Macadamia Market Systems Analysis
Shan State, Myanmar

March 2020

Commissioned by ILO and authored by Jon Keesecker

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State Secretariat for Economic Affairs SECO

International Labour Organization

Norad

Acknowledgements

The author would like to thank Ko Ko Win and Jonathan Bird for their technical inputs to the research and report writing for this study.

This document has been produced for the International Labour Organization (ILO) with funding from the Norwegian Agency for Development Cooperation (NORAD) and the Swiss State Secretariat for Economic Affairs (SECO). The views and opinions expressed in this report are those of the consultants and do not necessarily reflect those of the ILO, NORAD, SECO or any other stakeholder.

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Executive Summary

Macadamia is among the rarest tree nuts in the world, but global interest is growing quickly. In 2019, global production of macadamia kernel stood at 59,000 MT, or less than 8% of other individual nuts like almond, walnut, cashew or pistachio. However, macadamia production rose 57% between 2009 and 2019, faster than any other tree nut. Sixty-seven percent of output originates in Australia, South Africa and Kenya, but other sources such as China and Vietnam are also increasing cultivation. Imports have swelled, rising 23% between 2007 and 2017 to reach a total of 32,000 MT. Export markets are fairly consolidated. In 2017, the U.S. accounted for 28% of imports, followed by the EU (20%), China (12%) and Japan (10%). Along with rising prices, global supply value for macadamia rose three-fold from $370 million USD in 2008 to $1.14 trillion in 2019.

Macadamia has been cultivated in Myanmar for over a decade, where the main product is not kernel but nut-in-shell (NIS). In 2019, Myanmar produced an estimated 300-500 MT/year of NIS, or less than one percent of global output. Ninety percent of output is exported to China via Shan State, while 10% is used to produce about 15 MT/year of macadamia kernel and small volumes of oil, all of which is consumed domestically. However, in the past four years there has been significant planting of macadamia among growers large and small, and output should rise in the next two to five years. This new uptake is tied to rising farm gate prices for Myanmar NIS, which more than quadrupled between 2011 and 2018, rising from $0.51 to $2.33 USD/kg.

Myanmar macadamia production based in four or five states and regions, but the vast majority is in Mandalay Region and Shan State. Most output originates in Pyin Oo Lwin and Nyaungkhio Townships, which together have an estimated 70-100 large growers. About a dozen vertically-integrated processors here also generate all of Myanmar's kernel and oil output. Since 2017, large producers have led positive efforts toward greater private sector coordination by establishing a producer association and regional grower clusters, which could also include smallholders. Many more small growers are also believed to cultivate macadamia in southern and eastern Shan State, although most have planted only recently and will not harvest until 2022 or later.

However, a number of challenges currently limit the potential of macadamia production in Myanmar. Most growers report yields as low as three kg/tree of NIS, or just 30% of yields achieved by Australian growers using more advanced techniques. This is primarily due to limited information about the best varieties in Myanmar and poor access to grafted seedlings. Suboptimal post-harvest practices are also a major challenge. Even Myanmar's largest growers de-husk and dry too slowly, allowing mold or germination to reduce product quality. These and other challenges hamper productivity and prevent Myanmar producers from meeting the product specifications needed to export macadamia kernel or oil to markets beyond China.

This study suggests that key upgrading opportunities can improve productivity, product quality, market access and ultimately the return on investment for private sector actors involved in Myanmar macadamia production. The needed interventions include research into the best varieties and suitable areas for cultivation, adoption of grafting and pollination practices, access

to better inputs through nurseries and business providers, broader awareness of product specifications such as the moisture content of NIS or kernel and increased market-linkages with importers from the U.S., EU, Japan and Korea. Provided these improvements, Myanmar has the potential to become an important player in global macadamia markets and open up new possibilities for the growth of micro, small and medium enterprises in the country.

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Abbreviations

DALMS	Department of Land Management and Statistics
DOA	Department of Agriculture
FD	Forest Department
FDA	Food and Drug Administration
FGD	Focus Group Discussion
GAP	Good Agricultural Practices
GHP	Good Hygiene Practices
GMP	Good Manufacturing Practices
GSP	Good Storage Practices
HACCP	Hazard Analysis Critical Control Point
ILO	International Labour Organization
KII	Key Informant Interview
MAB	Myanmar Agricultural Bank
MFPEA	Myanmar Food Processors and Exporters Associaion
MFVPA	Myanmar Fruit and Vegitable Producer Association
MMA	Myanmar Macadamia Association
MMK	Myanmar Kyat
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOCM	Macadamia Oil Cake Meal
MOHS	Ministry of Health and Sports
MOI	Ministry of Industry
MONREC	Ministry of Natural Resources and Environmental Conservation
MSME	Micro, Small and Medium Enterprise
MT	Metric Ton
NIH	Nut-in-husk
NIS	Nut-in-shell
NLUP	National Land Use Policy
OC	Own Choice (tree variety)
R&D	Research and development
RBF	Responsible Business Fund
RKR	Reject kernel recovery
SKR	saleable kernel recovery
TKR	Total kernel recovery
UMFCCI	Union of Myanmar Federation of Chambers of Commerce and Industry
UNECE	UN Economic Commission of Europe

SECTION ONE: Objective and Methodology

1.1 Objective

The objective of this study is to conduct a market systems analysis of macadamia products in Myanmar's Shan State and to recommend upgrading opportunities that impact relevant businesses, beneficiaries, rules and supporting institutions. The rationale for the study is to inform efforts by the International Labour Organization (ILO) to promote development of value chains with high potential to benefit micro, small and medium enterprises (MSMEs). The work is part of ongoing ILO projects funded by the Norwegian Agency for Development Cooperation (NORAD) and the Swiss State Secretariat for Economic Affairs (SECO).

1.2 Methodology

The research was guided by the market systems approach, developed under the broader *Making Markets Work for the Poor (M4P)* approach and detailed in the ILO guide *Value Chain Development for Decent Work*. In brief, this framework categorizes key market systems components as core functions, rules and supporting functions. Core functions include product design, production, marketing, distribution and support services up to the point of final consumption. Rules include laws, policies and regulations as well as informal norms and values which guide behavior. Supporting functions include infrastructure, financial and training services and more. While the report employs supply chain or value chain terminology, the analysis generally fits within a market systems analysis.

Research activities for the study consisted of key informant interviews (KIIs) with value chain actors and direct observation of their activities. In total, 19 interviews were conducted in six locations, including: Yangon, Pyin Oo Lwin, Nyaungkhio, Ywangan, Hsiseng, and Hoppone. Field research was conducted through two visits between February 21, 2020 and March 6, 2020.[1] This included KIIs with growers, processors, traders and government officials, as well as one focus group discussion (FGD) with growers in Nyaungkhio. Desk research and further interviews were conducted in Yangon during February and March 2020. Where possible, efforts were made to include both female and male interviewees.

Challenges encountered during the research included the limited availability of administrative data, poor access to some value chain actors, and little prior data on the overall value chain structures. First, neither government nor private sector actors were able to provide hard data on topics such as grower population or production output. To address this, the study relies heavily on qualitative, anecdotal evidence with sources cited as needed. Second, some key actors—namely traders/exporters based in Muse—were unavailable for interview. To address this, the study relies

[1] Fieldwork and research were conducted during the earliest period of Covid-19 response in Myanmar. At the time of research, border trade with China was already curtailed (although the season for macadamia export had already passed). However, significant changes to domestic movement and business activity had not yet begun, therefore details in this report may have changed significantly.

on secondhand accounts of their activities from growers with whom they transact. Third, due to the paucity of existing research on Myanmar's macadamia value chain it was unclear at the outset of the field research in which locations fieldwork should be conducted. To address this, the research team aimed to be as flexible as possible within the time available to pursue leads where possible. Finally, limitation published data on some more niche topics (e.g. markets and specifications for macadamia oil products) required access to additional expertise that was not available within the study period. Such niche topics are therefore treated in somewhat less detail.

