industrial hemp into any one of these farming techniques can facilitate an overall management of the farm's ecosystem.

[80] Regenerative, restorative, conservative, permaculture, intercropping, crop rotation and agroforestry.

The notion of intercropping[81] is on the cusp of commercial farm use but is rather used for low input, resource limited agricultural homesteads. The variations of intercropping[82] which can be used for hemp agriculture can contribute to a sustainable farming practice whilst providing innovative ways of diversifying crop stock and creating a viable supply of hemp for alternate product development. The commonalities of intercropping pertain to agri-active zones which harness subsistence farming methods and are thereby correlated with low-input (high labour) and low yield farms. Therefore, these circumstances assist farmers who use intercropping by increasing the aggregate yields per unit of input, improve soil quality, increase income revenue and ensure against specific crop failure and certain market fluctuations surrounding crops.

The benefits of intercropping with *Cannabis sativa L.* manifest by activating natural pest management control, decreases the threat of soil degradation whilst improving the soil nutrient status due to the phytoremediation properties of hemps roots. It further enhances biodiversity of pollinating ecosystem agents which has complementary effects for productivity. Hemp facilitates resource-use efficiency through reduced water needs and an increase in soil fertility (therefore decreasing fertilizer input costs in the long run). However, a challenge for hemp may be due to the need for a consistent crop output and therefore cannot be inter-grown with other crops due to the specific plant spacing and density required when mature for fibre extraction. This relates to the light availability, space and optimal temperatures needed for hemp versus other possible intercropping crops[83]. The micronutrient availability within the soil can be enhanced by intercropping specific nitrogen, phosphorous and less-water intensive plants. Legumes have been proven to be non-nitrogen demanding in the soil and therefore complement the phytoavailability of this nutrient for hemp plants. Intercropping can be used in water scarce regions due to the ability of different root's structures to access different moisture composites within the microtopographic[84] and sub-terrestrial soil level (Mousavi and Eskandari, 2011).

[81] Intercropping is defined as a specific farming practice which involves two or more different types of crop species or genotypes which are grown together and coexist for certain duration of time (Brooker et al. 2014).

[82] Mixed-intercropping (growing two or more crops simultaneously with minimal arrangement), row-intercropping (regular rows of single crops simultaneously growing amoungst other crops), relay-intercropping (growing a second crop before maturation of the first crop) and strip-intercropping (growing crops simultaneously in strips).

[83] Known as the 'three sisters', maize, beans and squash work best for intercropping.

[84] Describes the scale of soil surface variation.

Within the Eastern Cape climate, various agro-ecological contexts demand more interpretive intercropping methods which may utilise the stress gradient hypothesis[85] based on site analysis, soil properties and climatic conditions. It is also important to mention the postulation of common mycorrhizal networks (CMN). CMN describes plant-to-plant communication through an allelochemical[86] signalling which directs energy to target plants and protects plants from harm. Such advanced understanding of root biomass systems allows the plants to prioritize nutrients to target plants through root systematic communication. Ideal CMN combinations with increased plant biodiversity allow for an increase in pollinator agents, protection against pathogens and an improvement in crop production (Brooker, Bennet, Cong, Daniell, George,Hallett, Hawes, Iannetta, Jones, Karley, Li, McKenzie, Pakeman, Paterson, Schob, Jianbo, Squire, Watson, Zhang, Zhang, Zhang and White, 2014).



Figure 83: Mixed-crop harvest of Cardriano Farm in Italy, 2018.

Therefore, the significance of this is that hemp is a recently investigated plant with multiple soil enriching properties, resilient and fast growing attributes which opens the doorway to the inquiry regarding hemp intercropping and the discovery of the best plants in which hemp should intercrop with. The opportunity to bioengineer small-scale farm steads and sub-regional farmer co-operatives with intelligent intercropping systems would contribute to the viability of the hemp industry whilst allowing market accessibility for small-scale farmers via a diversity of crop production. Therefore this would boost the financial viability of small-scale hemp farmers in the Eastern Cape whilst integrating indigenous knowledge systems of farming in the region with versatile new-age farming techniques. Through data layering of soil status, climatic conditions and crop physiology, the ideal intercropping relationship can be managed to provide the optimal output of raw material for fibre processing or seed availability depending on product development.

[85] The Stress Gradient Hypothesis is used to predict positive or negative reactions in companion plants. This analytical tool is used more often in stressful environments.

[86] Describes a specific chemical which is produced that has a negative effect on another species if released into the environment.

The use of hemp to address crop health can also be seen through its use as a rotational crop for other agricultural zones. Hemp's bioremediating properties would naturally rejuvenate the soil without inorganic soil fertiliser and therefore provide a nutrient-rich soil base for the next crop. Therefore hemp would act as a rotational crop and be harvested for biomass or could be planted for other specific hemp products. This would further allow for the increase in raw material for agro-processing centres. However, the legalities regarding requirements for commercial licenses would be contested.

The use of hemp's natural cannabinoid Cannabichrome (CBG) can be used to treat the gut disease staphylococcus aureus of livestock. This poses a healthier livestock population with a contributory financial opportunity for hemp farmers to produce healthy, hemp-fed cattle. The contribution of a healthier livestock population aids in promoting food security for the community and financial security for the farmer. These suggestions mentioned by Respondent 4 correlate with the research findings. This proves the potential of cannabinoid extraction for livestock health. Furthermore, Respondent 12 provides hemp as a livestock feed for cattle with results indicating the nutritional benefits of for the livestock. Furthermore this promotes the viability of hemp in terms of extending its reach to provide hemp-fed cattle as a unique product. This suggests a feasible and viable use of hemp as a sustainable crop in the Eastern Cape due to the reliance of livestock farming by agro-rural communities. Another avenue of crop health relates to hemps terpene extraction which can act as a natural pesticide for crops. This would help integrate more crop management health awareness via the reduced use of harmful integrated pesticide control management schemes currently used.

- <u>Bioremediation of soil through hemp agriculture</u>

The agro-ecological paradigm of hemp cultivation was briefly mentioned by the various respondents. Respondent 6 explained the opportunities for hemp farm integration in terms of farming hemp as a biannual crop within specific agro-ecological zones in South Africa. Specific reference was given to the fast and easy growth of hemp as a crop. The bioremediating properties of hemp and the postulation of counteracting nutrient dependant crops with the nourishment of hemp soil can contribute to the health of the agricultural landscape. Respondent 12 alludes to the use of hemp field soil as a commodity for retail to other farms. This is due to the bioremediating properties of hemp farming. This optimizes the purchasing farms next crop production, thereby stimulating the diversity of tradeable products within the hemp industry.

The bioremediation properties of hemp can also be integrated into a commercial monoculture agricultural landscape via the technique of crop rotation. The depletion of soil nutrients through monoculture crops is well researched. Yet the ability of hemp to nurture

soil health whilst growing provides an avenue for single-variety crop farmers. The method involves growing hemp as an off-seasonal crop to provide a nutrient-rebalancing effect for the soil after the primary crop has been harvested. This has the potential to reduce input costs of fertilizer for the farmer whilst facilitating conservative resource farming methods. The off-seasonal hemp can be used as a cash crop for agro-processing facilities thereby increasing the cost-benefit analysis of the farm.

The ability of hemp to bioremediate heavy-metal contaminated soil poses a mutually beneficial relationship for the mine rehabilitation within the Eastern Cape. By using hemp to 'clean' the soil, the government not only recovers abandoned mine dumps but also is able to stimulate localised-employment and generate revenue. As mentioned by Ahmad et al. (2015), Amaducci, Zatta, Raffanini and Venturi (2008) and (Prade, 201), the remediated hemp biomass can be used for industrial repurposing and thereby contribute to the supply of raw material into agro-processing facilities for hempcrete, bioplastic and textiles (depending on agronomic practices). The areas for intervention within the Eastern Cape would be Pondoland for extraction of heavy metals due to the harmful effects of coal mining to ecological areas and the dumping of heavy metal deposits (WWF, 2013). The provincial government could intersect the Elitheni Coal mines in Port Elizabeth as well as the anthracite mines in the Lady Frere region with hemp agriculture to rehabilitate old and inactive mines for further agricultural land or research and development. Furthermore, by generating more supply within a specific geographical space, the potential in the supply chain of value-added products increases.

