



Challenges
Zambia

Feasibility Study for the Cultivation of Macadamia in Zambia



Final Report

Challenges Group Zambia Ltd.

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Executive Summary

The Zambia Macadamia industry is dominated by commercial farmers. Zambia is still one of the smallest global macadamia producers but there is significant growth potential for the commercial, emerging and small farmer sectors. According to Selina Wamucii a platform that helps businesses from anywhere in the world to buy and import food & agricultural produce from African countries; Zambia's share of the world's total macadamia nuts exports in 2018 was 0.1%. Most small and emerging farmers face challenges such as high cost of plant material, orchard set-up costs, lack of knowledge and support, long-term investment, lack of cash flow, unknown market, cost of selling and most importantly many smallholder farmers are unaware of its high export value which makes the Zambian macadamia nut sector an underdeveloped industry. There is however, an increasing awareness among the emerging farmers. As the Zambian macadamia industry grows it will face a number of challenges, not least its route to export markets. Comparisons were made with value chains in Malawi and Kenya to link smallholder and emerging farmers to markets. It is clear that a wide range of stakeholders are interested in being active in the development of the Zambian macadamia industry and the recommendations of the report identify some options that are worth further consideration.

Note: Some information has been removed from this report in order to protect the IP of North Route Nursery.

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Abbreviations

NIS Nuts in Shell

CBI Centre for the Promotion of Imports from Developing Countries

VCA Value Chain Analysis

ZMD Zambia Meteorological Department

ZARI Zambia Agricultural Research Institute

NRN North Route Nursery

SHFs Small Holder farmers

SDU Small Holder Development Unit

AGOA African Growth and Opportunity Act

HIMACUL Highland Macadamia Cooperative Union Limited

ZEGA Zambia Export Growers Association

ZNFU Zambia National Farmers Union

ETICO Ethical Trading Company

Introduction & objectives

This report was prepared for Prospero and North Route Nursery to assess and explore investment opportunities in the macadamia industry in Zambia.

This study investigated NRN's position and potential within the macadamia ecosystem in Zambia as well as identified potential business opportunities to engage with emerging and smallholder farmers.

Some of the FS objectives included:

- Assess whether the macadamia tree crop could be intercropped with other annual food crops.
- Identify the resources emerging farmers need to successfully grow macadamia (inputs, labour, trainings, skills, infrastructure).
- Identify what varieties and growing methods would work best for Zambia.
- Assess the Zambian climate and suitability for macadamia production and which parts of the country are best suited.
- Explore potential routes to market for macadamia nut in shell vs processed kernel, and how these market opportunities influence the business models.
- Review cost of growing macadamia in Zambia and associated requirements, for the farmers who engage with the proposed model.
- Review of other macadamia projects in Zambia that are working with commercial emerging or small scale farmers.

Product description

The macadamia nut, considered to be the world's finest dessert nut, belongs to the Proteaceae family. It is native to the coastal rain forest areas of southern Queensland and northern New South Wales in Australia. Macadamia is unique in that it is the only native Australian plant to attain the status of a commercial food crop. Macadamia nuts are the fruit of the evergreen macadamia tree. The three species with commercial importance are *Macadamia integrifolia*, *M. ternifolia*, and *M. tetraphylla*. The nuts are today grown in many countries, including South Africa, Kenya, the U.S. (Hawaii), China, Guatemala, Malawi, Zimbabwe and Brazil. Once planted, the trees need three-five years before bearing fruit and ten years to reach full maturity. They require warm temperatures and good annual rainfall to yield a good crop. The biggest threats to production are droughts and heavy frost. The nuts are encased by a hard, woody shell that in turn is protected by a green-brown fibrous husk that splits open as the nut matures.

Table 1: Most popular cultivars being grown in Zambia to date

Variety	Description
Beaumont (695)	Medium to large nut
816	High crack out % medium to large nut, early flowering
A4	Hybrid, large to very large nut, fast growing
814	High crack out % small nut
719	Very high crack out % medium nut
842	Small nut
849	Medium to large nut
246	Medium quality nuts and seems to increase slowly the yields along the years
791	Universal pollinator because it's producing flower all along the year
344	Late maturing variety quite susceptible to thrips damage but seems to offer good buys later on
705/741/788	Clones that produce big nuts and in a huge quantities; canopy is very open and doesn't help for water preservation
800/816/804	Produces very good quality nuts and the round canopy helps in the preservation of water during drought

It is important to note that these varieties in different environments may exhibit varying behaviours, sometimes completely the opposite. The above listed are what have been provided by commercial farmers based on their specific locations and experience with these clones.

Macadamia nuts are calorie-rich nuts that are high in healthy fats, vitamins, and minerals. One ounce (28 grams) offers:

...

1. Rich in nutrients

- Calories: 204.
- Fat: 23 grams.
- Protein: 2 grams.
- Carbs: 4 grams.
- Sugar: 1 gram.
- Fiber: 3 grams.
- Manganese: 58% of the Daily Value (DV)
- Thiamine: 22% of the DV.

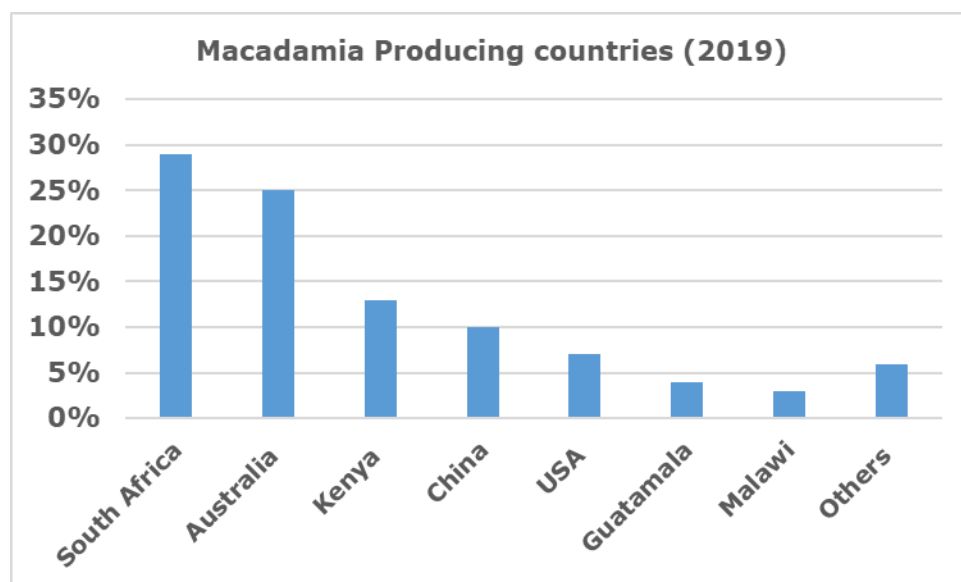
- Macadamia Integrifolia clones typically contain 70 to 75% oil, or good fats. This concentrated source of energy comes from high levels of healthy mon-unsaturated fats which are comparable to olive oil in terms of health benefits.

Section one: Context

Main macadamia producing countries

Macadamia production has continuously increased in recent years and is expected to also do so in the coming years. The largest producers of macadamia nuts are Australia and South Africa (54% of total world production), followed by Kenya, China, USA (Hawaii), Guatemala, Malawi.