SECTION TWO: Products and Specifications

The following section outlines macadamia products produced in Myanmar along with their specifications. Where possible, specifications are compared against products in global markets.

2.1 Kernel

2.1.1 Kernel Products – Kernel is the most common macadamia product on international markets. Macadamia kernels may be sold fresh or roasted, unsalted or salted, and in various forms of wholes, halves and pieces. In Myanmar, there is relatively little macadamia kernel on the market. What does exist is typically a roasted, unsalted mixture of whole and half kernels. There is no bulk sale of kernel in Myanmar, and all kernel is sold in small retail-size packages of 100-200g. At least six companies retail macadamia kernel in Myanmar, and at least two additional companies use kernel as food ingredients; all but one of these companies are domestic processors. (see Section 5.1 on Value Chain Actors).

Table 5. Kernel Products Available in Myanmar

Company or Brand	Company Location	Grams	MMK/pack	Price (USD/kg)
Tong Garden (brand)	Thailand	35	2150	$ 42.36
Jaguar (brand)*	Ywangan	67	3500	$ 36.21
Golden Triangle Co.	Pyin Oo Lwin	180	8000	$ 30.65
Olive Moon Co.	Nyaungkhio	170	7500	$ 30.43
Green Triangle Co.	Nyaungkhio	200	8500	$ 29.31
Sithar Coffee Co.	Pyin Oo Lwin	200	8000	$ 27.59
Golden Nut (brand)	Pyin Oo Lwin	200	8000	$ 27.59
Kamayut Co.**	Unknown	100	3500	$ 24.14
Kaung Htet (brand)	Unknown	50	1500	$ 20.69
Hsiseng Co.**	Hsiseng	220	5000	$ 15.67

**Product sold as NIS, but equivalent kernel price is listed. **Formal company name is unknown or does not exist.*

Table 1. Example Quality Specifications for Macadamia Kernel[2]

Criteria	Target / Threshold
Kernel moisture	1.8%
Appearance/taste	No irregularity
Foreign matter	None
Loose shell	< 1pc/100kg
Impacted shell	<1% of kernel by weight
Rejected kernel rate	2-3%
Mold	None

2.1.2 Kernel Specifications – International product specifications for macadamia kernel generally include factors such as moisture content, appearance, foreign matter (e.g. stones, shell fragments), impacted shell, reject kernels, and mold. In practice, kernel specifications vary by market (see Section 6.4 on Import Requirements). For illustration, a summary of criteria and thresholds from the Australian Macadamia Society are shown in Table 1. In addition to such specifications, products

[2] Based on Australian Macadamia Society product standard sheet.

are also classified (e.g. whole, half, etc.) and various tests are conducted to test for phytosanitary conditions. In Myanmar, however, specifications for kernel products are very slim. Processors report focusing only on approximate moisture content (which is untested). The products are not further measured or tested, and seldom are they separated by whole, half or piece.

2.2 Nut-in-Shell

2.2.1 NIS Products – Nut-in-shell (NIS) is the simplest macadamia product on global markets, and the main Macadamia product in Myanmar. NIS consists of dried kernel still covered by an intact shell but with the fleshy husk removed. Interviewees suggest that as much as 90% of Myanmar's macadamia output is sold in this form.[3]

2.2.2 NIS Specifications – Internationally, NIS specifications typically include the size of the nut (usually 21-25mm) as well as various kernel specifications listed above, measured by sampling (see Table 1). The sole NIS specifications monitored on the Myanmar market is size, moisture, visible damage and rancidity. Generally speaking, buyers value NIS that is large in size (>20mm in diameter) and low in moisture content (threshold is generally undefined). Moisture is not measured in any objective way, rather samples are cracked and the kernel is tasted. Importantly, buyers employ different specifications for NIS moisture: some prefer the NIS to be very dry, while others accept the NIS as only lightly dried.[4] Evaluation of nut damage and rancidity is based upon sight and odor.

2.3 Processed Goods: Oils, etc.

2.3.1 Processed Goods and Specifications – A variety of processed goods can be made from macadamia, such as macadamia oils, pastes and butters. Macadamia oil include both edible and cosmetic oils of various quality. Both internationally and in Myanmar, these products are often made from inputs not suitable for sale as NIS or kernel, either due to size or other aspects of quality. In Myanmar, the only good currently processed from macadamia is macadamia oil. At least four Myanmar companies are developing macadamia oil products, including: Shwe Pazun Co., Olive Moon Co., Golden Triangle Co., and Green Triangle Co. (see Section 5.1 on Value Chain Actors). All of these companies are still in the product-development stage and still determining if/how to produce edible and/or cosmetic oils. Only Olive Moon Co. has brought a product to market already, which is an edible oil. There are no known pastes, butters, or other processed goods currently processed from macadamia in Myanmar.

[3] In some cases, NIS is actually sold as nut-in-husk (NIH). Although technically they differ, for the purposes of this report NIS and NIH are not distinguished as separate products. NIH is generally de-husked by buyers immediately after the point of sale. As such it is priced almost identically to NIS (relative to mass). Where NIS sells for 5000 MMK/kg, NIH sells for 2300 MMK/kg—or the equivalent of 4600 MMK/kg NIS—such that the 400 MMK/kg difference accounts for the investment required for de-husking.

[4] This presents an obvious dilemma for growers. Drier NIS is higher in quality (increasing price) but lower in weight (decreasing price). As such, growers may be incentivized to produce lower-quality NIS.

2.4 Byproducts: Shells, Cake, etc.

2.4.1 Byproducts from macadamia processing also have marketable purposes. For example, Australian companies have increasingly looked at biochar and nano-powders from discarded macadamia shells.[5] Various marketable uses for Macadamia Oil Cake Meal (MOCM) are also being explored.[6] In Myanmar, none of the growers or processors interviewed market such macadamia byproducts; all growers generally burn or otherwise discard macadamia husks and shells.

Images 1-4. Macadamia Products in Myanmar

Image 1. Macadamia NIS produced in Myanmar.

Image 2. Macadamia kernel produced in Myanmar.

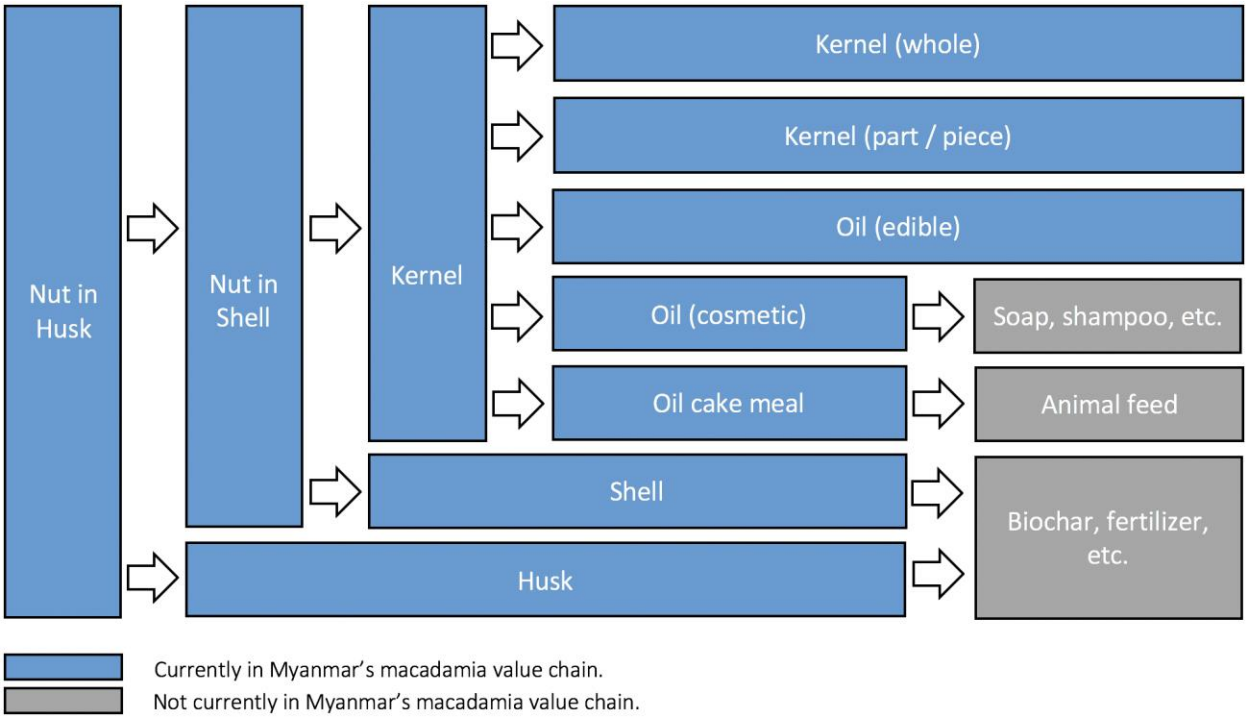
Image 3. Macadamia oil produced in Myanmar.