- Pollinating ecosystem agents

The ability of staminate hemp pollen to attract pollinating ecosystem agents contribute to the health of biodiversity amoungst pollinating Hymenoptera. Therefore the use of industrial hemp within an agri-ecosystem can serve as a vital crop for the cross-pollination of other crops. The intersection of the environmental and social benefits of hemp agriculture includes the opportunity to create a subsidiary income stream through the integration of Cape Honey Bee/African Honey Bee[87] hives. This opportunity to



Figure 84: Hemp as a healthy ecosystem crop

[87] As previously mentioned, the Eastern Cape is the border of the *Apis Mellifera Capensis* and *Apis Mellifera Scutellata*. Therefore the honey bee farm will depend on the location of the farm within the province.

create a multiple revenue stream farming operation will foremost establish ecosystem-support for the endangered honey bees in South Africa whilst creating a brand opportunity for the farmer with an exclusive CannaHoney[88] product. As previously mentioned in the literature review, hemp pollen provides vital nutrients for honey bees which can be transformed into bee bread containing trace elements of the dominant terpenes from the staminate pollen sacs. Therefore the use of honey bee hives within an agricultural landscape with hemp farms, the opportunity to create a sustainable identity of hemp and honey in the Eastern Cape can manifest.

Respondent 9 affirms the relationship between pollinating ecosystem agents and hemp agriculture. More specific to this are the African Honey Bee and Cape Honey Bee. Respondent 9 promotes integrating bee keeping into agri-ecosystems with the exception of bee keeping close to any farms using pesticides, fungicides, herbicides and any pest management control preventative. These acutely threaten bee health. Respondent 9 informs that pesticides create a misdirection for the worker bees (cannot find the hive) whilst fungicides stay on the nectar and pollen of the plant which is transported back to the hive by the bees and therefore poisons the hive cell walls. This ultimately destroys the hive from the inside. Respondent 9 suggests that integrating CBD focused hemp farming with honey bee hives would allow for the infusion of CBD and honey. This would provide a profitable and valuable product for national and international trade. The challenges, explains Respondent 9, is the upfront capital costs involving setting up a honey bee farm and CBD extraction facility. After proposing the idea of natural terpene infused CannaHoney, respondent 9 was positive about the advances of hemp cultivation with honey bees and financial viability. Respondent 9 believes a 5-year bee keeping contract with government subsidies for small-scale hemp farmers regarding the overall health management of agricultural zones through integrating bee keeping with hemp farms would provide flexibility and resilience to bee keepers and hemp farms in the region.

The diversification of hemps profile facilitates the opportunity to integrate permaculture farming methods with the agro-environment. This insight from the literature agrees with Respondent 3's approach that permaculture is growing through the relevance for sustainable food production in local communities. The results suggest there is a need to create a synergy between non-pest management control crops such as strawberries, blueberries, basil and other companion plants to allow for market flexibility for small-scale permaculture farmers. Based on the results, Respondent 9 and 3 agree with the notion of a farmer co-operative set-up operating within a sub-regional agricultural zone. The comments from Respondent 9 would be to integrate the carry capacity amount of bee farms

[88] Natural terpene and cannabinoid infused honey.

within different sub-regions. This would support the management of pollinating crops and bee life through an abundance of pollen and nectar via different floral senescing of crops.

c) Technological



The technological perspective with regards to hemp farming was primarily discussed by Respondent 3 and 10. Respondent 3 investigated the use of a digitalized geospatial layering data of farm conditions to optimise agronomic practices and crop health. Through the advent of a digital co-operative that aims to bring stakeholders and respective parties into a data repository that harnesses an active trading system which is trust and evidence-based, the optimal crop production within a sub-region can be harnessed. These facets would contain soil data, potential of yield gaps in crops and the details of the people using these platforms. This notion of technological integration would provide the comprehensive analysis of the hemp ecosystem within the Eastern Cape and within sub-regional agro-rural communities.

The agri-tech opportunity for farms would provide sustainable technologies driving efficiency of input materials and decreasing the waste of energy. The platform would provide a virtual identity for a hemp farmer. Respondent 3 explains that in order to create a sustainable hemp market, the use of smart technologies that use data centred complex systems that analyses financial security and market demand would provide a platform for engagement amoungst hemp farmers. Therefore this would provide real-time data representations of farm conditions in the Eastern Cape and the input to output ratio of specific products.

This aligns with the proposed farmer co-operative scheme mentioned previously and supports the digitalization of farmers in the Eastern Cape. Expanding on this idea, the use of farmer co-operatives in a sub-region would allow for the wider region to produce a balanced crop output with digital communication. Therefore, there would be sustainable market entry for farmers within the same sub-region due to a diversified crop growth within the farming agri-communities.

However, Respondent 3 states that the challenges around agri-technological innovation is the need for input data from farmers, which is a complex situation in most farming scenarios. Another challenge for rural small-scale farm holders in the Eastern Cape is the language barrier. The conversation explored the notion of deconstructing language barriers via a multi-lingual digital platforms that gives translated information. The conflicting security of land within tribal areas in the Eastern Cape poses a challenge towards the optimization of arable land. This is partially due to inner-tribal land conflicts and a lack of registered parcels of land thereby diminishing private sector confidence. However, the

progressivity factor regarding the viability surrounding hemp agriculture supports investor risk analysis in terms of developing industries from the bottom-up. Therefore, the increase of consistent supply and stable market access would increase prices, thereby supporting financial buy-in for the industry in the Eastern Cape.

The overlapping comments made by Respondents 3 and 10 was the need to develop a traceability factor for hemp products. This would provide consumer security and a product intelligence for hemp businesses.

Respondent 10 developed technology aims to drive the hemp fibre industry into the space of integrating with other compatible industries, automobile, polymer matrix manufacturing and other industries, due to the reliance of consistent high-value hemp fibre supply. The technology is an AI-driven machine-learning hemp decorticator. The Smart Stalk System aims to deliver cost-effective solutions for consistent supply, high quality and profitable hemp stalks. The prevalence of the need to develop high quality fibre would allow for other compatible industries to synergise with hemp biopolymer structures and other fibre-applicable products. The large capital upfront costs are disproportionate for the current economic climate in South Africa. However, the system aims to develop high-quality fibre in an output processor which can develop flexible products on demand, increase yield of crops and provide material for commercial trade. The integration of innovative technologies would support the hemp industry in the Eastern Cape as the production of high quality fibre could be used for high-technical applications such as hemp-based biopolymer structures. This would drive an export-based hemp industry whilst combating the use of conventional petroleum based plastics.

The lack of systems efficiency in the hemp industry for biofuel production, textile fibre processing and hemp decortication is a challenge which will be addressed with investor confidence in potential financial returns of the hemp industry driving innovative technology and consumer awareness driving demand about the benefits of using hemp-based products for the environment.

d) Governmental

- Green industrial revolution through localized development and international trade



South Africa has recently promulgated the commercialization of industrial hemp and the Eastern Cape holds a key to the future in terms of available arable land, biophysical advantages and demographic status. The Eastern Cape hemp industry is a market opportunity for foreign direct investment and international trade agreements. The trickle-down effect of foreign investment can help address poverty within specific areas through localized value-added employment options. The appeal of investing in available arable land

in the Eastern Cape interests international parties for the exchange rate difference, less expensive labour costs and favourable climatic conditions. However, through the development of localized systems of production and multi-agro-processor equipment within the viable distance from one another (using the Agri-park concept), the Eastern Cape could become a prioritised hemp province.

The proximity to ports for exports would be a leading factor in developing an export-based hemp industry which manufactures and sells value-added goods. The three ports in the Eastern Cape propose a viable development of sustainable hemp products. The recent investment in Coega Industrial Development Zone for Mercedez and Vokswagen could stimulate the development of hemp-based biocomposite interior features for motor vehicles. This could provide a sustainable green identity on the viability of hemp biocomposites in the Eastern Cape contributing to the bioeconomy via the use of a sustainable and renewable biomass.