Figure 1 Main Macadamia producing countries 2019



Source: Centre for the Promotion of Imports from developing countries

The Zambian Macadamia industry

While there is interest in macadamia nut cultivation owing to its high export quality, the sector remains a niche part of the farming system, dominated by a select number of larger players and commercial enterprises. One of the biggest challenges facing prospective macadamia farmers is the long wait for return on investment. In a traditional orchard it typically takes around three to five years to harvest and some seven years to pay for the capital cost of establishing the orchard. There has been limited government support at the national level through the Ministry of Agriculture for the macadamia nut industry although the government does want greater farmer uptake and interest in cultivating the crop as part of its crop diversification agenda. The National Institute for Scientific and Industrial Research (NISIR) is also in the process of embarking on research into macadamia nuts. The Zambia Agriculture Research Institute has developed a macadamia production guide that farmers can use and they have setup a demonstration plot in Lusaka's showgrounds to provide more information and raise awareness. There is also a growing interest among donors in entering the macadamia nut sector, although many do not yet have formal plans or are implementing projects.

According to Selina Wamucii a business to business platform based on mobile technology for the sourcing of fresh produce from African farmers, Zambia exported 110 tonnes of macadamia nuts in 2018 mainly as Nut In Shell (NIS) for processing in South Africa. Once processed the quantity of kernel from the Zambian crop would be ca. 30 tonnes. Through 2018 alone, the demand for macadamia nuts has increased, changing by 23.64 % in comparison to the year 2017. Between 2015 and 2018, macadamia nuts exports increased by 81.82 per cent, bringing the country \$0.34m in 2018. The macadamia nuts exports are categorised as¹:

- Fresh or dried macadamia nuts, in shell (HS code 080261)
- Macadamia nuts, fresh or dried, whether or not shelled or peeled (HS code 080260)
- Fresh or dried macadamia nuts, shelled (HS code 080262)

The annual change in volume of Zambian macadamia nuts between 2015 and 2018 was 81.82 percent when compared to the growth rate between 2017 and 2018. Zambia's share of the world's total macadamia nuts exports in 2018 was 0.1%.

Many smallholder farmers are unaware of its high export value, as there is little knowledge dissemination on macadamia nut cultivation and other associated costs. This tree-nut crop also requires high initial setup costs and investments which many farmers may not afford.

Obstacles and Opportunities in the Value Chain

Propagation costs

The cost of trees in Zambia is a potential barrier to some of the emerging and small farmers becoming involved in macadamia production. It is important to graft macadamia as this shortens the period to maturity. Macadamia does not grow well when planted true to seed, seedlings obtained directly from seeds have low yields of poor quality and therefore should not be used and therefore clonal propagation is required to maintain the quality and productivity of the macadamia trees. It is thus important to ensure that the Zambian macadamia industry develops a consistent nut kernel that the international market will recognise. The grafting process produces plants that are true to type depending on the clone that the scion has been taken from.

Some commercial farmers in Zambia particularly those based in Eastern province have purchased grafted macadamia from Malawi. These include 246 which produces medium quality nuts and seems to increase slowly the yields along the years. Clone type 800/816/804 are clones which produce very good quality nuts and the round canopy helps in the preservation of water during drought. 333, 246, have high shelling percentages. The South African macadamia growers have looked to their Zambian counterparts to join in growing the crop. In South Africa 70% of the macadamia grown is Beaumont (695) which is reflected by the large number of farmers in Zambia who are also growing the same clone.

The Kenyan nurseries use a number of grafting methods to propagate macadamia in the nursery. Some of these are top-working which involves grafting established trees to another variety, the existing tree, the "stock", is cut back, leaving just one or two limbs (nurse limbs) to supply the tree with energy. ... Once the tissues of stock and scion make new connections, the scions begin to grow into a new tree. It is important for Zambia to learn from the Kenyan experience and to start with the clones most suited to the market requirements and to the agro-ecology of the country. In Kenya the most successful grafting method is top-wedge grafting. It should be noted that Kenya does have a large tea industry with a well- established tree nursery capability and research infrastructure that the macadamia industry has been able to draw on.

Insufficient stakeholder collaboration

Being a new crop in the Zambian agriculture industry there is no association or body to spearhead activities related to the development of the macadamia industry in Zambia. ZARI under the ministry of agriculture has recently began conducting research under its tree crops unit to help promote the crop and has developed a macadamia production manual and a demonstration plot that farmers can access to acquire knowledge on growing macadamia nuts. This production manual should form the basis of agronomic support to farmers. The manual needs developing further to include market access.

Commercial farmer activities

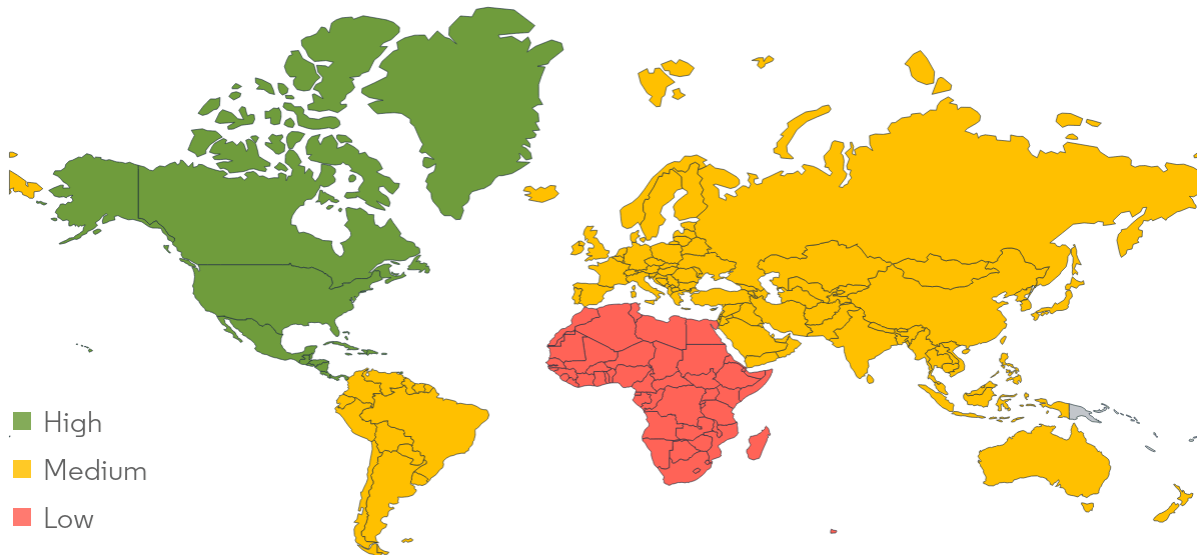
It is mainly commercial farmers in Zambia who grow macadamia nuts. These farmers are spread out across the country with established orchards growing different varieties of macadamia both conventionally and organically with irrigation infrastructure. They source their plants locally from NRN while some from Malawi and others from South Africa; the more established farms are grafting the trees own their own are members of South Africa's Macadamia Growers' Association (SAMAC). The Zambian farmers can learn from SAMAC which has successfully organised the macadamia industry providing inspirational and innovative industry leadership with the aim of developing sustainable wealth through Macadamia Nuts; It also provides broad based research and development, focusing on the commercial and technical fundamentals of Macadamia Nuts and ultimately the prosperity of its members. Some commercial farmers are intercropping the macadamia with cashew nuts and tobacco. Commercial farmers have been selling their nuts to Green Farms of South Africa and some are exploring sales to processors in Malawi and NIS trade to China. There are several investments that the farmers are making from increasing the size of their orchards to setting up de-husking plants. Other commercial players have specialised in supplying inputs such as fertiliser and other chemicals to the macadamia growers; other provide soil testing.