Image 4. Macadamia byproducts (husk and shell).

[5] Australian Macadamia Society. Accessed March, 2020. Www.australianmacadamias.org.

[6] Acheampong-Boateng, O. et al. 2016. The Potential of Replacing Soyabean Oil Cake with Macadamia Oil Cake in Broiler Diets.

Chart 1. Relationship Between Inputs and Products in Macadamia Value Chain



SECTION THREE: Markets, Prices and Import Requirements

This section summarizes markets and prices—both domestically and internationally—for macadamia products produced in Myanmar, as well as import requirements for select export markets. It also provides a brief analysis of the most promising market opportunities for Myanmar's macadamia products.

3.1 Kernel Markets and Prices

3.1.1 Export Markets – In 2017, global trade in macadamia kernel was 31,902 MT of kernel and growing. Macadamia imports grew 23% during 2007 - 2017, rising from 25,933 MT to 31,902 MT of exports. The U.S. and China saw the largest growth during this period, increasing their macadamia imports by 29% and 19%, respectively. As far as uses for these imports, most kernel imports are for whole consumption, with just 30% being used as ingredients (contrast with almond, for which 60% of imports are used as ingredients).[7] By some accounts, U.S. and Japanese imports are more often used as ingredients in food production (particularly confections and breads) while European markets are more often consumed whole as a snack product.

Chart 2. Global Macadamia Exports: 2007 – 2017 (MT of Kernel)[8]

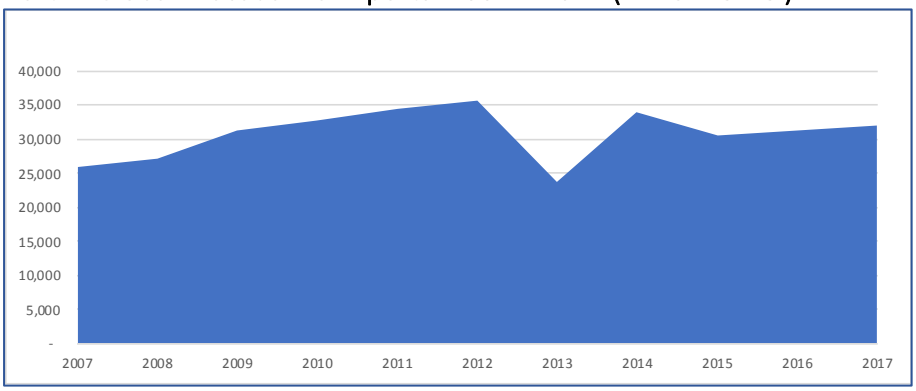


Table 2. Exports

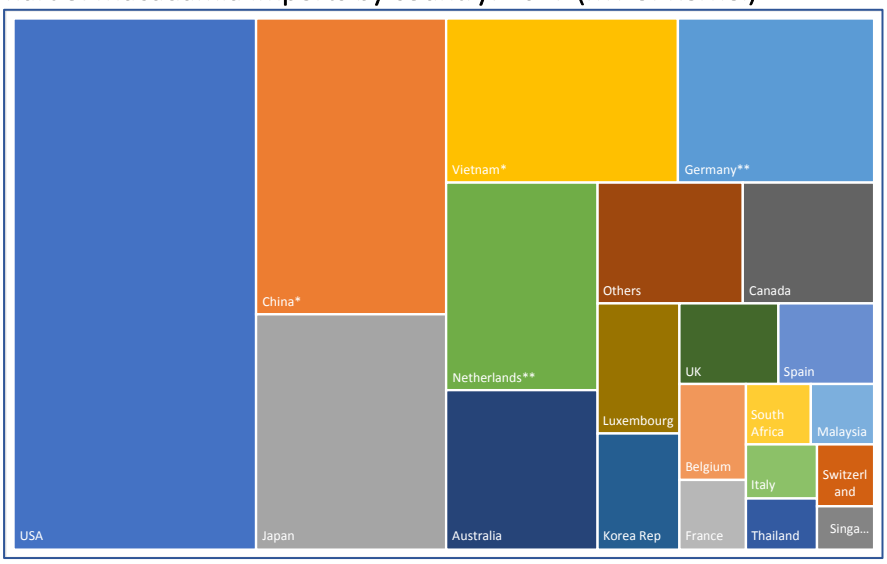
Year	MT
2017	31,902
2016	31,187
2015	30,614
2014	33,947
2013	23,756
2012	35,576
2011	34,320
2010	32,659
2009	31,260
2008	27,113
2007	25,993

Just over ten countries account for 90% of all kernel imports, led by the U.S., China, Japan and EU. While volumes have increased in recent years, the list of major importers has not. The U.S. alone accounted for 28% of all macadamia imports in 2017, and 23% of all macadamia imports over the preceding decade. China is the second largest importer, accounting for 12% of imports in 2017 and 16% of all imports over the preceding decade. Other large importers in 2017 included Japan (10%), Vietnam (8%), Germany (7%), the Netherlands (7%), Australia (5%) and Canada (3%). In addition to China and Japan, other notable importers in East Asia include Korea, Malaysia, Thailand and Singapore.

[7] Cooperative Research Center for Developing Northern Australia. 2019. Capturing the ASEAN Agricultural Opportunity for Northern Australia.

[8] International Tree Nut Council. 2019. Nut and Dried Fruits Statistical Yearbook - 2018/2019.

Chart 3. Macadamia Imports by country: 2017 (MT of Kernel)



*Countries importing NIS. **Countries focusing on re-export.*

Table 3. Import Countries

Country	MT	Percent
USA	9,000	28.2%
China*	3,921	12.3%
Japan	3,116	9.8%
Vietnam*	2,666	8.4%
Germany**	2,240	7.0%
Netherlands**	2,188	6.9%
Australia	1,676	5.3%
Others	1,237	3.9%
Canada	1,104	3.5%
Luxembourg	750	2.4%
Korea Rep	665	2.1%
UK	552	1.7%
Spain	536	1.7%
Belgium	447	1.4%
France	315	1.0%
South Africa	282	0.9%
Malaysia	269	0.8%
Italy	266	0.8%
Thailand	255	0.8%
Switzerland	242	0.8%
Singapore	173	0.5%
World Total	31,900	100%

3.1.2 Domestic Markets – The domestic market for macadamia kernel in Myanmar is very small and probably consumes not more than 15 MT of kernel annually. Kernel production in Myanmar is estimated to be roughly 15MT, all of which is consumed domestically (see Section 4.2 on Output). Most consumption probably occurs in Yangon and Pyin Oo Lwin, where processors distribute their products. There is no reliable data on the growth of the domestic macadamia market, although there has been an increase in the number of kernel producers in recent years. At present, there appears to be little consumer research to suggest domestic market growth, and most expansion is supply-driven. Market share is still highly consolidated, with about eight companies bringing macadamia-based products to market (see Section 5.1 on Value Chain Actors). If the self-reported production figures from processors are to be believed, more than 90% of the domestic market for macadamia kernel may be controlled by one processor (see Table 9). As described above, most of these companies retail kernels, while a few use macadamia as ingredients in baked goods (see Section 2 on Products and Specifications).