A further development which would stimulate government and the economy is the use of international and local hemp trading for tax generation. The amount of hemp produced, processed, manufactured and sold can create a new revenue stream of company, manufacturer, logistic and retail tax. The value-added tax would decrease government debt and hopefully allow for a financial boost in the green economy. Therefore, the Eastern Cape province would tax sectors of the supply chain and create a new avenue for fiscal generation which could be used to stimulate development within the province and advance government services to the areas in need.

In a working paper mentioned by UNU-WIDER (2020), there is a proposal for a South Africa-Malawi inter-regional trade route as one of the intra-African cannabis and hemp partnerships. The strategy aims to team up and develop an evolving partnership with Malawi which would promote the accessibility of hemp-products to the public. The aim is to stimulate small-holder tobacco farmers to produce hemp and therefore use that hemp to contribute towards trade agreements between the SADC. Therefore the opportunity arises to use GMP (Good Manufacturing Practice) licensed hemp from Malawi to feed into South Africa's regional agro-processing centres to create hemp-based products. The alliance would represent a stronger agri-partnership between Malawi and South Africa and a larger supply of hemp to develop raw-material-intensive products such as hempcrete or biofuel. The opportunity is further stimulated by the supported positive outlook on emerging farmers from the USA with the recent election of President Joe Biden. This, coupled with the AFCTA agreement and the AGOA trade deal would boost the entry into markets for hemp farmers.

The agri-enterprise zone earmarked within the Coastal Transformation Corridor aligns with the proposed hemp industry development by acting as vehicle for agro-rural socio-economic

transformation. Furthermore the proposed *Ilima Labantu* from the Eastern Cape Vision can prove to be another policy protocol in which the hemp industry can contribute towards the attainment of a revived rural economy and an increase in agricultures value-add to the overall provincial economy.

Respondent 1 addresses the new jurisdiction of hemp as a crop under the Department of Agriculture, Forestry's and Fisheries and as an internationally tradeable good under the Department of Trade and Industry. However, Respondent 2 confronts the issue of a lack of coordination between governmental departments which poses a threat to the harmonization and optimization of the crop and its potential sustainable, energy efficient product development. Respondent 2 alludes to the lack of alignment amoungst an under-capacitated government which has misinformation about hemp. The misinformation is addressed via the implementation of the 0.2% THC limit needed for hemp crops. Due to South Africa's hot and sunny climate, the strains grown for hemp production will be threatened to stay below this amount. South Africa's climate is prone for high-THC yielding crops. In addition to this, Respondent 2 discusses the high capital inputs needed for farm permit requirements[89], this will small holder farmers from using this crop as a viable source of revenue whilst only allowing for commercial farms to generate income which may fuel large corporations to dominant the hemp market. Respondent 2 affirms that over-regulation of hemp will mitigate the full potential of the crops versatility within industries.

This aligns with Respondent 3's perspective about the awareness of a non-integrated government sphere within the Eastern Cape. A further hindrance is the complex situation regarding intra-political territories within the tribal authorities within the Eastern Cape. This aligns with Respondent 8's perspective about the conflicting relationship between traditional ownership and privatisation within agricultural region due to a lack of security of land tenure. The conflict perpetuates the complicated introduction of commercial hemp farms for local manufacturing and production within the Eastern Cape. However, respondent 11 conversed with 5 traditional Xhosa chiefs in the Eastern Cape who are highly interested in growing hemp for industrial production Respondent 7 provides insight into the need for a robust domestic industry to contribute to a successful local manufacturing industry whilst there is a need to have a unique approach to hemp cultivation in South Africa.

From a governmental perspective in the Eastern Cape, Respondent 8 addresses the failure of the Agri-Park system in the Eastern Cape due to nepotism and corruption within the governmental departments. There is much commentary about the lack of a reliable government interface and coordination mentioned by numerous respondents. South Africa

[89] Refer to annexures

is precariously positioned to be a major hemp role player in the industry. There is the possibility of synergising industries to produce sustainable and energy efficient products to combat carbon intensive industries whilst stimulating employment opportunities and generating downstream capital generation.

Respondent 11 mentions that the challenges facing hemp farmers is the lack of functional from the legislation, the lack of government support for farmers and the expense of setting up hemp permit requirements. There is an overarching fear of investor confidence falling into neighbouring countries due to South Africa's lack of enabling legislation. The opportunity for legal hemp cultivation is open in Swaziland, Lesotho, Zimbabwe, Mozambique, Botswana and Namibia. The postulation of hemp farming being an evolving regulatory crop can advance the current legal and political framework. Such that specific practices are coordinated under a Good Agricultural Practice (GAP) policy with specific Standards of Procedure (SoP's). This would diminish the need to destroy 'hot crops' (crops with a higher THC level than required), thereby saving capital loss for the farm whilst shifting the 0.2% THC limit to the retailer and manufacturer to diminish. Furthermore, this would boost foreign investor confidence and increase the supply of industrial hemp for viable product development.

e) Sustainability and Resilience

Focusing on hemp agriculture in terms of addressing sustainable and resilient objectives, Respondent 1 and the literature confirms that a huge advantage for hemp is the recovery rate of for biomass versus other sources of biomass in South Africa. The fast growth rate cycle of hemp supports the advantage of integrating the crop into industrial biomass systems in South Africa. Respondent 3's comments aligns with the literature which suggests hemp can be integrated into the circular economy through its renewability, biodegradability and re-use opportunities. The recent promulgation of hemp as a commercial asset and the legislation following this forms part of the green industrial wave attempting to mitigate climate change through nature-based solutions and innovative industries. Hemp addresses a multitude of sustainable and resilient avenues, such as the use of hemp as a textile versus conventional cotton use. Hemp has a lower carbon footprint than cotton

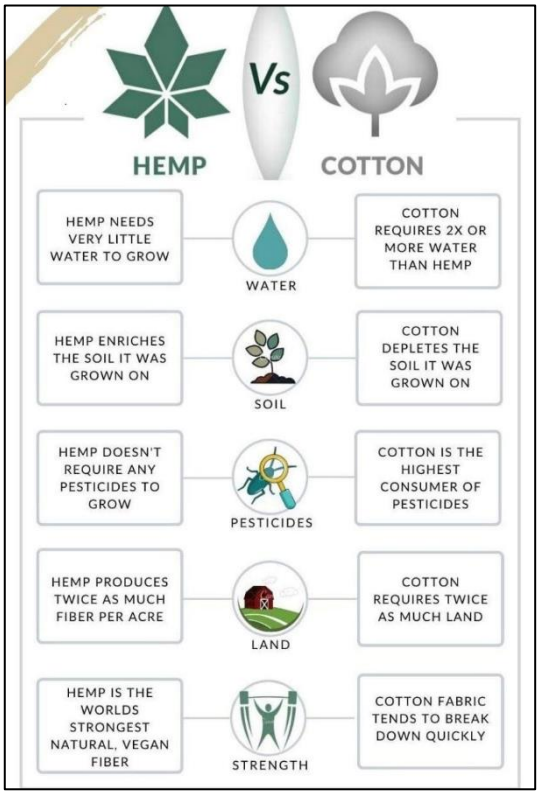


Figure 85: Hemp versus Cotton

and can serve as a vital avenue for sustainable production of apparel, technical-material and fabric.

Respondent 10's aim at developing hemp-based biocomposite polymer structures was formulated to diminish the amount of non-recyclable and non-biodegradable polypropylene structures in the environment. The use of hemp as a plastic substitute can mitigate petroleum-based plastic, thereby diminishing the need to harvest non-renewable resources from the sub-terrestrial environment.