The commercial farmers saw macadamia as a high value non-perishable export crop that had no interference with the government like the staple food maize; with the internal Zambian agricultural markets being unstable, they saw export market to be stable and as a way of earning forex which allows for more stability in cash flow. There is also a growing number of commercial farmers that are intending to set up processing facilities to make macadamia oil on their farms when their orchards mature. Cilla Frost a commercial farmer based in Chisamba currently sells to Umoyo Health Store and other local shops. At the time of the study in winter commercial farmers expressed concern in the drop in the temperatures which could potentially cause frost as the macadamia nut trees are highly sensitive to frost particularly for trees under 3 years. Some commercial farmers resorted to spraying chemicals like potassium silicate and Zelaxin on the frost risk areas of the plant like the stems to mitigate against this risk. It is important for farmers to thoroughly assess locations and ensure they plant in suitable areas.

Section two: Global Macadamia Market

Figure 2: Global Macadamia Market Growth

Global- macadamia-market- Growth Rate By Region



Source : Mordor Intelligence

European market situation

Europe is the second-largest importing region of macadamia nut kernels, after the United States. Europe accounts for around a 30% share of the total world's imports. On average, European imports of macadamia nuts have increased in volume by 4% per year in the period 2014-2018. More than half of all imports from outside Europe come from Kenya, Malawi and South Africa.

Pre COVID the projections for the next five years in the European market for macadamia nuts was expected to increase with an annual growth rate of 5-7%. This rate is higher than that of most other nuts. The main reasons for the expected market growth are the attractive and unique taste of macadamia nuts as well as the health benefits they provide. Another driver for the growth is the increasing usage of macadamia nuts by the food processing industry in Europe. Cereal and protein bars and ice cream toppings are the fastest-growing categories using macadamia nuts as an ingredient in Europe. The impact of COVID-19 is yet to be fully realised but there has been a softening of some prices offered to kernel buyers by ca. \$1.00 to \$1.30/kg depending on the style.

The European import market for macadamia nuts is highly concentrated in Germany and the Netherlands. However, both countries are not only consumers of macadamia, but also key transit points for other European destinations. Macadamia imports enter the EU mainly through the Netherlands and Germany and are re-exported to mostly Italy, Spain, the UK, the Scandinavian countries and other high-income European Union countries.

Looking at average prices for macadamia kernel imports to Europe, an upwards trend can be observed in the last five years: the average price across all imports increased from € 11,336 to €15,522 per

tonne. In comparison, average prices per tonne of other tree nuts ranged between € 4,972 for almonds, € 6,690 for walnuts and € 8,377 for cashews⁵.

The highest prices were achieved for Australian imports, a country that is recognised for the high quality of its macadamia produce. South Africa also achieved higher-than-average prices in the last two years. Kenyan nuts used to achieve comparatively low prices but showed an increasing trend in the last two years, almost catching up with other key origins in 2018.

United States of America market analysis

The United States is the leading importer of macadamia kernel globally. In 2018, the country imported 11,215 tonnes of kernel, accounting for around one third of global macadamia kernel trade. NIS imports totalled 1,027 tonnes, ca. 98 percent of which came from Brazil, giving it only a small role in a market segment dominated by Asian countries.

In the USA the more important use of macadamia as an ingredient in the food industry, contrary to the predominant snack segment in Europe, means that quality requirements are lower than in other important tree nut markets and this contributes to the USA being the top importer.

There is a large market share of Kenyan macadamia in the U.S. Firstly, the African Growth and Opportunity Act (AGOA) came into effect in 2000. Export promotion by USAID under the East Africa Trade + Investment Hub (EA Hub) as well as quality improvements led to a continuous growth in U.S. import volume and value of Kenyan macadamia since 2000.

AGOA aims to increase competitiveness of eligible sub-Saharan African countries and to establish stronger commercial ties between the U.S. and relevant countries by reducing tariffs on select goods. Zambia has barely utilized the preferential market access opportunities under the AGOA trade preference program in the past due to among other factors, lack of awareness of existing opportunities in various states of America and the preferences of consumers, limited quantities produced for exports, inability to meet product requirements for the US market and logistical costs. Macadamia nuts are listed in the response strategy and action plan for Zambia as a potential product for export and the government of the Republic of Zambia remains committed through the National African Growth Opportunity Act (AGOA) Response Strategy, 2018-2025 and Work Plan has been prepared as one of the tools that the government will use to not only assist policy makers in their day to day planning and evaluation of Zambia's utilization of preferences under AGOA but also to assist the private sector to create business linkages and enhance their capacity to export value added, quality products into the US and regional markets⁶.

China/ Hong Kong

Asian countries and specifically China prefer NIS. China and Hong Kong are by far the most important destinations for NIS exports globally. In 2018, China and Hong Kong accounted for a total of around 31,000 tonnes (85 percent) of globally traded NIS. Imports of kernels only reached 1,300 tonnes to mainland China and 1,060 tonnes to Hong Kong in 2018. China is known as a nut processor, meaning that a share of the shelled nuts is re-exported. China is also itself producing macadamia and expanding that production rapidly. Production (in-shell basis) was forecast at nearly 20,000 tonnes in 2018/19, a doubling from the previous year due to increased bearings. According to estimates, Chinese kernel production is expected to at least triple in the period from 2019 to 2022. Due to increasing consumption, the increasing domestic supply is likely to be absorbed within the domestic market and imports will still remain high⁷.

Chinese consumers preferred high quality, well-priced and nutritious food and buying online is increasingly becoming popular creating additional market opportunities into the Chinese market.

Section three: Trends influencing the macadamia market

Key trends with relevance to the EU, U.S. and global macadamia and tree nuts market can be summarised using the STEEP (Social, Technological, Economic, Ecological and Political trends) model. It is not always possible to make a clear-cut distinction between the different categories and the impact of the global COVID-19 pandemic on these trends is still not clear. Adding value at source by producing a quality kernel rather than exporting NIS should be possible as the Zambian macadamia builds sufficient capacity to establish its own processing capacity.

Social trends

Marketing of health benefits

Macadamia nuts have the highest levels of mono-unsaturated fats of any seed and high levels of omega-7. They are gluten-free, rich in vitamins, amino acids and other nutrients, and provides rich source of energy. ⁸ These traits serve to market macadamia as a high-value, energy dense, nutrient rich, low-volume plant based "superfood". The INC promotes, among other, studies on the ability of the tree nuts to lower cholesterol. In 2018, the global macadamia industry launched a € 200,000 research project to provide evidence on the role of the nuts in a healthy diet. The project investigates claims that regular eating of macadamia and other tree nuts protects against coronary heart disease, decreases the risk of type-2 diabetes and helps with weight management. ⁹ This research suggests that food like macadamia has the potential to significantly reduce the cost to health systems globally to combat a number of non-communicable diseases. In UK during the COVID pandemic 1 in 3 deaths are related to diabetes which is further supports the need globally for a food based approach to healthy living.

Demand for healthy foods is thriving

Vegan, vegetarian and health-conscious plant based food choices have been on the rise in mature consumer markets already for several of years, and the trend is expected to continue. In these dietary choices, macadamia is promoted as a healthy, energy-rich snack, as well as a dairy alternative in pastes and butters. Nuts, including macadamia nuts, are well reputed among European consumers. Consumption of nuts is expected to reach the highest growth in the snack segment. In major macadamia nut-consuming countries, the nuts are considered a healthier alternative to other savoury snacks like crisps and extruded snacks, and healthier than peanuts. Among healthier and more natural food choices, organic products are also seeing strong market growth. There is also a strong growth for mixed nut snacks in which macadamia adds value to. Macadamia oil has a high smoking point and is therefore valuable as a frying oil, particularly in Asian cuisine. It is also useful in salad dressing but it is a very niche product at the moment.