3.1.3 Kernel Prices – Global market prices for macadamia kernel vary depending on product specifications, but in general they have been rising year on year. The total market value of Macadamia kernel rose three-fold between 2008-2019, climbing from $370 million USD to $1.14 billion USD (see Chart 4).[9] Taking into account production figures, the value of global supply per kg produced (a rough estimate of bulk wholesale prices) rose from around $9 USD/kg in 2009 to $17 USD/kg in 2018. For example, in 2017 European wholesalers were selling bulk kernel for $19-21 USD/kg.

Myanmar-produced Macadamia kernel currently retails for around 50% less than kernel on international markets. Whole kernel for individual consumption is often priced around $40 USD/kg,

[9] Ibid.

with European retailers selling packaged kernel for $35-47 USD/kg in 2017.[10] By contrast, at the time of writing in 2020, Myanmar-produced kernel products retail for between $20-30 USD/kg. Table 5 lists all known macadamia kernel products currently retailing in Myanmar.[11]

Chart 4. Global Supply Value of Macadamia: 2008-2019 (Kernel basis)[12]

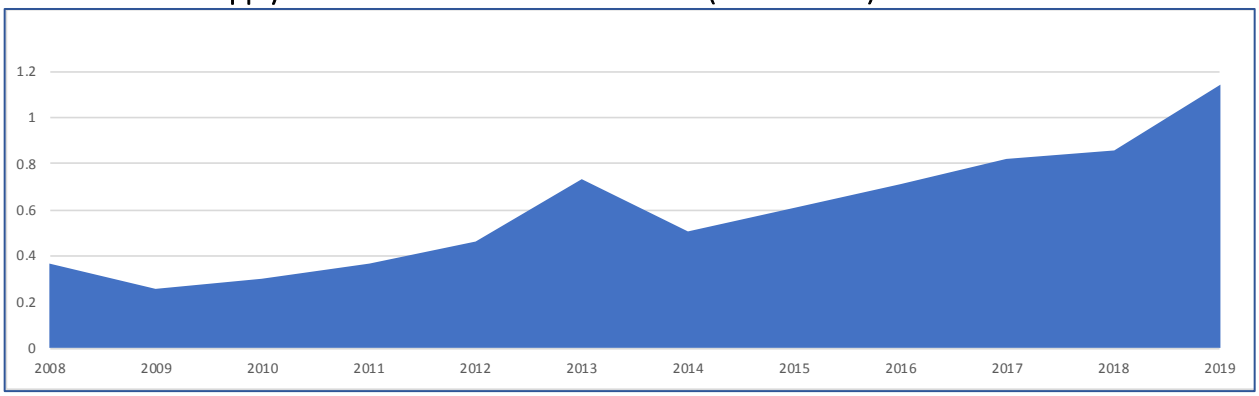


Table 4. Global Supply Value

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Supply Value (billion USD)	0.37	0.26	0.3	0.37	0.46	0.73	0.51	0.61	0.71	0.82	0.86	1.14
Production (MT)	-	27,951	27,639	28,714	29,484	36,907	37,497	41,687	47,256	49,813	50,394	59,307
USD/kg	-	9.30	10.85	12.89	15.60	19.78	13.60	14.63	15.02	16.46	17.07	-

3.2 NIS Markets & Prices

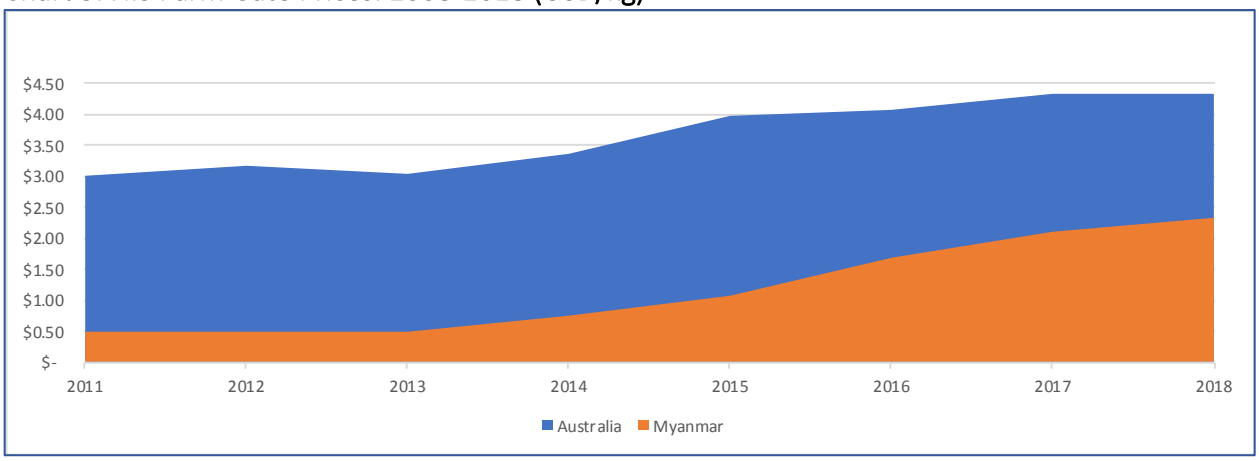
3.2.1 Export Markets – In 2017, global exports of NIS stood at 67,000 MT, most of which was shipped to Vietnam and China.[13] The main countries satisfying international demand for NIS are South Africa and Australia, which together contributed 61% of all NIS exports in 2017. China and Vietnam soaked up most of these exports. In fact, 99% of NIS exports from South Africa and Australia were destined for China and Vietnam in 2017 (69% and 30%, respectively). Myanmar NIS exports—all of which are destined for China—are a small fraction of all NIS exports, making up less than 1% of all Chinese NIS imports.

3.2.2 NIS Prices – Like macadamia kernel, prices for NIS vary according to product parameters but have also risen considerably in recent years (see Section 2.2 on Nut-in-Shell). This is true both globally and in Myanmar. Between 2011 and 2018, Australian farm gate prices for NIS rose 44%, climbing from $3.00 USD/kg to $4.33 USD/kg (based on 33% SKR).[14] Myanmar NIS prices are much lower but have also risen much faster during the same period. In October 2019, Myanmar growers

[10] Centre for the Promotion of Imports. 2017. Exporting Macadamia Nuts to Europe.
[11] Jaguar products are sold at a higher per-kilogram price than other products, however it is sold as roasted and scored NIS which includes a "key" for consumers to crack the nuts themselves.
[12] Ibid.
[13] International Tree Nut Council. 2019. Nut and Dried Fruits Statistical Yearbook - 2018/2019.
[14] Australian Macadamia Society. 2019. AMS Fact Sheet: Farm Gate Prices.

report NIS prices of 5000-6000 MMK/viss ($2.00-2.50 USD/kg).[15] While still low by international standards, Myanmar prices have risen greatly over the past decade. Between 2011 and 2018, Myanmar NIS prices rose 500%, climbing from $0.51 to $2.33 USD/kg. Nonetheless, Myanmar farm gate prices for NIS are on average still just 53% of Australian prices.