- Trading carbon credits and meeting sector emissions targets

The high rate of carbon sequestration of hemp can be used to meet the sector emission targets for different carbon intensive industries in South Africa. The relationship for government and the environment in terms of resilience from the hemp industry is the ability of hemp to generate oxygen and store carbon in high proportions based on its growing size and plant density. According to Vosper (2019), one hectare of industrial hemp capture by up 22 tons of carbon dioxide in its growth cycle (90 to 120 days). The provincial government can contribute to an increase in carbon capture via hemp farms through endorsement and strategic business incubator models. The optimization of hemp farms for their high carbon sequestrating rate will align us with supranational policy agreements whilst staying focused on the South African Low-Emission Development Strategy 2050. The Desired Emission Targets and Sector Emission Targets can be offset via surrounding hemp farms next to industries to display the ability of hemp to store carbon. The sustainability of hemp agriculture for the green economy can be seen through the use of carbon credits for international trade. The value of the carbon traded can be injected back into the green economy or into the hemp ecosystem to further advance industrial processes to optimise energy efficient production methods of alternative products.

- Hemps versatility

Respondent 11 further advances the reach of sustainability with regards to hemp agriculture by building music studios out of hempcrete to demonstrate the use of green building materials whilst engaging youth skills development. Respondent 11 mentions three critical sustainability criteria to consider when using developing any products with hemp. These are:

1. The legislation must be mobilised to allow for cultivation and growth.
2. The farmers must have successful farming practices with consistent and sustainable supply into the market.
3. The consumer must be aware of the sustainability and resilience around hemp-based products.

These criteria consider the mechanisms need to harness the viability of the hemp industry based on a South African perspective.

Respondent 8 and 12 consider the notion of social sustainability by meriting certain hemp-based employment opportunities for women empowerment programs. The need to provide transformative women empowering programs within the hemp ecosystem is considered by respondent 12 who noticed that by employing agro-dependant women in the labour force of pruning hemp and tomato crops, the productivity and output increased after a month. Therefore, the respondent's views and the research align in terms of the demographic data analysed. The opportunity exists in the Eastern Cape to address the needs of agro-dependant women in order to allow for job security and growth within the business hierarchy.

The fourth industrial revolution poses the opportunity to allow for online satellite learning campuses to be integrated into the international education system for hemp-online learning. The social sustainability and resilience is addressed through Respondent 5's aim of developing Cheeba Africa which aims to provide cannabis and hemp education. Through this perspective, the holistic integration of cannabis education can be delivered to the masses in a scientific and rational approach. The Cannabis Development College posed by the provincial government and the recent emergence of Crafted Hemp Farms college located in the Eastern Cape offer the opportunity to expose South African hemp education to an international audience (Matavire, 2020). Therefore by stimulating the development of cannabis and hemp colleges in the Eastern Cape, international students could apply and be registered in the Eastern Cape Cannabis and Hemp Colleges thereby increasing the revenue of the institution. The appeal of this educational opportunity would allow for a specific niche education about growing hemp in the Eastern Cape climate and the integration of addressing agro-rural socio-economic opportunities through hemp agriculture.

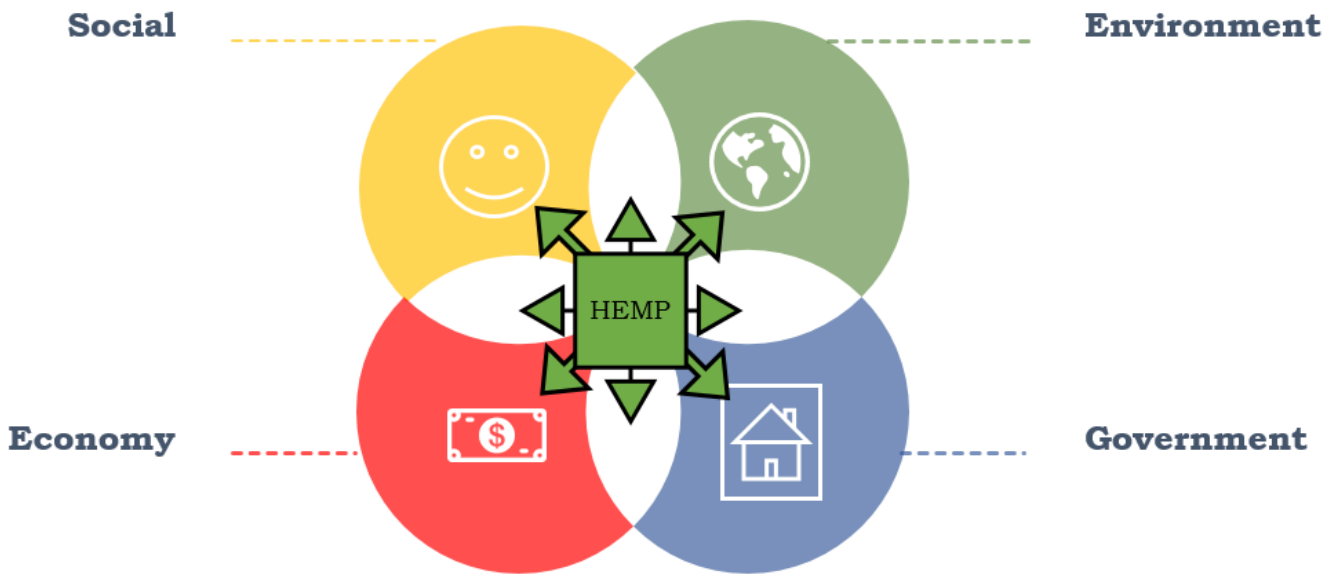
The above-mentioned will create consumer certainty whilst establishing a greater awareness of cannabis and hemp. The health system and medical care units can integrate CBD as a medical substance into the mainstream framework. This is being supported by the farm I visited in the Eastern Cape[90] and other hemp-based companies in South Africa. The postulation that CBD and hemp-based nutrition can be administered to citizens within rural settings can help address many health-related issues. Therefore, medical hemp farms can be used to help combat carcinogenic targeted cells, anti-inflammatory agents and anxiety.

[90] Refer to annexures to see more detail regarding the field research study.

Furthermore, the use of hemp micro-greens and hemp seeds as a super-food for communities and citizens in the Eastern Cape can contribute to a more balanced nutrient intake. The high amount of protein, Omega 3 and Omega 6 oils plus all other active minerals discussed in Chapter 2.2 contribute towards increasing the health status of the Eastern Cape citizens. The paradigms mentioned above align the use of hemp as an industrial crop with the ability to address the Sustainable Development Goal (SDG) 8, SDG 2 and SDG 3 (New Frontier Data, 2019). This further aligns the government with its prowess of increasing the quality of life standards which would display sustainable leadership within the international community.

6. Sustainable Hemp Agriculture in the Eastern Cape

Developing energy efficient products whilst effectively addressing agro-rural socio-economic opportunities



The industrial hemp industry does not offer a panacea for all climate combating technologies or challenges in the Eastern Cape. However, the global re-emergence of hemp, South Africa's promulgation of the commercial production of hemp and the evidence of a lower carbon footprint of hemp-based products presents a tool for provincial government and local industries to curtail the greater threat of climate change, develop energy efficient materials for urban areas and address the challenge of agro-rural poverty. The research indicates that the potential surrounding hemp agriculture and the growth of the hemp industry intersects with economic rejuvenation, social upliftment, government revenue and environmental benefits. The cross-sectoral and multi-beneficial plant provides an avenue for new sustainable growth in industrial manufacturing and healthy agricultural environments. The concluding remarks of the research report signify the sustainable and resilient ability of hemp to offset its carbon emissions when manufactured into a substitute product, such as hempcrete, textiles, biofuel or bioplastic. Therefore the research displays the rise of hemp products as a climate combating substitute for resource intensive industries.

The further research and development opportunities for the hemp industry in the Eastern Cape can be to add more analysis to cultivation sites aimed to identify ideal genetics for fibre production, seed production and hurd whilst including the industrial supply chain in the manufacturing of energy efficient substitute products. The research can aim to identify ideal microclimates, soil properties and ecosystem synergies to cultivate the best phenotypic expressions for industrial

applications. The research could aim to develop data regarding the creation of the hemp supply chain and employability of hemps industrial processes in terms of agro-rural employment. Integrating sustainable products such as hempcrete into the urban areas to facilitate the use of a green building material for construction. Another area for research would be to consider epigenetic engineering of industrial hemp strains to generate ideal phenotypic characteristics of hemp for industrial, medical, cosmetic and nutritional value. This could be in the form of drought resistance, disease resistance, climate tolerant, terpene boost and the increasing of biomass of hemp thereby providing a more viable crop for investment. The recent evidence of high-performing hemp batteries against lithium batteries poses a new avenue for energy production. Lastly, using hemp as livestock feed would allow an easy entry for small-scale agro-rural farmers to generate sustainable income.