Natural cosmetics

With environmental and health awareness as an important trend, the use of natural products as well as environmentally friendly production methods in the cosmetics industry is increasing and is expected to further grow in the future. The chemical composition of macadamia nuts with high levels of palmitoleic acids, oleic acids and omega-7 also makes them a desirable ingredient in various cosmetics, skin and hair care products. Macadamia oil (MO) is also increasingly being used in the cosmetics and pharmaceutical fields as it is a versatile fat and being marketed as specialty oil. The oil is obtained by cold pressing the nuts. ¹⁰

Technology trends

Traceability, transparency and integrity are increasingly important features in today's supply chains. In order to build trust and credibility, companies are under pressure from consumers, NGOs, governments, and other stakeholders to disclose more information about their supply chains. For example, food companies encounter increasingly more demand for information about ingredients,

food fraud, food safety, pesticide residues, modern day slavery, child labour, environmental sustainability and animal welfare. Failure to meet these demands carries the risk of severe reputational damage.¹¹ While the issue has traditionally been stronger in Europe, awareness in other mature markets like the U.S. is also increasing. As shares of packaged food grow, it is expected that consumers in emerging markets will also demand more transparency¹².

In Kenya the LIMBUA was set up in 2006 to address some of these challenges and is now working with >5000 farmers and is one of the largest organic macadamia producers worldwide. It is with these issues in mind that the Zambian macadamia producers, processors and exporters need to work together to ensure a common approach is developed for the benefit and promotion of the sector as a whole.

Digital technology for transparency

Digital technologies are increasingly leveraged to manage risks and drive engagement across value chains.¹³ In recent years, blockchain has been presented as the answer by different parties, particularly in low-trust environments where participants cannot trade directly or lack a reliable intermediary. Block chain allows information to be verified and value to be exchanged without the involvement of a third party. The initially expected benefit for agriculture is namely cost reduction as it is expected to drive operational efficiencies.¹⁴ Blockchain could also play a role in complementing existing certification schemes as the traceability aspect is made easier and cheaper to handle. However, as with other technological solutions, also for block chain counts that the system is only as good as the quality of the data that is being added. Precision farming is another example of where technology is driving change within the farming sector. By utilising GPS and GIS technologies farmers are able to monitor and manage their farms in ways that optimise inputs, reduce waste and improve their ability to incorporate traceability systems.

Mobile technology

Mobile phones and business-related applications, e.g. for money transfer or to obtain market information have rapidly spread also in low-resource settings in the last decade. These mobile solutions offer a significant opportunity for value chains in the Zambian macadamia sector to develop trust between actors within the value chain and to provide a stronger link between the producer and consumer. With the increase in digital platforms such as the Selina Wamucii Insights; a market platform for food & agricultural produce from Africa's, businesses from anywhere in the world are able to buy and import food & agricultural produce from any African country with ease. An online macadamia auction has also been recently launched in South Africa which the Zambian commercial farmers are been made aware of.

Ecology trends

Climate change impacts

Agriculture is one of Zambia's most important economic sectors and a key to food security, economic growth, employment creation, off-farm employment and foreign exchange earnings. The sector is dominated by small-scale farmers. Climate variability is already affecting Zambia, and projected climate change impacts include rises in temperature, shifts in precipitation, and possible increases in the frequency and intensity of weather events which adversely affect the agriculture sector which is dominated by small scale farmers and dependant on rain. Several agroforestry initiatives are being implemented to mitigate the effects of climate change; WeForest Zambia collaborates with Farmers' Organizations in order to protect natural miombo forest plots on farmers' farms. They facilitate the associations to integrate viable livelihoods on the farms to incentivise forest restoration to diversify the farmer's sources of income while they plant and protect local forests. Kasisi Agriculture training college also promotes agroforestry and organic farming in the Chongwe area. The Grassroots trust in Southern Zambia works with farmers to regenerate eco-systems whilst improving profitability. In the Eastern province COMACO has established a landscape level UN RED to provide communities with carbon payments to protect their forests and to income from honey and other forest products.

Sustainability certification

Voluntary certification schemes mirror the growing consumer awareness and the resulting changing industry profile towards sustainability. Key sustainability issues that affect public perception relate to the working conditions of farmers (health, safety, fair wages and pricing), biodiversity and climate change. For macadamia, organic and Fairtrade certification are the most important certifications linked to sustainability issues. Organic retail sales in the EU reached a value of € 37.4 billion in 2017, a y-o- y increase of ca. 20 percent. The EU is the second largest market for organic products after the US, accounting for 40 percent of the total consumption by value of organic products worldwide. The popularity of organic certification for macadamia nuts follows the general market for organic products in Europe, where the largest national organic foods markets by value are Germany France and Italy. According to 2015 figures, Europe accounts for around 80 percent of retail sales of Fairtrade-certified products, followed by the U.S. with a 16 percent share.¹⁵

In Zambia, the Organic Producers and Processors Association of Zambia (OPPAZ), which was set up in 1999 as a body affiliated to the Zambian National Farmers Union, promotes the organic movement in Zambia. However, this body is now defunct and some organic producers are without any certification while others certify internationally with Ecocert but this has also proved challenging due to the high cost of annual subscription fees making it unaffordable to most farmers. The Zambia Bureau of Standards (ZABS) has developed local standards for organic products but this is not internationally recognised.

Economic trends

While still the smallest traded tree nuts the Macadamia market continues to grow and is expected to grow in the coming years at high rates in many markets around the world. The global macadamia market is projected to grow at a CAGR of 6.8% during the forecast period (2020-2025).¹⁶ The market is growing at a faster pace with the growing importance of healthy eating and consumers are more frequently choosing nuts as a healthy snack option and incorporating them into their daily diets. In addition, organic macadamia is also gaining popularity with increasing demand coming majorly from the European countries. The wide application of processed macadamia in different industrial segments, such as the food and beverage industry, and cosmetics and personal care industry, is also augmenting the growth of these nuts in the global market.¹⁷ Macadamia production is also growing in line with increasing market demand, the outlook for future macadamia production is also positive including in Zambia where some commercial farmer's trees are maturing and are beginning to harvest the nuts.

Political trends

Socio-political developments

Several emerging macadamia producing countries with potential to expand production are experiencing civil unrest or are politically unstable. This includes countries such as Zimbabwe and two of the largest macadamia producers South Africa and Kenya. ¹⁸ Political stability is a key factor in economic development and resulting concerns can have wide-reaching impacts. On a country level, socio-political developments are key underlying factors for the development of a commercial sector like macadamia, e.g. in relation to the eradication of poverty and inequality, provision of resources to increase agricultural productivity or access to land. Land value is a factor that has the potential to limit growth in countries like Hawaii, Australia, South Africa and Costa Rica where return on capital employed for macadamia production needs to compete with other horticultural crops like coffee and avocados and other emerging sectors such as tourism. In a globalised world, such developments have impacts across country borders and these factors offer Zambia the potential to expand its production and become a significant producer and exporter of macadamia.

Section four: Macadamia Business Models from the Region

Malawi models

Three macadamia production through to processing business models are outlined below. Thyolo Nut Company, based in the Southern Region of Malawi is a commercial macadamia estate with its own macadamia processing facility. TNC is part of the PGI group which has a rose production operation in Zambia. Their factory processes macadamia kernels mainly for their own production but also process macadamia from other commercial macadamia farms of varying sizes, including Tropha Estates and some smallholder production including HIMACUL. Commercial farmers such as Losacco & Co based in Eastern province currently sell their macadamia nuts to the Malawian market. Some of the commercial farmers in Zambia like Adam farming are considering sourcing their macadamia clones from Malawi stating similar climates to Zambia than South Africa and hence clones likely to perform better in Zambia. Proximity reasons were also given as Malawi is closer and it also possesses clones that South Africa does not.