Chart 5. NIS Farm Gate Prices: 2008-2018 (USD/kg)



3.3 Oil Markets and Prices

3.3.1 Oil Markets and Prices – Global trade in macadamia oil is quite small, but prices for oil produced in Myanmar are still double that of international competitors. If macadamia is among the rarest nuts on the global market, trade in macadamia oil is even smaller. Yet macadamia processed goods are still quiet broad as a product category, covering a variety of edible and cosmetic oils produced in varying grades. Only two macadamia oil products are known to currently retail in Myanmar, both of which are edible oils. Although the imported oil sells at a higher price in Myanmar than in Australia, it still retails for 50% of the cost of macadamia oil produced in Myanmar. For example, Macadamia oil from one Myanmar brand retails in small outlets in Nyaungkhio for $67 USD/liter (e.g. 20,000 MMK for a 200ml container). Imported Australian macadamia oil from Pressed Purity retails in CityMart stores in Yangon for $34 USD/liter (e.g. 12,600 MMK for a 250ml container). By comparison, Pressed Purity macadamia oil retails in Australia for $22 USD/liter ($5.50 USD for a 250ml container).

3.4 Import Requirements

3.4.1 European Union – Macadamia imports must comport with food safety standards outlined in the European Union's General Food Law. This law covers among other things matters such as maximum allowed levels of contaminants and pesticide residues (e.g. cymoxanil, phosphane,

[15] NIH prices are generally half that of NIS, which is effectively the same since the ratio is reportedly 2:1. This 2:1 convention is probably imprecise, and certainly insensitive to different levels of dryness. As such, it may be fair to infer that growers are delivering NIS with fairly high moisture content; otherwise they are not receiving much added value by taking the effort to de-husk and dry.

bifenthrin). Importantly, food safety certification is generally required by EU importers (e.g. IFS, FSSC22000, BRC) and organic and fair-trade products must comport with EU standards. Organic certificates from independent control bodies are commonly required for countries like Myanmar which lack comparable national standards.

Packaging and labeling for European imports are also important but may differ somewhat by European country. In general, packaging must preserve the taste and appearance while protecting the product from bacteriological and other contamination. Typically, bulk macadamia is imported to the EU in 11.34kg (25lb) vacuum-sealed bags. Labeling usually includes class, grade, size, year, allergens and general nutritional information.

Macadamia classification and grading is not defined by the EU, therefore most importers apply UN Economic Commission of Europe (UNECE) classification and grading standards. UNECE places macadamia products into two "classes" which are defined by thresholds for allowable defects.[16] These defects include underdeveloped kernels, rancidity, pest damage, odor and portion of goods meeting other minimum requirements (e.g. rot, foreign matter, etc.). UNECE also lays out distinct "grades" which include four for NIS and eight for kernel. NIS grades pertain largely to size, while kernel grades are defined in terms of various sizes and mixtures of wholes, halves, chips, or diced macadamia.

3.4.2 United States – Food imports to the U.S. must meet the same legal requirements as foods produced domestically and are subject to inspection by the Food and Drug Administration (FDA). FDA standards generally cover ingredients, labeling, storage and prevention of contamination. As with EU imports, food safety certification such as HACCP are generally important, and various other third-party certifications are recognized for organic and other product categories (see Section 7.1 on Rules, Regulations and Standards). The United States does not appear to have a universal classification or grading system.

3.4.3 Korea – Korea imports of macadamia must satisfy requirements in Korea's Plant Quarantine Act and Food Sanitation Act.[17] Both NIS and kernel imports generally require the acquisition of a phytosanitary certificate—issued in the country of origin—certifying that the product has been thoroughly inspected and is free from foreign material such as pest, soil, weeds, seed, etc. (e.g. in Australia, this is issued by the Department of Agriculture). Labeling requirements stipulate that product must bear Korean language labels conveying the product name, producer name, packing date, quantity as well as storage and handling instructions. Organic and pesticide-free products are treated as two different classes in Korea and require a certificate issued from a certifying agent.

3.4.4 Japan – Macadamia imports to Japan are governed by the Customs Act, Plant Protection Act and Food Sanitation Act.[18] The Customs Act covers topics such as country-of-origin labeling, while the Plant Protection Act requires quarantine and contaminant screening (e.g. pest, plants) for raw

[16] UNECE Standard DDP-3: Macadamia Kernels. 2011. United Nations Economic Commission for Europe.
[17] Korea Importers Association. Accessed March, 2020. Www.import.or.kr.
[18] Guidebook for Export to Japan – Nuts. 2011. Japan External Trade Organization.

nuts that have not been heat-processed. The Food Sanitation Act requires compulsory testing by the Ministry of Health, Labour and Welfare for additives, pesticide residues and mycotoxins (in addition to similar testing performed in the country of origin). Documentation requirements for the import of nuts to Japan are rather extensive, including more common documents such as phytosanitary certificates and ingredient tables as well as less common documents like production flow charts of manufacturing facilities.

3.4.5 China – Although China applies its own set of strict standards for food imports, interviewees report no strict standards for Myanmar macadamia imports at the Muse border crossing in Shan State. For all practical purposes, current Myanmar macadamia reportedly meets all import standards administered at the Muse border crossing.[19]

3.5 Analysis: Market Opportunities

3.5.1 Kernel Market Opportunities – In the next two to five years, Myanmar producers could aim to export macadamia kernel to major foreign markets like the United States, the EU, Japan and Korea.

- **Export Markets - All major export markets are probably equally viable for Myanmar macadamia kernel.** From a food safety standpoint, none of the major kernel markets—the European Union, United States, Japan and Korea—appear easier to access than others. All have food safety import requirements (e.g. phytosanitary standards) that are fairly strict for Myanmar producers. Furthermore, from a quality standpoint, all of these markets require specifications (moisture, foreign matter, etc.) well above those currently achieved by Myanmar processors.

  That said, there may be minor reasons to first target export markets like the U.S., Japan and possibly the EU. For example, the U.S., Japan and EU may be initially more promising due to the benefits of existing market linkages with Myanmar. This is because macadamia is often intercropped as a shade tree for coffee in Myanmar, and Shan State coffee growers may be able to capitalize on their existing market linkages in the U.S., Japan and the EU (i.e. the major macadamia markets to which Myanmar coffee is currently exported). Furthermore, U.S. and Japanese markets in particular may be preferable for another reason. The appetite for macadamia as a food ingredient in Japan and the U.S. may prove slightly more attractive than EU markets which more often consume whole kernel, as the market for pieces generally imposes slightly less rigid quality specifications than that for whole kernel. Nonetheless, all of these major export markets present product-quality hurdles that will be challenging for Myanmar producers to overcome in the next one to two years.

  Further research into smaller nearby markets—such as Thailand or India—may also yield export opportunities for Myanmar growers. Although not among the largest importers of

[19] Unfortunately, without the ability to interview importers at Muse, it was difficult to fully outline Chinese import standards for Myanmar macadamia passing through the Muse land border.

macadamia, land borders with these countries could render these markets more accessible to Myanmar growers.[20]

- Domestic Market – In the next one to two years, Myanmar's domestic market is probably the only viable market for macadamia kernel. Although product quality is currently far from adequate for export, it is currently suitable for retail distribution in Myanmar. While there is little available data on domestic macadamia consumption in Myanmar, the growing number of processors bringing products to market suggests there is a possible growth in demand for whole kernel (see Section 5.1 on Value Chain Actors). Reliable demand for baked goods also presents a domestic market opportunity. Furthermore, macadamia kernel from Myanmar is likely to remain competitive against international competitors given the price disparity of products currently on the domestic market.