The significance of this is that hemp agriculture is a labour absorbing industry whilst contributing to the development of the green economy. The generation of value-added employment to address a lack of formal and women employment experienced by agro-rural communities in the Eastern Cape would increase the quality of life for many citizens. Therefore, by generating proportional economies of scale with an enabling legislation to fast-track hemp as an abundant, renewable, durable and energy efficient crop, the Eastern Cape can become a key hemp industry in Africa and the world.

Within the *Cannabis* family, industrial hemp has not received as much recent attention as the recreational marijuana strains. Yet, these two plants are married in their ability to create community and connection amoungst people with diverse backgrounds and from different classes. The recognition and assimilation of hemp into the fabric of mainstream commercial industries and societal paradigms has the potential facilitate sustainable growth. The opportunity to harness the subsidiary benefits from *Cannabis* can be used as an additive for the full mobilisation and optimization of the industry. The Eastern Cape is a uniquely beautiful part of the world, with rich history in its culture and a diverse set of indigenous ecosystems. Therefore, the potential to grow a new crop to stimulate employment opportunities and harness the potential of the landscape can create a dynamic and ineffable positive change for the citizens in the Eastern Cape.

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8. Annexures

8.1. Hemp research and development permit requirements (Sotana, 2020)

Hemp permit conditions includes:

Monitoring (Size & Structure)

- Size –Area 2ha or more, security-access controlled wire-mash + razor wire on top
- Structure of fence- 2m height + locked all times

Record keeping + control of storage for audit purposes

- Seed quantity + harvested products + processed products
- Quarterly reports (Circulate format by SAPS)

Regular practises when handling hemp are:

- There is a phytosanitary certificate and proper agronomic description of the seed from project Manager. This includes the THC level less than 1% as required by law.
- Germination test was done by project manager.
- That your land is fenced up to 2m high security fence with razor wire on top as required in the hemp permit conditions. The farm is secured and far away from public place.
- That you have notified the local SAPS station commander. Gave him/her copy of valid hemp permit. As required in hemp permit conditions.
- The soil is prepared for planting.
- The recommended plant spacing is 25cm and seeding rate per ha is 25 to 50kg. Hemp is sown dense for fibre. But sparce sowing for CBD.
- Regular monthly testing of THC at Dohne Agricultural Development Institute in Stutterheim. Sample ten inflorescence (top 15cm portion of the plant) by project Manager.
- Make sure that you carry your original hemp permits when collecting or traveling with hemp seed or material samples or seedlings.

Handling, monitor & Transport

- (Record prior to transport, local SAPS notified)

Hemp project was budgeted about R3m per annum in the province. The project was massively funded by national government. A farmer production guideline booklet was published in 2005 marking the end of Phase 1. A total of six tractors and implements were bought and handed over to to six farms. But 10 oil pressers were bought for farmers in 2004 but were never handed to them by DRDAR.

Organized agricultural formation in this regard was established in 1999, called Indalo Oils & Fibre Industries Cooperative Limited (INOFI) of EC Hemp Producers Association which makes the total of 15 hemp farmers in the Eastern Cape province. These farmers are affiliated to the Hemp SA commodity group. They are led by Mr Matinise (Chairperson in Buffalo City), Ms Madliwa (Secretary in Great Kei), Mr Rozani (Nyandeni), Mr Jungqe (Ntsika Yethu), and others.

Challenges: EC Hemp farmers wrote various letters to the MEC DRDAR, Premier, Ministers DALRRD, and Minister of Health - raising the following issues to be addressed:

- Hemp permit to move from research only status to commercial status.
- Processing of hemp permits to be done by the Project Manager and endorsed by PSC before submission to SAHPRA for approval and issuing.
- Hemp SA trust to be revived.
- DRDAR to be clear on issue of Project Manager.
- Product Development to continue.
- Hemp seed breeding and multiplication in SA to continue.
- Infrastructure like 2m security fence to be provided by government as it was done before.
- On-going consultation with MEC DRDAR, Premier, Ministers DALRRD, and Minister of Health.
- Government to provide inputs or production cost per ha.
- Investment promotion to be on-going.
- Separate hemp farmers from recreational users and spiritual users.

Summary of hemp requirements are:

- Duration is 12 months (for growing season)
- Purpose is for farming / growing, agro-processing, and product development
- Name of the farm / facility
- GPS Coordinates
- Map
- ID copy of the farm manager and assistants
- Carefully Complete the 2 page form
- Farm description
- 2m high security fence
- R903 application fee
- Far away from public places – school, hospital, clinic and church
- Products: fibre, oil, CBD, other by-products
- Signed and approved by DG of Health

Respondent No.	Date	Position	Relevance	Highlighted points from discussion
1	25/08/20	Forestry South Africa Official	Biomass availability. Biocomposite relevance of hemp	• The expected National Hemp Masterplan will integrate government departments and set short-term targets, enable strategies • Logistics problem in South Africa • Hemp has conscious consumer advantage • Benefit & Cost analysis of hemp as a biocomposite and costs of production versus other competitive products/materials • Hemp as a competitive biocomposite substitute • Diversification of raw material • Department of Trade and Industry being the economic driver of hemp products • Recovery rate of hemp (fast growing) versus recovery rate of timber (slow growth) • Increase in CBD availability will lose profit in the long if hemp is not diversified as an alternative raw material - Hemp raw material input - Opportunity to integrate - Logistics challenge - Market accessibility and receptiveness } Cost of production
2	01/09/20	Fields of Green for All Official	Challenges against the full potential of industrial grade hemp.	• Police corruption • Nepotism • Lack of full mobility of model • Under capacitated government with misinformation about the plant • Misalignment of government sectors to be in place to execute decisions about crops & industry related activities around cannabis & hemp • 0.2% THC limit on industrial hemp products will only allow big commercial farmers to create large corporation dominance in the hemp market. Proposes a judgement of allowing any hemp/cannabis plant to grow and still using that for industrial applications as opposed to controlling the THC. • Difficult for our landrace strains to yield low THC strains. Therefore, the regulations for a low 0.2% will pose an opposition to local landrace strains. SA climate naturally yields a high THC composition. • Sheds light on the awareness of licensing model and how it only appeals to those with large capital. Therefore it opposes small-scale agriculture. • Need a change of heart from the Government. Government is regulating citizens for arrest. Therefore, the 'plant counting' methods to enable police arrest is flawed. • Government aims to create off-take agreements to generate income for the institution. • Presents the 4 pillared approach of holistic cannabis and hemp farming.