Table 2 Tropha Estates

Tropha Estates Limited	
LOCATION	Northern Region, Malawi
TYPE OF SCHEME	Contract farming and commodity aggregation
SMALL HOLDER DEVELOPMENT UNIT INVOLVEMENT	Direct support to Tropha
FARMERS IN SCHEME	4216
PERCENTAGE OF FEMALE FARMERS	56%
DESCRIPTION	Purchase of dried chillies and paprika, provision of extension services. It has started the development of macadamia outgrower schemes. The annual uplift (2016) in income for smallholders selling to the company was \$28 for chillies and paprika and \$40 for macadamias.

Source: AgDevco; Transforming Communities in Northern Malawi

AgDevCo is an impact investor which aims to contribute to the transformation of African agriculture from subsistence farming to a modern, commercial sector AgDevCo provides debt, equity, and hands-on support to establish and develop commercial-scale agribusinesses.

AgDevCo invested \$5.7m to develop a 1,170 ha irrigated farming hub of two macadamia farms, an annual crop farm and a 1,000 MT macadamia processing facility. The financing was structured as \$3.7m of loans into Tropha and a \$2.0m equity investment into its parent company, Jacoma Estates. In addition to using throughput from the hub estates, Tropha aims to source from over 1000 macadamia farmers by 2026 in an underdeveloped part of Northern Malawi improving these farmers' access to a profitable value chain and developing local emergent farmers into SME agriculture businesses. The funding will also provide up to 100 hectares of year-round irrigation to local smallholder farmers to grow cash crops, such as chillies, and food crops.

Tropha directly impacts on the incomes of two distinct groups: smallholder farmers and employees. In 2018, the company paid more than \$530k in wages to employees, and purchased over \$190k worth of

crops from smallholder farmers – over half of whom were women

AgDevCo's Smallholder Development Unit is strengthening Tropha's outgrower schemes for chili, paprika and macadamia nuts, and installing database software to manage this expansion. The software captures productivity, sales and farmer training data and is improving product traceability and internal auditing. With more accurate commercial information to hand, opportunities are being explored with microfinance institutions to provide financial services to farmers. The SDU team is also providing specialist support in integrated pest management, GLOBAL G.A.P. traceability and certification, with the aim of opening up additional export markets.

Table 3 Highland Macadamia Cooperative Union

Highland Macadamia Cooperative Union	
LOCATION	Malawi
TYPE OF SCHEME	Cooperative Union with district level primary cooperatives
EQUAL EXCHANGE ROLE	Supported smallholder farmers in developing, handling, selling and increasing their macadamia crops.
MEMBERS IN SCHEME	3800
DESCRIPTION	HIMACUL is second tier cooperative Union with district level farmer cooperatives based in all three regions of Malawi, smallholder farmers are grouped in business centres which in many cases have one or more lead farmers. HIMACUL has developed a database of farmers with Neno Macadamia Trust which has formed the basis of a pilot carbon payment scheme. It also provides HIMACUL with the mechanism to aggregate and pay for NIS from the farmers. HIMACUL was established in 2011 following an African Bank development project, Macadamia Smallholder Development Project, which ran from 2001 to 2009.

Source: HIMACUL

The Highland Macadamia Cooperative Union Limited (HIMACUL), formerly established in 2011, represents smallholder macadamia growers in Malawi. With 3800 small farmers with district level cooperatives in all three regions of Malawi in the following districts; Mulanje, Neno, Mwanza, Dowa, Ntchisi and Rumphu. Through investing in cooperatives and associations the annual establishment has peaked at 70,000 trees a year and over 1000 Ha is currently under smallholder management in the country. The majority of this crop has been established in the last 4 years. Kernel volumes are at present small but will grow significantly as this crop matures.

The macadamia industry in Malawi is facing a turning point. For over 40 years' private estates have exported this high-value nut into the international market, but as innovation of the plant and handling of the crop finds its way forward, the smallholder sector of Malawi has a unique opportunity to take the knowledge and experience of the private estates and join a growing industry.

Since 2008 the smallholder crop has been processed by Thyolo Nut Company under a grower contract. The crop has been marketing into the UK retail through Twin Trading and Liberation Foods, a Fairtrade nut company established in 2007. Liberation is a community of interest company which is co-owned by an International Nut Cooperative (INC) and HIMACUL became a member of the INC in 2020.

HIMACUL's crop is currently exported to the UK through ETICO (The Ethical Trading Company) and Nutcellars.

Thyolo Nut Company

Thyolo Nut Company grows and processes high quality macadamia nuts on its estate, 50 kilometres from Malawi's commercial capital Blantyre. Malawi Macadamia nuts are well known for their quality and high oil content and those of Thyolo Nut Company are no exception. In May 2008, the South African Bureau of Standards registered Thyolo Nut Company as an organisation meeting the requirements of the Bureau's standard, SANS 10330:2007 for a Hazard Analysis and Critical Control Point System (HACCP) in respect of the receiving, processing, packing, supply and export of macadamia nuts. This is

the buyer's guarantee of Thyolo Nut's adherence to HACCP fundamentals that ensure a quality product that is safe

to use. The nuts from Thyolo Nut Company's orchards are processed in the company's nut cracking facility, the most modern in Malawi, to produce this quality product.

Thyolo Nut Company is a wholly owned subsidiary of London based PGI Group Ltd. The holding company has other agribusiness interests in Malawi, Zambia and Zimbabwe, where it grows, processes and exports top quality tea, macadamia nuts, cut flowers and vegetables.

Thyolo Nut Company produces 2,500 tonnes of nut in husk on 850 hectares of macadamia orchard. From this, together with additional crop from surrounding estates including Tropha and HIMACUL, 350 tonnes of edible kernel are produced and exported to all parts of the world. Nuts are sold for direct consumption by the end user as well as for use in baking and confectionary. The company first planted macadamia trees in the 1970's. In 1990, development of large orchards began and these will continue to produce an increasing crop to 2015 and beyond as the trees mature.

Until 2006 these nuts were exported in their shells for further processing. In 2007 Thyolo Nut built and commissioned a nut cracking facility to process the nut in shell into saleable, edible kernel. By exporting only the kernel, carbon emissions from road and sea transport have reduced by 70%.

Factory production and orchard nut handling capacity is presently being upgraded and increased to process the larger crop and reduce the time from tree to processed product, thereby improving quality.

Kenya Macadamia Models

Kenya is currently the third top macadamia producer with a global market share of 13 percent (7,750 tonnes on kernel basis). The bulk of Kenyan macadamia is produced by about 200,000 smallholder farmers. Kenya's macadamia production increased rapidly during the last decade, from around 11,000 tonnes nut-in shell (NIS) production in 2009 to 42,500 tonnes in 2018.¹⁹ Kenya's Agriculture and Food Authority (AFA) projects that with increased acreage under the crop, production will reach 60,000 tonnes NIS by 2022. Two business models are outlined below, the LIMBUA group which is an organic model and the Kenya Nut company, which is also a processor.

LIMBUA Group

LIMBUA Group, a macadamia processing plant was put up in the region in 2010 by Peter Wangara and his business partner Matti Spiecker after extensive research which incorporated Egerton University's Department of Crops, Horticulture and Soils and Kenya Organic Agriculture Network.