  Domestic growth in macadamia consumption will depend greatly on consumer awareness and market development through concerted marketing efforts. Familiarity with macadamia products is likely quite low among Myanmar consumers, yet macadamia products may offer considerable value. Relative to other tree nuts, macadamia is high in healthy fats and suitable to a variety of diets, meaning it could hold significant appeal to both a wide consumer base but also a narrow swath of health-focused consumers in Myanmar. That said, macadamia remains at present extremely foreign to many Myanmar consumers, particularly relative to peanut which is a staple of much Myanmar cuisine. Even with significant marketing efforts, macadamia may remain a relatively niche retail product. It is perhaps more promising as an ingredient in baked goods, which are widely consumed in Myanmar.

3.5.2 NIS Markets Opportunities – During the next two years (and beyond), Myanmar producers may focus on improving product quality of NIS exports to China, which is likely to remain the primary NIS market for the foreseeable future. China is not only the sole export market for Myanmar NIS, it is also the primary global market for NIS generally. While China itself cultivates macadamia, it is nonetheless expected to remain an NIS importer for a decade to come. One international expert suggested that Myanmar could likely continue to see market demand for NIS from China through 2030. Interviews with Myanmar growers suggest an appetite among Chinese importers for both more and better NIS. On the one hand, Chinese buyers can absorb much larger quantities of NIS than at present. On the other hand, the quality and price of Myanmar NIS is so far below that of producers like Australia, importers may be rewarded for quality improvements (see Section 6.1 on NIS Markets and Prices). It is therefore possible that improved NIS quality could lead to higher prices for Myanmar growers.

[20] One interviewee suggested Indian importers may be interested in macadamia from Myanmar.

SECTION FOUR: Production Processes

This section summarizes the production processes for macadamia products in Myanmar, including required inputs and cultivation and processing practices. Where possible, inputs and practices are benchmarked against international best practices.

4.1. Input Requirements

The main inputs for macadamia cultivation and processing include: land, planting material, pollination services, fertilizer, water/irrigation, equipment/machinery and labor. Table 6 summarizes recommended best practices for inputs alongside reported practices of large and small macadamia growers in Myanmar.[21]

Table 6. Comparison of Myanmar Inputs Against Recommended Best Practices

Input	Recommended Best Practice	Myanmar - Large growers (5 - 300 acres	Myanmar – Small growers (0.5 - 5 acres)
Land	Well-drained soil of 1m depth; moderate slope; 5.0 – 6.5 pH; elevations below 1900m.	Generally suitable; areas of 5 to 300 acres.	Generally suitable; areas of 0.5 to 1 acres.
Planting material	Grafted seedlings of 18-24 months; >1 variety/block.	Seed and seedling (un-grafted); mixed varieties.	Seed; unknown varieties.
Pollination services	Honey bee hives near orchard to support pollination.	Occasional in-house honey bee hives.	Not applied.
Fertilizer	Animal manure, grass cuttings, mulch; not more than 20% annual nitrogen application.	Chemical fertilizer, grass cuttings, chicken manure, or none.	Grass cuttings, chicken manure, or none.
Pesticide	Not recommended	Not applied.	Not applied.
Irrigation	Irrigation required if rainfall below 1200 mm/year (target of 1500 - 3000 mm/year).	Rarely applied.	Not applied.
Equipment	Raised drying racks or silos; automated de-husker; automated cracker.	Raised drying racks; hand / automated de-husker and cracker; oven / solar house.	Ground-drying with tarpaulin; de-husking hammer.
Labor	Clearing/weeding; fertilizing; pruning; harvest; de-husking; packing/shipping.	Clearing/weeding; fertilizing; pruning (limited); harvest; de-husking; packing/shipping.	Clearing/weeding (limited); fertilizing (limited); harvest; de-husking (limited).

4.1.1 Land – Macadamia cultivation requires good, well-drained soil, and international experts suggest that many areas of Shan State may be suitable.[22] In particular, many areas of northern and southern Shan State are reported to have appropriate conditions, and no growers interviewed

[21] Best practices are based on the Myanmar Macadamia Industry Guide to Orchard Best Management Practices authored by Michael Thomas.
[22] Interviews.

suggested otherwise. Moreover, the full extent of suitable land in Myanmar remains unknown, and there may be many more suitable locations not currently producing. In Myanmar, macadamia is generally grown on privately-owned agricultural land or leased forest land (i.e. in Nyaunkhio). All growers interviewed for this study reported growing on land they own, and there were no reports of growers renting land for macadamia production.[23]

4.1.2 Planting Material – Commercial macadamia cultivation typically uses grafted seedlings as planting material. Internationally, grafting is standard practice as it is essential to achieving good, consistent yields. In Myanmar, grafting is uncommon and virtually all current production is based on simply germinating from seed (i.e. NIS). This is true of both large and small growers in Myanmar who planted between 2003 and 2009. Today, most smallholders continue to plant seed because it is free or inexpensive relative to seedlings. By contrast, since 2016 Myanmar's large growers have begun growing trees from purchased seedlings (none of which is in production yet). There are also several instances of grafting underway, however none is known to be in production yet (see Section 3.2 on Cultivation and Harvest).

- Variety – Several promising macadamia varieties are currently being trialed in Myanmar, yet growers and experts agree that the best varieties for Myanmar remain unknown. Some macadamia varieties yield well while others do not, and in some cases this is location-dependent. Best practices suggest planting only high-yielding varieties and planting two or more such varieties in the same block.[24] In Myanmar, growers usually have three or more varieties planted in the same block, but often this is a mix of yielding and non-yielding varieties. Furthermore, many large and small growers do not know exactly which varieties are growing on their land.

  Recently, growers have attempted to identify the most promising varieties in Myanmar, including the introduction of at least 10-20 new varieties in Myanmar nurseries. According to one international expert, the most promising of these includes: 741, 842, 246, A203, 849, and A38.[25] Other varieties introduced to Myanmar in recent years include 344, 744, 788 and Own Choice (OC).[26] In Nyaungkhio, the Department of Agriculture (DOA) has prioritized H2, OC, 344 and 246 for grafting, and many large Nyaungkhio growers report having these on their land already. However, none of the growers interviewed have been able to confirm that particular varieties consistently yield better than others.

- Price – Planting material can be acquired for free, or it can cost as much as 7000 MMK/tree ($4.80 USD). Acquiring small amounts of NIS for germination can often be done for free. In areas of heavy production, smallholders share surplus seed freely with neighbors. However, in at least one area of southern Shan State with little production, macadamia seed is sold for 12,000 MMK/kg ($8.25 USD/kg, or $0.08 USD/tree).

[23] This excludes growers in Nyaungkhio Township who lease forest land for cultivation.
[24] Thomas, M. Myanmar Macadamia Industry Guide to Orchard Best Management Practices. 2017.
[25] Interview.
[26] Thomas, M. Myanmar Macadamia Industry Guide to Orchard Best Management Practices. 2017.

Seedlings are perceived as expensive by smallholders but generally deemed affordable by large growers. The Nyaungkhio DOA sells un-grafted one- or two-year-old seedlings for 400 - 1500 MMK each, depending on height and age. Private nurseries charge a bit more, with one private seller in southern Shan State charging three-fold prices of 1500 – 5000 MMK. At present, prices do not vary by variety. Grafted seedlings—although rarely available—reportedly sell for 7000 MMK in Pyin Oo Lwin, or 8000 MMK from Chinese importers ($4.5 – $5.5 USD). The Nyaungkhio DOA hopes to market grafted seedlings in 2020 for 3000 MMK ($2 USD).

4.1.3 Pollination Services – Retaining pollination services, or keeping honey bee hives on the orchard, is recommended to improve yields. Pollination services are extremely rare in Myanmar, but some growers do keep honey bee hives to increase pollination. One large macadamia grower in Nyaungkhio reported keeping bees for this purpose, however no smallholders reported this and it is believed to be extremely uncommon.