				• "Green Gold Rush" which people are pushing for & it will decrease the integrity of the cannabis and hemp industry. • Danger of regulations poses threat
3	08/09/20	Agr8 Official	Small-scale crop holder integration through digitalization and geospatial data layering. Experience of working in multiple communities in Kwa-Zulu Natal. His understanding of the challenges of rural agro-economies and how to develop small-scale crop holders with enough capacity and technical know-how of their agronomic, climatic and cultivation data intersects with an area of opportunity for my research.	• Green industrialisation through hemp-based products • South Africa does not focus on a trust and connected ecosystem in agriculture • Commercial grows versus small-scale. Small-scale farmers are naturally segregated and do not work together • Digital co-operative aims to bring in stakeholders and parties in a data repository and an active trading system that is trust based and evidence-based. Soil data, Potential of crop, details of the people (using these platforms) • Challenges in Eastern Cape to develop tribal land and competition amoungst tribal owners and land tenures. • Need coherent logistics and timely exposure of products needed amoungst the market. • The attempt to integrate hemp-based products into a circular economy. • Creating an identity for a digitalized hemp farmer integration model. • Data centred complex system analysing financial security and market demand using smart technologies. • Need input data required for parcel size of lands. • Real-time data validates the clarity around hemp space • Deconstructing language barriers through multi-lingual digital platforms • The option for permaculture is growing through its relevance in the sustainable food • Balance crop production through integrate data management of farms in close proximity which will therefore allow for a constant market entry for all farmers due to the specific crop availability from one farm versus another. • Traceability factor for hemp products • Awareness of non-integration within government departments in the Eastern Cape & the lack of coordination amoungst authorities. • Need integration of resources cross-sectoral in order to fully optimize the capital input from different local enterprises

4	10/09/20	Exclusive Medicinal Cannabis Cultivator (under a SAHPRA license)	Cannabinoid research	• Medical Cannabis Cultivation license. • Opportunity for CBG isolation with other trace cannabinoids as a carrier to support the gut health of livestock. • Hemp-pollen integration within agricultural landscape.
5	11/09/20	Cheeba Africa	The first educational platform for Cannabis. He is a pioneer in the industry and creates selected modules pertaining to the information and myth busting behind cannabis and hemp. The conversation is relevant due to the accessibility of cannabis education, the significance of creating an awareness regarding hemp and cannabis and where he sees the future of the cannabis and hemp educational paradigm	• The enterprise focuses on the applications of CBD for medical treatments, cannabis education and social leadership programs for youth engagement. • Recommends the fast-tracking of regulations and legislation to maximise the speed of implementation for hemp and cannabis. • He stresses the need to prioritise South African Cannabis Education with accreditation to legitimately recognise educated professionals in the field • The licensing of courses will be international and will also develop local educational courses to up-skill local individuals. • The respondent also recommends a non-accreditation program which would fast-track the implementation but states that quality education and reputation of the provider should overide cannabis education for the faster implementation. • Recommends the perspective of health of CBD to be accommodated with a progressive treatment program. • Postulates the need for capital investment for increasing economic margins and the long-term sustainable collaborative business for the hemp or cannabis industry. • Need a unique South African approach to cannabis and hemp regulations • Need a trickle-down effect from the Foreign Direct Investment and private sector capital investments. • Hemp situation needs a high yield in order to maintain production lines for products. • The yield per gram is less than THC and CBD therefore the volume for the farm is an economic margin which is seen as a challenge. • Beginning of the dialogue behind hemp in South Africa • The access to land in the Eastern Cape for rural farmers can be used stimulate hemp • The plant is about community, connection and health and wellness and not about making money.

6	11/09/20	Hemporium Sustainable Applications of hemp	The respondent has worked in Hemporium in alternate applications production whilst synergizing the companies' expertise in various related fields in the hemp industry. The respondent is a research of the hemp industry in South Africa.	• Extensive process to receive hemp and cannabis license/permit • Awaiting the release of the National Hemp Masterplan • Focusing on CBD, cosmetics, hemp apparel and hemp used in construction • The Research and Development around hempcrete: - Need substantial water on site to perform task which poses a restriction for segregated rural communities - Energy saving and costs reduction through the life-cycle of a hempcrete constructed building allows the recovery of capital - The capital intensive nature of manufacturing fibre from hemp is a gap for large commercialisation programs to increase and evolve the production methods. • Hemp farming provides a sustainable and resilient agricultural practice to combat the carbon intensive construction industry • Alludes to the significance of COVID-19 and the need for rapid economic growth being a catalyst for cannabis and hemp implementation.
	29/09/20	African Cannabis Advisory Official (ACA)	ACA is a leading cannabis catalyst for companies to look for as an investor in the cannabis and hemp space in South Africa. Using extensive financial experience, strategic partnerships and knowledge of the operating environment in South Africa to grow the cannabis industry.	• Medical cannabis is most prioritised • Focusing on hemp agriculture with a direction of understanding the economics, technology and the regulatory environment within which this plant has grown. • South Africa needs a robust domestic industry to contribute to a successful local production industry • Capital intensive processing industries will remain a problem • Interested in the expanding understanding regarding the economic viability of alternative product development in South Africa

8	22/10/20	Green Eastern Cape Professional Cannabis and Hemp Consortium	Represents the perspective of local-small holder's farmers in the Eastern and how to integrate a sustainable value-added supply chain with the rural agricultural opportunities in the Eastern Cape.	• Agri-park failures • Farmers resolutions not being met • Hemp to form part of the Economic Recovery Plan • The need for safe land tenure • Lack of commercialisation in accordance with the regulatory board • Considers the notion of a non-permit hemp industry • Challenges of distributing revenue within the hemp ecosystem if the monopolisation of the industry is seen in hemp • Cultural value disregarded within the understanding of the plants significance • Challenges of researching soil conditions, agronomic practices needed, meteorological data and strains needed within small-scale farm holders within the Eastern Cape. • Lack of data regarding farmers • Traditional land and conflicting privatisation within agricultural spaces • Approach to integrate women into low-tech product development • After contacting the respondent, I was cordially invited to partake in the Cannabis Conference of 2020 in East London as part of the EC Professional Cannabis and Hemp Consortium. This was due to the nature of my research and the inquiry of the viability of industrial hemp for rural socio-economic upliftment.
9	29/10/20	Leading Apiarist in South Africa.	An expert in managing the overall health of the *Apis mellifera Scutellata* (African Honey Bee) and *Apis mellifera Capensis* (Cape Honey Bee) in agricultural landscapes. Recently, the respondent is shifting into the Cannabis and Hemp space by attempting to create a healthy agricultural ecosystem through bee	• The notion of pollination & its micronutrients for the Bees life is essential. Contains white protein. • Follows a traditions of Bio-amplifying the Bees, therefore does not feed them or provide any artificial additives (no cosmetics or pesticides), thereby providing BioHoney. • Has worked in Eastern Cape in Tribal Land, Free State, Gauteng, Northwest, Kwa-Zulu Natal, Maputo, Italy, France, Germany and Switzerland. • By integrating CBD into honey, the increase in revenue will boost a farmer's income stream much more than just CBD or just Honey sales. • Bees life is harmfully affected by crop monoculture • There is a high capital input to make equipment for honey and CBD integration. • Respondent agrees with my research that the postulation of a farmer co-opt scheme integrating Bee Hive in a sub-regional hemp space will provide a revenue stream that can help break even. Government has isolated the respondent and his resources as a critical agro-resource • Rural opportunities could be made economically viable via a government grant scheme in a 5 year contract. • Permaculture as a tool for an agro-environment can provide off-seasonal pollen and nectar which will

			pollination whilst creating a sustainable recovery for the endangered bee species of South Africa,	maintain the health status of Bee life in South Africa. • There must a mentorship/apprenticeship program to sustain the knowledge transfer of Bee Keeping. • The threat of pesticides, fungicides, herbicides and all pest-management control poison is a massive threat to Bee life in South Africa. Pesticides create a misdirection for all the worker Bees and never come back into the Hive. Whilst Fungicides stay on the nectar and pollen of the Bees and they return that back to the Hive and therefore kill the Hive from the inside. • Therefore, the opportunity to use hemp as well as strawberries, blueberries, basil and other companion plants will provide a feasible permaculture environment. • Citrus farms cannot be integrated with Bee life due to the harmful toxins used.
10	06/11/20	Canada's Industrial Hemp Corporation official (CIHC)	Recently patented and is developing Artificially Intelligent machine-learning technology which creates consistent output of hemp fibres for any industrial application purpose. This is a disruptive technology within the hemp ecosystem delivering high quality and consistent fibre output.	• The CIHC is aimed at delivering low-cost, high quality hemp fibres and biocomposites. • The CIHC is aimed at delivering a Smart Stalk System, this is an artificial intelligence, machine-learning software which uses laser scanning imagery to process hemp stalk decortication. • This accentuates the potential of processing high-quality hurd's and bast fibre. This advantage will stimulate the supply chain to process high-quality products available for industrial, commercial and retail purchase. • CIHC aims to stimulate other hemp and flower farmers to acknowledge the remaining portion of the plant after harvest (whether for seed or fibre) in order to create supply. However, this agrees with my research in that the stalk will be of low quality for fibre use. • The technology of CIHC aims to deliver low-cost methods of quality hemp stalk generation.
11	21/01/2021	Original Cape Town Hemp official, Growing OG's Cape Town official and the Cannabis Industry	Original Cape Town Hemp which specializes in a CBD isolate range for medical and therapeutic purposes.	• Original Cape Town hemp provides consumers with a range of hemp textile apparel. These provide healthier clothing options for the citizenry. Furthermore, the company sells a CBD isolate range for multiple conditions relating to inflammation, sleep, stress and appetite. The multiple range of products developed displays the versatility of hemp for multiple product developments. • However, a hindrance for the co-founder is the need to import hemp fibre and hemp hurd. This is a financial burden as the price for imports is relatively