Starting as a pioneer for the cultivation of organic macadamia nuts with small-scale farmers, LIMBUA is one of the leading organic macadamia producers worldwide today. In this role, the German-Kenyan company views itself as an innovative link between small-scale farmers in Africa and demanding quality customers from all over the world. Using technology to a high degree enables the direct support and supervision of the small-scale farmers and an effective value addition of macadamia and other crops from their mixed farms. LIMBUA operates three modern decentralized production facilities and a nursery directly within farmer communities on the slopes of Mount Kenya. Since its creation it follows a unique, holistic philosophy²⁰.

The farm which started with only eight small-scale farmers then, is now working with over 5,000 farmers in the county while others come from the neighbouring Embu County. For quality purposes, the farmers are trained on how to curb pests and diseases and the requisite standards they must meet for the export market. "Apart from ensuring that our farmers have the required and certified seedlings, we insist on organic production of the nuts. This is after the we realisation that many farmers were over applying fertiliser and pesticides to grow the nuts."

Requirements for niche markets: Organic macadamia nuts

Consumer demand for organic food is fast growing particularly in Germany. To market macadamia nuts as organic in Europe, they must be grown using organic production methods in line with European legislation in this respect. Growing and processing facilities must be audited by an accredited certifier before a farmer is allowed to use the European Union's organic logo on products, as well as the logo of the standard holder (for example, the Soil Association in the United Kingdom or Naturland in Germany). Soil Association certifies ca. 70% of all organic products traded in the UK while Naturland is the main standard used for German products. Online brands typical command a premium of up to 50% over conventional macadamia.

As regulations on pesticide residues in key markets like Germany become tighter commercial growers are finding it increasingly difficult to access new chemicals to control the main pests such as stink bug. Stink bug cause significant losses to macadamia kernel in South Africa ca. \$600/ha/yr. Bats are natural predators of stink bug and are estimated to result in avoided costs of between 9% and 23% of current cost of damage caused by stinkbugs.

Producers who intend to grow organic macadamia in Zambia will need to contact either the Soil Association or Naturland who provide guidance on the steps and costs required to convert production from conventional farming to organic. Soil Association certification fees include the application costs and annual certification fees. Application costs range are £399, £444 or £483 depending on the size of farm with certified sizes of <5ha, <10ha or >10ha. The annual certificate costs range from £399/y for the smallest farms up to £1,060/yr for farms larger than 500ha. There are other costs involved such as the inspection fees £397/day if the inspection takes longer than 1 day.

The certification of a farmer group or cooperative such as Limbua in Kenya has additional benefits such as improving the traceability of the crop to individual farmers or groups of farmers. The certification costs can be apportioned among members of a farmer group or cooperative based on the area of macadamia grown per farmer. However, to maximise the value that can be achieved by securing an added value market it is critical that the farmers are able to achieve good yields and continuously improve their kernel crackout percentages by adopting good field hygiene and post-harvest handling practices.

Following the growing global demand for organic food products, and with greater awareness of the benefits of organic management techniques for soil fertility, balancing ecosystems and yields. Producers in Zambia such as Amatheon Agri, Bee Sweet Honey and COMACO have had certifications done by ECOCERT an organic certification organization, founded in France in 1991. It is based in Europe but conducts inspections in over 80 countries, making it one of the largest organic certification organizations in the world. Seeing that ECOCERT has worked with organisations in Zambia, they are most probably best placed to work with organic macadamia certification in Zambia.

Sustainability certification

The two most commonly used sustainability certification schemes are Fair Trade and Rainforest Alliance. Fair Trade international has developed a specific standard for nuts intended for small-scale producer organisations. This standard defines protective measures for workers in macadamia nut processing facilities. Fair trade also defines the terms of payment and Fairtrade Minimum Price for conventional and organic macadamia nut kernels in 10 different styles and sizes. In order to improve the sustainable production and sourcing of macadamia nuts, a group of primarily European companies and organizations formed the Sustainable Nuts Initiative in 2015. The main objective of this initiative is to improve the circumstances in nut-producing countries and work towards sustainable supply chains²¹.

According to experts, in Kenya an acre of land can hold up to 71 macadamia trees. This should earn a farmer, going by the current government market regulation of at least USD 1.57 per kilo of nuts, up to USD 12968.90 acre if a farmer 80Kg per tree depending on agronomic practices and favourable weather conditions. At the primary harvest, that comes 2 years after transplantation of seedlings, a farmer will fetch between 30kg and 50kg per tree reckoning on the range and the attention given to the trees. Production increases with each harvest

Kenya Nut Company

Kenya Nut was established in 1972 in the Kenya highlands with a focus on growing quality macadamia & cashew nuts. This has since grown to include coffee, cocoa and oils. With over 4,000 employees, the company operates seven farms on over 8,000 acres, with a complete production system from seedlings to ready-for-sale products and an international market. The Kenya Nut company provides a superior quality product through careful cultivation and modern processing techniques. Macadamia nuts and coffee from the company's farm are certified organic and the processing of products is done in a Hazard Analysis and Critical Control Point (HACCP) environment.

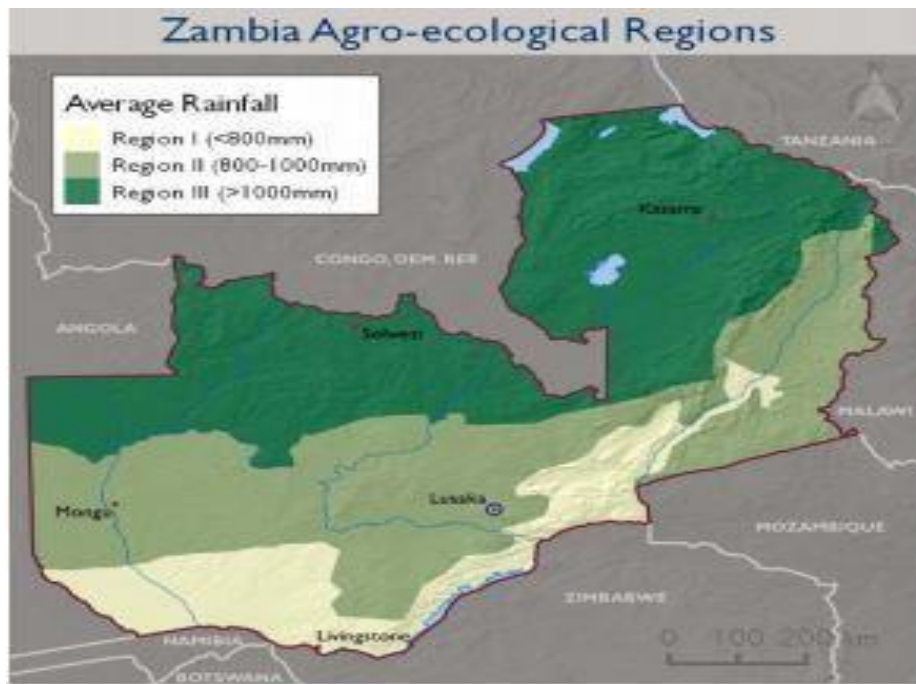
Zambia's climatic conditions and suitability for macadamia production

Zambia has a predominantly humid subtropical climate with small patches of semi-arid steppe in the southwest of the country. Three climate regions are recognized based on rainfall dynamics and vegetation:

- **Region 1:** Tropical savannas covering the country's major valleys, including the driest areas of Zambia, with annual rainfall usually below 800 mm. This is Zambia's most drought-prone region.
- **Region 2:** Warm semi-arid climates of the Sandveld plateau, the southern provinces of the Kalahari sand plateau and the Zambezi flood plains of the western province; annual rainfall is 800–1000 mm
- **Region 3:** Humid subtropical climates characterized by annual rainfall above 1200 mm and by highly leached soils. Despite these differences, all regions experience:

Three distinct seasons: a hot and dry season from August to November, a wet season from November to April and a cool and dry season from May to August. High rainfall variability: Rainfalls are volatile and subject to the position of the Inter-Tropical Convergence Zone (ITCZ) and the El Niño Southern Oscillation (ENSO), resulting in average precipitation of 150 to 300 mm per month during the wet season²².