4.1.4 Water, Fertilizers and Pesticides – Fertilizer and irrigation is typically recommended for macadamia, although fertilizer, irrigation and pesticide are all lightly-used in Myanmar. For fertilizer, most growers interviewed fertilize with chicken manure (northern Shan State) or cow manure (southern Shan State). This is typically applied two or three times per year during the growing season. The use of chemical fertilizer was reported by only one large grower in Nyaungkhio. Irrigation is important in winter and large growers are aware of this, but few have access. In Nyaungkhio, it is estimated that less 10% of the 50 largest producers have access to irrigation in winter. In recent years, several large orchards here have installed irrigation systems but these are not yet operational.[27] Pesticides are not recommended and are indeed rare in Myanmar.[28]

4.1.5 Equipment and Machinery – NIS production requires two main pieces of equipment: de-husking machinery and drying equipment. Internationally, de-husking is performed with automated machinery. In Myanmar, large growers use automated de-husking equipment manufactured in Mandalay and modeled after Chinese imports. Smallholders de-husk manually using a hammer or similar tool. In Nyaungkhio, a handful of the largest growers (>50 acres) own de-husking machinery while others rent/borrow excess capacity at harvest time. For drying, international producers use drying racks or more advanced forced-air silos. In Myanmar, large growers use tiered, slatted racks usually situated in a ventilated building or home. In some cases, large growers use large hothouses or drying ovens to dry NIS more rapidly. By contrast, Myanmar's smallholders dry on the ground using bamboo mats or tarpaulin.

[27] These growers have used small grants from the Danish-funded Responsible Business Fund to install irrigation systems. However, in 2019 the stream previously used as a water source proved insufficient and attempts have been made to source groundwater using wells (none have been successful yet).

[28] In one instance in Pyin Oo Lwin, a fungicide was used unsuccessfully by a large grower to treat what turned out to be an insect pest.

Table 7. Price of Equipment for Macadamia Production (Sourced in Myanmar)

Equipment	Purpose			Price (USD)
	NIS	Kernel	Oil	
De-husker				$ 1,000.00
Drying racks				$ 100.00
Cracker (manual)				$ 25.00
Cracker (automated)				$ 550.00
Drier				$ 50.00
Roaster				$ 500.00
Oil-extractor				$ 350.00

Images 5-8. Macadamia Production Equipment

Image 5. De-husking machine.

Image 6. Hothouse with drying racks.

Image 7. Cracking machine with drying racks.

Image 8. Manual cracker.

Kernel production may involve one or more pieces of equipment, but cracking machinery is most important. Internationally, kernel production may involve separate machinery for cracking, sorting, and packing (and in some cases, roasting). Myanmar producers typically employ cracking, roasting and packaging machinery. Cracking is performed with cracking machinery manufactured in Mandalay (again based on Chinese models) or in some cases by hand.[29] Manual cracking is still quite common, even for large producers, and one only shifted to automated cracking equipment as recently as late 2019. Importantly, Mandalay-made crackers reportedly damage the kernel, resulting in a large number of halves/pieces; hammers are more labor-intensive but also more precise. For further drying, Myanmar producers sometimes use a small fan-based machine (4kg capacity) to blow hot air over the kernels. For roasting, most producers use an Easy Bake oven (6kg capacity). Prices of machinery are included in the Table 7.

4.1.6 Labor – The labor requirements for macadamia production in Myanmar are fairly light during most of the year but high during peak harvest (August to October). Key roles during the growing season include clearing and weeding, the application of fertilizer and pruning (see Section 8.1 on Labor). Additional roles during the harvest and post-harvest stages include harvesting from trees, collecting from the ground, de-husking, and management of drying and packing. If kernel or oil is produced, further labor is required for operating cracking, roasting and oil-making machinery. The only role which producers describe as "skilled labor" includes manual de-husking or cracking (i.e. with a hammer), which can be much more rapid and efficient of the worker is experienced. Typically, labor includes roles for both women and men, who are paid day rates of roughly 5500 MMK and 6000 MMK, respectively (see Section 8.2 on Gender). These labor rates for women and men are typically the same across all functions they perform.

4.2 Cultivation and Harvest Practices

4.2.1 Nursing and Maturation – High-yielding and high-quality macadamia cultivation typically involves raising seedlings in nurseries before grafting and transplanting them. In Myanmar, large and small growers alike cultivate macadamia from seed in irrigated raised beds before potting and transplanting. Large growers are more likely to purchase seedlings from nurseries, typically at one or two years of age. If grafted, trees should begin producing after year four, with full production potential after 10-15 years (see Section 4.2 on Productivity). Many Myanmar growers who planted macadamia around 2004 report that trees began showing yields after 5-8 years. Macadamia trees can produce for 40 years or more, although the oldest trees encountered during research were 16 years in age.[30]

[29] One producer in Pyin Oo Lwin uses an automated macadamia cracker imported from Brazil.
[30] Macadamia Industry Benchmark Report. 2019. Queensland Government.

Images 9-12. Macadamia Production Equipment

Image 9. Macadamia seed at Hsiseng nursery.

Image 10. Macadamia nursery at Nyaungkhio DOA.

Image 11. Smaller Ywangan orchard (40 tree/acre).

Image 12. Larger Nyaungkhio orchard (40 tree/acre.

4.2.2 Grafting – High-yielding and high-quality macadamia cultivation requires grafting to more desirable varieties at 18-24 months of age. As mentioned above, Myanmar growers have only recently begun to experiment with grafting. During research, grafting was observed at one large orchard in Pyin Oo Lwin as well as the DOA nursery in Nyaungkhio.[31] In both cases, the trees have not yet reached flowering age. In the first instance, the grafting was attempted using a local team with experience grafting other plants, however the variety names were unknown. In the second

[31] One additional account of grafting by a Pwin Oo Lwin grower (with technical support from private Australian consultants) was reported but not observed.

instance, the DOA has acquired four varieties using scion from a nursery in Chiang Mai, Thailand and plans to attempt grafting for the first time in May 2019 (see Section 5.1 on Value Chain Actors).

4.2.3 Spacing and Intercropping – International best practices suggest planting from 80 trees/acre (intercropped) to 125 trees/acre (monocropped). The smaller spacing consists of 4m between trees and 7-9m between rows, while the larger spacing consists of 5m x 10m. However, proper spacing is also somewhat dependent upon variety, and denser planting requires pruning to avoid trees encroaching on one another. Large growers in Nyaungkhio—those which planted around 2004—use much greater spacing, planting only 40 trees/acre (10m x 10m). This spacing is also recommended by the DOA in Nyaungkhio.[32] By contrast, smallholders in Ywangan who also planted around 2004 have planted 100 trees/acre.

Intercropping is quite common, and in Myanmar macadamia is most often intercropped with coffee, avocado and mango. In coffee-growing regions it is not uncommon for macadamia to exist as a shade tree rather than a cash crop.[33] In Ywangan and Pyin Oo Lwin, macadamia is typically intercropped with coffee, while in Nyaungkhio and non-coffee regions of Ywangan it is sometimes alternately planted with mango or avocado. Intercropping density among smallholders is variable, with some intercropping quite densely and others allowing more space.

4.2.4 Care and Harvest – Best practices for field management generally includes pruning, fertilizing, weeding, and eventually proper harvest procedures. External resources provide a more thorough outline of best practices for field preparation and harvest.[34] For example, clearing and weeding is required to prevent rodents from taking up residence in the field. Harvest can last for three or four months, and during this period the ground should be regularly cleared of debris to prevent foreign matter mixing with nuts. In general, nuts of different maturity should be kept separate within their own group to prevent mixing nuts of different variety and quality.