		Development Cooperative Western Cape official	Growing OG's which develops hemp acoustic insulation studies for youth musician CIDC WC which aims to advocate for hemp expertise based of rational evidence and scientific enquiry for hemp to government and private sector.	high versus the opportunity for domestically grown and traded hemp fibre and hurd. • Growing OG's is a non-profit organization which is aimed at delivering hempcrete and hemp acoustic insulation panels into music studios in South Africa for the engagement with underprivileged youth musicians. The company addresses skills development in aspiring musicians whilst accommodating for the use of a sustainable green building material with excellent acoustic properties and beneficial health effects for the occupants. • Furthermore, the participant has interacted with 5 Xhosa chiefs in the Transkei region collaborating with them regarding hemp agriculture and cannabis farming. The participant developed cannabis tracking documents, educational transcripts, cultivation practices and access to genetics for specific farms in order to optimise their growth. These compose of data capturing methods for tracking growth and plant health. The farmers receives three strains for cultivation. • The respondent aims to use these hemp farms for the development of hempcrete and hemp plaster for sustainable housing conditions. This is aimed to develop healthy and energy efficient housing for vulnerable groups in the Western Cape. • The challenges facing hemp farmers is the legislation and the lack of government support for the farmers and the high expense for hemp permits. • The respondent explains three aspects allowing for successful hemp integration as a raw material in our society: - The legislation must be mobilised to allow for cultivation and growth - The farmers must have successful farming practices with consistent and sustainable supply into the market - Consumer must be aware of the sustainability and resilience around hemp-based products. • The CIDC WC was founded to be a Western Cape provincial body representing experts and professionals speaking to farmers and other influential people in the province. It governs holistic information variables about hemp and cannabis farmers in order to enact farmer cooperatives within the region. • Swiss and SA government identified the link between the sick house syndrome and a low-life expectancy in rural areas. Hemp housing aims to address the sustainable housing facet. Disease prone living environments are prevalent in South Africa. • All commercial licenses granted for high THC strains cost 1 to 2 Million Rand in South Africa with international off-take agreements in place. This financially displaces rural growers.

				• The respondent proposes self-regulation for hemp crops. Thereby using GAP standards with specific tracking analyses for government. • South Africa's climate is conducive for high THC strains thereby posing a challenge for government required <0.2% THC limit for hemp. • The ownership for less THC must be shifted to the retailed in order to lessen the chance of farmers having 'hot crops' (describes crops not meeting the legal limit for THC and therefore having to be burnt or discarded).
12	25/01/2021	Crafted Hemp Farm official	Crafted Hemp Farm aims to be the pioneering farm enterprise specializing in hemp production for fibre, oil and seed propagation. The farm enterprise is a commercial hemp grow established in South Africa. The farm operates throughout South Africa but focuses particularly in the province of the Eastern Cape and Kwa-Zulu Natal.	• According to the respondent, the aim of hemp farming is predetermined in terms of what production of raw material you are attempting to focus on, whether it be fibre, textiles, building material, oil, CBD or seed. • Once determined which product is the primary focus, the choice of cultivar of strain, determined by the geospatial location (weather conditions and soil health) and agronomic practices are the most important active considerations. • Crafted Hemp Farm delivers positive social impact in the paradigm of transformative socio-economic rejuvenation. The inclusion of a female labour-force associates within the company. This prioritises gender empowerment and combats the statistical representation of an inactive female labour force in the Eastern Cape. • Crafted Hemp Farm acknowledges the use of hemp as a livestock feed for cattle. By proving the viability of hemp as a nutritional substance for cattle, they have seen an improvement in one case of a sick male bull recovering from a jaw-wart after being fed hemp biomass for a period of less than a month. This proves the ability of hemp to contribute to the better overall management of livestock health and therefore provides the farmer with more security regarding the selling price of the stock.

8.3. Figures

- Figure 1: https://madebyhemp.com/understanding-hemp-sustainability-impact-environment/
- Figure 2: https://tryplainjane.com/blog/the-ancient-history-of-hemp-07c814/
- Figure 3: https://www.kenderhealth.com/wp-content/uploads/2020/02/AdobeStock-1024x695.jpg
- Figure 4: https://za.pinterest.com/eatmorehemp/hemp-facts/
- Figure 5 and 6: https://sensiseeds.com/en/blog/the-endocannabinoid-system-and-how-it-works/
- Figure 7: https://www.nzhempress.co.nz/blogs/news/what-are-hemp-terpenes
- Figure 8: Flicker et al. (2019:199)
- Figure 9: https://headyvermont.com/2019/08/26/vtcna-health-tips-hemp-and-bioremediation/
- Figure 10: https://slideplayer.com/slide/8844194/
- Figure 11: https://madebyhemp.com/understanding-hemp-sustainability-impact-environment/
- Figure 12: Morrissey, MacCann, Torres and Whitney (2019)
- Figure 13: New Frontier Data (2019)
- Figure 14: New Frontier Data (2019)
- Figure 15: New Frontier Data (2019)
- Figure 16: https://www.medicalcannabisdispensary.co.za/cannabis-oil-south-africa/
- Figure 17: https://www.whatcannado.com/supply-chain
- Figure 18: ESECC (2019)
- Figure 19: https://www.vectorstock.com/royalty-free-vector/supply-chain-infographic-templates-with-connected-vector-9848528
- Figure 20: Sontana (2013)
- Figure 21: https://www.easydata.co.za/dataset/P0302D/
- Figure 22: https://www.easydata.co.za/dataset/P0302D/
- Figure 23: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 24: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 25: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 26: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 27: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 28: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 29: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 30: https://surveys.easydata.co.za/TableViewer/tableView.aspx

- Figure 32: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 33: https://surveys.easydata.co.za/TableViewer/tableView.aspx
- Figure 34: Hamann and Tuinder (2012)
- Figure 35: (DEDEA), 2009
- Figure 36: Hamann and Tuinder (2012)
- Figure 37: DEDEA (2009)
- Figure 38: DEDEA (2009)
- Figure 39: Hamann and Tuinder (2012)
- Figure 40: ARC LNR data acquisition via email correspondence with ARC.
- Figure 41: https://www.sa-venues.com/maps/easterncape/physical.php
- Figure 42: Hamann and Tuinder (2012)
- Figure 43: Tribal land in Eastern Cape
- Figure 44: DEDEA (2009)
- Figure 45: DRDLR and DPME (2019)
- Figure 46: DRDLR and DPME (2019)
- Figure 47: DRDLR and DPME (2019)
- Figure 48: DRDLR and DPME (2019)
- Figure 49: Synopsis of SWOT based on previous data
- Figure 50: ECSSSEC (2019)
- Figure 51: Excel data on biocomposite exports
- Figure 52: (DRDLR, 2015)
- Figure 53: Manyevere, Muchaonyerwa, Mnkeni, and Dhau (2017)
- Figure 54: DRDLR, (2019).
- Figure 55: DRDLR, (2019).
- Figure 56: DRDLR, (2019).
- Figure 57: DRDLR, (2019).
- Figure 58: DRDLR, (2019).
- Figure 59: DRDLR, (2019).
- Figure 60: Manyevere, Muchaonyerwa, Mnkeni, and Dhau, (2017)
- Figure 61: Fanadzo, Chiduza and Mnkeni, (2010)
- Figure 62: Sotana (2013)
- Figure 63: Eastern Cape Hemp Pilot Project Initiative
- Figure 64: Google Earth
- Figure 65: Hemp related exports
- Figure 66: NAMC (2017)
- Figure 67: Google Earth