Figure 4: Zambia Agro-ecology Regions



The highest seasonal temperatures are reached in the hot, dry season, September to November (22-27°C), and coolest in the winter months, June to August (10 - 20°C). The hot summer months are very dry, receiving almost no rainfall between June and August. Rainfall in Zambia is also strongly influenced by the El Niño Southern Oscillation (ENSO), which causes further inter-annual variability. El Niño brings

drier than average conditions in the wet summer months in the southern half of the country, whilst the north of the country simultaneously experiences significantly wetter- than average conditions.

Table 4: 30-year meteorological office data: 1981/82 to 2010/11

			Annual rainfall	Maximum temperature			Minimum temperature			Growing conditions
			Mean mm /yr	Mean annual °C	Mean month °C	Mean daily °C	Mean annual °C	Mean month °C	Mean daily °C	
Priority	Province	Districts								
1	Northwestern	Solwezi	1265.4	27.6	33.6	35.4	13.2	4.8	1.0	Excellent
2	Copperbelt	Ndola	1158.9	28.5	34.2	38.5	14.3	6.5	3.2	Good
3	Central	Mukushi	1147.6	28.3	33.9	38.7	14.0	6.3	1.5	Good
3	Central	Serenje	1042.9	27	32.5	39.2	14.0	5.6	0.6	Good
4	Eastern	Chipata	1107.5	28.9	34.6	39	17.1	9.9	4.8	Good
4	Eastern	Petauke	923.8	28.8	35.1	40.7	16.9	10.8	1.1	Marginal
5	Western	Kaoma	868.1	29.9	36	39.4	17.1	9.9	4.8	Marginal
6	Lusaka	Lusaka	861.8	28	34.3	39.6	14.9	8.0	3.0	Marginal
7	Southern	Choma	767	27.1	34.2	38.9	12.9	0.0	-3.6	Marginal

Notes:

Changes to districts in 2011 mean that only some of the districts that have started to grow macadamia have this 30-year data set. The data from these districts has been used for other districts in the same province. However, there are distinct difference of weather patterns in some provinces which the table above doesn't cover fully. For example, the rainfall in the Central and Eastern provinces reduces from East to West. Provinces where the survey data hasn't identified macadamia being grown such as Muchinga, Northern Province and Luapula are not included in the table above. However, some of these areas may be similar to the good growing conditions in northern Malawi.

There is a need to take a more detailed look at the long term climatic trends for the different districts in Zambia to show how changes in rainfall and temperature may affect the growing of macadamia. For example, the data above suggests that the areas most suited to growing macadamia do not have a frost threat. However, for two weeks during this study there were concerns about the unusually low temperatures with commercial farmers discussing options to reduce the chance of frost damage to their orchards. Another example is in Solwezi where the survey data from a commercial farmer was given was noticeably higher than the 30-year average. It is also worth noting that in areas where there has been a significant loss of natural forest cover there will be other factors to take into consideration such as a marked increase in diurnal temperature range leading to conditions that may be too hot or too cold and out of the range of optimum growing conditions for macadamia.

The growing conditions given in the table are:

Excellent With good rains and temperature

Good The rainfall is good. There are some years when the temperature can be too hot or too cold which may affect flowering or fruit set

Marginal The rainfall is too low for ideal growing of macadamia. This is combined with either too hot or too cold conditions.

Further action required;

Clones More work in Zambia is needed to identify which clones are suited to the different growing conditions in each district. The use of Beaumont (695) and A4 which has been introduced from South Africa may be suitable for some commercial farmers with the right equipment to manage the harvest. However, the nuts don't fall readily from these clones and orchards established with emerging and smallholder farmers may require a wider range of clones which are available in Malawi.

Irrigation Commercial farmers and some emerging farmers may be able to mitigate the low rainfall with irrigation especially during the tree establishment

Priority	Province
1	Northwestern
2	Copperbelt
3	Central
4	Eastern
5	Western
6	Lusaka
7	Southern

The summary tables for the provinces listed as priorities based on the met office 30-year data illustrate some different characteristics.

Northwestern province is an excellent area for macadamia production from a long term weather perspective. This area has not yet seen much macadamia growing although there is one emerging farmer located there. The main actors who may be worth engaging in an outgrower, cooperative or emerging farmer scheme are the three main organisations that market forest honey. However, these organisations aim to protect the natural forest so growing another tree crop may not be appropriate unless the forest has already been cleared.

Copperbelt province and Central province (Mukushi, Serenje and Chitambo) are good area for growing macadamia and from the data provided it has the highest concentration of commercial farmers growing macadamia in any of the provinces across Zambia. The combination of favourable weather and good arable land suggests that this province will become an epicentre for large scale macadamia production. Some of the commercial farmers have also indicated that they are planning to add value to their crop by developing their own processing facilities. The table below highlights these farmers;

Farmer	Location	
Losacco & Company	Vubwi	Intends to process own crops when orchards mature
Xander Gordon	Chisamba	Looking into processing as a group of growers
Zamac	Mpongwe	Intend to process on farm starting to asses this viability.
J Seleti	Rufunsa	Intends to process cashew nuts and macadamia
Bakhita Farm	Mpika	Plans to sell locally processed nuts and produce mac-oil

Eastern province has both good and marginal districts from a long term weather perspective. The districts closer to the Malawi border i.e. Vubwi and Chipata are well suited to growing macadamia. However, the districts further west become more marginal as the rainfall become less and the temperature range is also less favourable. This region has a high concentration of organisations that are working with outgrower schemes and commercial farming projects with emerging farmers and smallholder farmers. There is also a large UN RED project that COMACO are managing which is looking to protect natural forests across the province and finding ways to support farmer income either from the forests e.g.: honey or diversified farming which may include macadamia. The commercial macadamia grown in the districts closest to Malawi have a much more diverse selection of clones which are similar to those grown in Malawi.

The World Agroforestry (ICRAF) is also active in the province, it is a centre of science and development excellence that harnesses the benefits of trees for people and the environment. Leveraging on the world's largest repository of agroforestry science and information, it develops knowledge practices from farmer fields to the global sphere, to ensure food security and environmental sustainability. The programme has also supported macadamia industry developments in Asia.

Luapula, Northern and Muchinga province are excellent for macadamia production from a long term weather perspective. Geographically the Luapula Province of Zambia lies within a zone of seasonally high rainfall on the Central African Plateau, between latitudes 8° and 12°24' south and longitudes 28°30' and 30° east. Altitudes vary from 900 m above sea level in the lower Luapula Valley to over 1,300 m at Kawambwa. The province thus falls within the high rainfall high rainfall belt classified as region III with an average annual rainfall of over 1,000mm. Rainfall levels are high throughout these provinces. The highest rainfall is found on the plateaus of Kawambwa and the North of Samfya district. The good rainfall pattern gives a broad positive outlook for agriculture activities in Luapula Province. Interestingly there was only one commercial farmer identified in Mpika (Northern Province) currently growing macadamia and one emerging farmer from Milenge district in Luapula Province. The Northern province is also known for coffee production due to favourable weather conditions. There is thus need to explore further in these three provinces for emerging farmers who would be interested in growing macadamia nuts.

The long term weather data shows that the Western, Lusaka and Southern province are marginal when it comes to growing macadamia.