- Figure 68: https://news.bio-based.eu/heading-for-a-circular-economy-and-sustainability-with-biobased-and-biodegradable-plastics/
- Figure 69: https://www.gardensall.com/hemp-vs-marijuana/
- Figure 70: Jami et al. (2019)
- Figure 71: Scrucca, Ingrao, Maalouf, Moussa, Polidori, Messineo, Arcidiacono and Asdrubali (2020).
- Figure 72: Novakova (2018:5)
- Figure 73: https://www.genhempinc.com/growers
- Figure 74: https://www.european-bioplastics.org/how-much-land-do-we-really-need-to-produce-bio-based-plastics/
- Figure 75: National Agricultural Marketing Council (2017).
- Figure 76: CALM (2018)
- Figure 77: Sotana (2013:36)
- Figure 78: Horne (2020:187)
- Figure 79: https://fashion-history.lovetoknow.com/fabrics-fibers/hemp-fabric
- Figure 80: ECPC (2014:70)
- Figure 81: https://twitter.com/cannatourism
- Figure 82: https://www.becoolproject.eu/2018/09/10/1292/
- Figure 83: Personally made
- Figure 84: https://www.projectcbd.org/environment/marijuana-not-monoculture
- Figure 85: https://wamaunderwear.com/blogs/news/hemp-vs-cotton

8.4. Presenting my research at the Cannabis Conference of 2020 for the Eastern Cape Professional Cannabis and Hemp Consortium to promote the inclusion of agro-rural farmers from Buffalo City Municipality and describe the viability of hemp agriculture to develop energy efficient materials: 27th November 2020



The Eastern Cape Professional Cannabis and Hemp Consortium represents the agro-rural partnership led organization for the upskilling and licensing of small farm holders within the Buffalo City region. Therefore, the respondent whom I interviewed, from the Eastern Cape Cannabis and Hemp Consortium, invited me to partake in the Cannabis Conference of 2020 on behalf of the organization to promote the successful license approval of small-scale hemp farmers within the area. The presentation was done in the Department of Agriculture, Forestry's and Fisheries department in the East London government building on the 27th November 2020. I collaborated as a participant in the Cannabis Conference 2020 and afterwards presented a research presentation to a board room consisting of the body of the Eastern Cape Professional Cannabis and Hemp Consortium, entrepreneurs, investors and farmers detailing the viability of alternative hemp-base product development.

8.5. Hemp Farm Field Visit: 10th – 13th February 2021

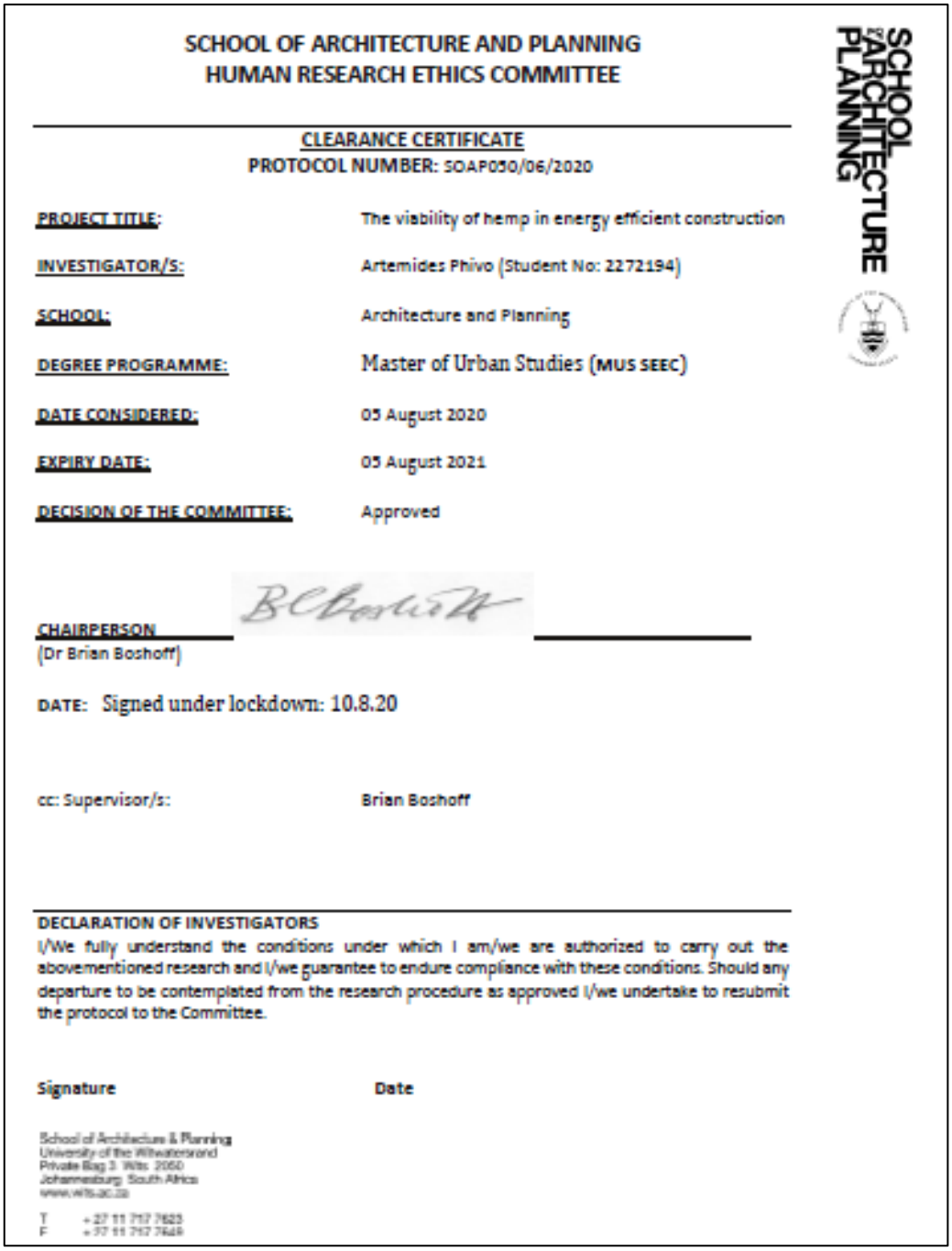
The Farm is located in Buffalo City Municipality, Eastern Cape.

The flower is grown for CBD extraction. I was invited to the farm for the benefit of my research and to contribute to a greater understanding of the potential socio-economic impact of the farm whilst attempting to ascertain a more credible and viable approach to hemp farming. Due to the field visit only happening so late towards the submission deadline, I was not able to incorporate the full findings and information into my research.





8.6. Ethics form



SCHOOL OF ARCHITECTURE AND PLANNING
HUMAN RESEARCH ETHICS COMMITTEE

SCHOOL OF ARCHITECTURE PLANNING

CLEARANCE CERTIFICATE
PROTOCOL NUMBER: SOAP050/06/2020

PROJECT TITLE:	The viability of hemp in energy efficient construction
INVESTIGATOR/S:	Artemides Phivo (Student No: 2272194)
SCHOOL:	Architecture and Planning
DEGREE PROGRAMME:	Master of Urban Studies (MUS SEEC)
DATE CONSIDERED:	05 August 2020
EXPIRY DATE:	05 August 2021
DECISION OF THE COMMITTEE:	Approved

CHAIRPERSON
(Dr Brian Boshoff)

DATE: Signed under lockdown: 10.8.20

cc: Supervisor/s: Brian Boshoff

DECLARATION OF INVESTIGATORS
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to endure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature **Date**

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8.7. Plagiarism declaration



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UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Phivo Luke Artemides (Student number: 2272194) am a student registered for the degree of MUS (SEEC) in the academic year 2019-2020.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this in not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature: Phivo Luke Artemides Date: 26/02/2021