Clones and growing methods for Macadamia suited to Zambia

Selecting macadamia varieties to plant in orchards is a complicated and subjective challenge for growers and nurseries as performance usually varies from region to region and there is no perfect variety for all climatic and conditions. Some common variables to consider are yield benchmarks, climate management capacity, equipment, and most importantly, yield, income, cost and profit per hectare are considered as decision making drivers.

Recommended climatic requirements for macadamia

Attitude: 1000 - 1500 although above 500 meters above sea level can be acceptable in certain locations.

Temperatures: between 10 and 30 degrees Celsius

Rainfall: not less than 1000 mm annual and well distributed otherwise irrigation is required.

Based on the information collected from commercial farmers who are growing different varieties in different locations in the country the following were found to be the most prominent for various reasons. For these farmers the weather and soil conditions were the most important factors in the selection of the variety.

Table 6: Commercial farmer varieties

Location/ District	Varieties	Comment
Chisamba	Beaumont (695), A4, 816, 788	788, 816 and Beaumont, are the – Early flowering varieties in Chisamba 816 copes with the heat/ high temperatures
Rufunsa	Beaumont (695)	Suited to climatic condition of district
Choma	Beaumont (695)	Suited to climatic condition of district
Vubwi	A/199, 246, 344, 772, 791, 800, 804, 845, A4, 199, 849	246, 791, 772, 804, 849 are early flowering varieties in Vubwi district of Eastern province
Sioma	Beaumont (695)	The Beaumont are hardy and cope quite well in harsh conditions.
Serenje	Beaumont (695), A4, 816, A16, 842, 849	
Mpika	Beaumont (695), Integrifolia 788, Integrifolia 816	
Mpongwe	816	Preferred commercial variety in new plantings. Good resistance to husk spot. Upright, moderately dense tree, very high% kernel recovery. Large uniform kernels, early to mid-season nut drop.

Flowering of macadamia trees occurs over several months, so nuts will mature over an extended period, and multiple harvests are required to gather the entire season's crop. Weed management is an important component in macadamia nut production because weeds compete for water and nutrients. They also provide shelter for insect pests and their predators and can enhance or reduce insect damage. Weeds can make rodent management more difficult and also can interfere with harvesting. Macadamia nut trees are sensitive to frost hence they are most suited in tropical climates like

Zambia's.²³

The current macadamia production is based mainly on clones imported into Zambia from South Africa and Malawi. 70% of the South African macadamia industry uses Beaumont (695) and A4 varieties. These clones do not drop their nuts with physical or chemical assistance and are best suited to commercial macadamia producers with appropriate equipment.

Resources required by emerging farmers to grow Macadamia

Summary of margins at various levels across the macadamia industry value chain for exported macadamia kernel, 2016/17 from Malawi. ²⁴

Table 7; Resources required by to grow Macadamia (adapted from Malawi)

Production Costs (Smallholder growers)	Zambian Kwacha/Kg /Kernel	US \$ KG Kernel equivalent
Pre-harvest costs		
Weeding (labour)	0.723	0.07
Fertilizer	0.207	0.02
Fertilizer application labour	0.413	0.04
Pests and disease	0.310	0.03
Pruning	0.413	0.04
Harvest Costs		
Picking (labour)	17.974	1.74
Packaging material	0.620	0.06
Transport	0.310	0.03
Total costs	20.867	2.02
Factory price (assuming 25%) final crack out	72.31	7.00
Smallholder margin	51.4	4.98
Production costs (Estates)		
Pre-harvest costs	16.218	1.57
Harvest costs	2.789	0.27
Total field costs	19.007	1.84
Factory price (assuming 30%) final crack out	103.30	10.0
Commercial Producer margin	84.298	8.16
Processing		
Processing costs including packaging	20.66	2.0
Estate indirect costs	4.028	0.39
Total production and processing costs	127.988	12.39
Transport and logistics costs	12.912	1.25
Market agents fee	0.826	0.08
Total costs FOB	141.727	13.72
Average export market price (all grades)	170.445	16.50
Commercial factory margin	28.717	2.78
Estate margin (production & processing)	113.01	10.94

Macadamia costs of production will vary based on many factors and variable inputs; these inputs are directly influenced by the biological traits of interest. Some of these are planting and tree replacement; (ii) fertiliser operations; foliar spray operation; insecticide operations; disease control; herbicide operation; (vii) slashing and mulching operations; skirting and hedging; and harvesting. planting density. Establishment of macadamia orchards requires investment of capital which, after several years of zero or low yields, is expected to provide a high return on investment as the orchard matures

The Australian agriculture marketing center based on the cost of production for New South Wales of macadamia states that trees start to bear fruit, it can cost around \$3,000 to \$3,500 per hectare per year to operate a 312 tree per hectare orchard, making each tree around \$10 to \$12. This includes fertilization, irrigation, mulching, pest/disease/weed control, tree training, machinery operation, and labour costs. With harvesting, mechanical harvesting, de-husking, drying, and storing costs are generally around \$1,000 to \$1,500 per hectare, if there is a yield of 3,500 kilograms in-shell nuts per hectare. As a result, annual production costs for a mature orchard are around \$4000-5000. Significant income shouldn't be expected

until the fifth year, when the trees are mature and costs generally exceed income until the eighth year. Accumulated costs generally exceed accumulated income until at least the eleventh year. At an in-shell nut price of \$2.50 per kilogram, a yield of 3,500 kilogram in-shell nuts per hectare, and production costs of \$4,500 per hectare, the income from mature trees should be around \$4,000 to \$4,500 per hectare before fixed or overhead costs are subtracted. This makes a mature, 20-hectare orchard's income roughly \$80,000 to \$90,000 before fixed or overhead costs are subtracted, though these figures can vary and taxation will affect the breakeven point.

The production guide developed by ZARI also emphasises the need for planting more than one tree for cross pollination. Using quality grafted trees from productive cultivars, having an ample supply of beneficial insects, particularly bees and good irrigation management.

Potential routes to market for macadamia nut in shell vs processed kernel

The feasibility study has found that as the Zambian macadamia industry grows there are commercial farmers who are interested in adding value to their own production which may provide a route to market for NIS and kernel macadamia grown by emerging farmers and organised smallholder cooperatives or associations. Green Nut farms of South Africa estimated gross kernel selling price ("GKSP") based on the style ranged from \$/Kg \$19.80 for style 0 to \$10.20 for darks.

Section Six:

Location

Based on the meteorological data analysed for the different parts of the country the most suitable provinces are North western, Copperbelt and Central Provinces.

Intercropping

Emerging farmers are encouraged to intercrop in a multi-story agroforestry farming system with other short-term crops such as vegetables and legumes such as groundnuts. Initial PhD research (<http://www.open.ac.uk/people/zx789244#tab1>) being carried out in Malawi indicates that intercropping legumes in macadamia increases the yield of both macadamia and the legumes. The hypothesis is that the legumes provide nitrogen and mulch for the macadamia and the macadamia moderate temperature, act as a wind break and reduce soil moisture loss for the intercrop. Intercropping macadamia nuts with quicker bearing crops is one way to generate early returns. Emerging farmer macadamia nut producers should be encouraged since not all the farmers have access to land suitable for large scale monocultural orchard production

Bee management

Establishing honey bee hives near or within the orchard for increased pollination and nut set. Smallholders in Malawi are doing this too; they include one or two hives /ha within the field. Revenue from the honey is an important additional income and the bees do improve pollination. The orchard can generate additional revenue through honey production and increased macadamia nut crop yields. Macadamia flowers provide bees with a valuable source of nectar. For some small farmers the choice of macadamia clones which flower throughout the year are desirable to extend the period that honey can be produced by the bees from macadamia flowers.

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