Generally speaking, Myanmar growers follow field management best practices to varying degrees. Observation of half a dozen large and small Myanmar growers suggested ground is generally well cleared of brush. Smallholders are unlikely to prune, and even large growers report doing this only occasionally (possibly because they use quite wide spacing). At harvest, nuts are sometimes picked from the tree while in other cases they are collected only once they've fallen to the ground. Myanmar growers will generally collect regularly over three or four months, with perhaps one month of peak production. For example, one large grower collects off the ground almost daily during a three-month period but hires workers to pick nuts from trees during one month of peak production. Smallholders have less labor capacity and therefore collect nuts somewhat less frequently.

[32] No explanation for the DOA recommendation was provided. However, one interviewee suggested that wider spacing may be necessary if trees are pruned infrequently. That said, one large grower reported that the wider spacing allowed for wind damage to the trees.

[33] In Ywangan, one coffee grower estimated that perhaps as much as a quarter of Ywangan's 30,000 coffee growers have at least some macadamia trees serving as shade trees.

[34] Thomas, M. Myanmar Macadamia Industry Guide to Orchard Best Management Practices. 2017.

4.2.5 Seasonal Calendar – In Myanmar, the growing season starts in January and lasts through the end of October. The season begins in January/February, at which time the trees can benefit from irrigation. Flowering begins in February when beekeeping is recommended to encourage pollination. In July/August the nuts begin to mature, growing large and green. Nuts are fully mature and begin to drop as early as August, although in southern Shan State this reportedly occurs a month later in September. In northern Shan State, most nuts have fallen by October, while one grower in southern Shan State (Hoppone Township) reported harvest continuing into December.[35] In some locations—higher in altitude—two harvests are possible, with a second, smaller harvest occurring in February/March; this is reportedly the case in Pyin Oo Lwin and Ywangan, but not in Nyaungkhio. The volume of second harvest is unclear; one Pyin Oo Lwin grower reported a fairly small second harvest, while another Ywangan producer reported as high as 80% of volume in the second harvest relative to the first. A full cultivation calendar is shown in Table 8.

Table 8. Cultivation Calendar

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Irrigation												
Flowering												
Small harvest												
Nuts maturing												
Large harvest												

4.3 Post-Harvest and Processing

4.3.1 De-husking and Sorting – The first step in the post-harvest process is de-husking, or removing the fleshy green material surrounding NIS. De-husking should be performed within 24hrs of dropping to prevent heat respiration and facilitate drying. As such, de-husking must be performed continuously throughout the harvest season as nuts ripen. De-husking can be performed on-farm with automated machinery before NIS is transported off-farm for drying. After de-husking an initial sorting of NIS should be performed based on size or rodent damage and also to remove any leftover foreign matter.

Most Myanmar growers—large and small—de-husk too slowly, aiming to finish within 48hrs of collection. In fact, this target is often not achieved due to availability of labor, and NIS remains in husk for longer than 48hrs.[36] As discussed previously, de-husking is performed either with an automated machine or manually with a hammer (see Section 3.1 on Input Requirements). After de-husking, some Myanmar growers sort NIS based on size and/or remove NIS that float in water.

4.3.2 Drying and Sorting – Drying NIS is the most critical post-harvest step to ensure high-quality macadamia products. The appropriate drying duration depends largely on temperature and relative humidity. The overall goal is to reduce moisture content from 20-30% at harvest to as low as 3.5% for NIS and as low as 1.5% for kernel.[37] Proper drying also loosens kernel from shell to

[35] Interview.
[36] In Pyin Oo Lwin, the second macadamia harvest in February-March coincides with the labor-intensive coffee harvest.
[37] International Tree Nut Council. 2018. Technical Information Kit - Macadamias.

allow for proper cracking at a later stage. Generally speaking, on-farm drying should be completed within 7-10 days.[38] Drying can be done by spreading NIS on racks or using specially-designed forced-air silos. Thirty degrees is generally sufficient, and lengthy sun exposure or heating above 60 degrees Celsius can cause shell cracking or rancidity and therefore should be avoided.[39]

Many Myanmar growers do not set a target moisture, nor do they test moisture using machinery. The most advanced Myanmar growers report a much-too-high target moisture of 5-15%, but most do not set a target at all (relying instead on taste). Most growers dry NIS by spreading nuts on racks, although some processors use ovens or solar houses to accelerate drying.[40] Drying duration can vary greatly in Myanmar. Smallholders dry for between one and five days, while large growers dry more thoroughly over two to four weeks. It is not uncommon for drying to last for up to six weeks while growers wait for buyers to arrive (see Section 5.1 on Value Chain Actors). Actors who dry NIS—whether growers, processors or traders—sometimes perform a second sort after drying. This may involve removing NIS with cracks, those which float in water, or those which do not reach a particular size (usually 2mm in diameter).

4.3.3 Cracking, Sorting, Roasting and Packaging – For kernel production, cracking should be performed as soon as NIS reach optimal dryness, based on kernel samples. As previously discussed, advanced macadamia production employs automated crackers carefully designed to avoid kernel damage (see Section 3.1 on Input Requirements). Kernels are then sorted for size, color, portion and defects—all of which drive grade and price. Roasting may or may not be performed, depending on buyer specification. When packing, kernels must be protected from moisture and oxygen, therefore vacuum packing or nitrogen flushing is recommended. Cold storage is not required in the short-run but may be needed over time to maintain quality. Packaging material should consist only of materials using non-toxic ink or glue.

In Myanmar, large growers crack using automated machines, while smaller growers use hammers or lever-based crackers, as described above (see Section 3.1 on Input Requirements). After cracking, most Myanmar processors do not sort kernels into wholes and halves (perhaps because poor cracking machinery causes significant breakage). Myanmar processors typically roast macadamia kernels in industrial baking ovens at 100-200 degrees Fahrenheit for 5-15 minutes. Packaging in Myanmar varies considerably. Kernels are sometimes packaged in vacuum-sealed bags, non-vacuum backs, and screw-top containers.

4.4 Oil Extraction

Internationally, macadamia oil is typically produced using cold-press machinery, while in Myanmar processors are more likely to adapt existing machinery used for peanut oil production. Cold-press machinery relies on cooler temperate and avoids the use of chemical intervention. In Myanmar,

[38] Australian Macadamia Society. Fact Sheet 2: Drying Macadamia NIS On-Farm.
[39] Thomas, M. Myanmar Macadamia Industry Guide to Orchard Best Management Practices. 2017.
[40] This is typically performed by growers who control the timing of their sale by transporting NIS themselves. It is not recommended as a best practice.

little is known about the equipment or processes involved in macadamia oil extraction, in part because most Myanmar processors are still experimenting with and refining the processes involved and quite reticent to discuss it. However, it is most likely that macadamia oil production in Myanmar borrows heavily from the machinery and processes of Myanmar's peanut oil industry.

SECTION FIVE: Value Chain Overview, Actors and Analysis

This section provides a brief overview of Myanmar's macadamia value chain and reviews the actors involved, including their populations, locations and core activities. It also provides an analysis of challenges and inefficiencies for each actor.

5.1 Value Chain Map

5.1.1 Value Chain Description – Actors in Myanmar's macadamia value chain generally consist of input providers, workers, growers, processors, village brokers and trader-exporters. Relationships in the macadamia value chain are not terribly complex relative to other agricultural commodities in Myanmar. For NIS, activities are generally divided between production and marketing. Production is handled by one group of actors (input providers, nurseries and growers), while marketing is handled by another (brokers and traders/exporters). The primary transaction occurs at the farm gate, where brokers and trader-exporters collect inventory from growers. For kernel, production and marketing are more vertically integrated with most activities performed by processors and processor-growers. Inputs are provided by growers and nurseries (in this case, inputs also include NIS). However, most subsequent activities are handled by processors, including cultivation, processing, and even distribution of inventory to retailers. These relationships are roughly mapped out for NIS and kernel in Chart 6 and Chart 7, respectively.

Chart 6. Value Chain Map: NIS Products.

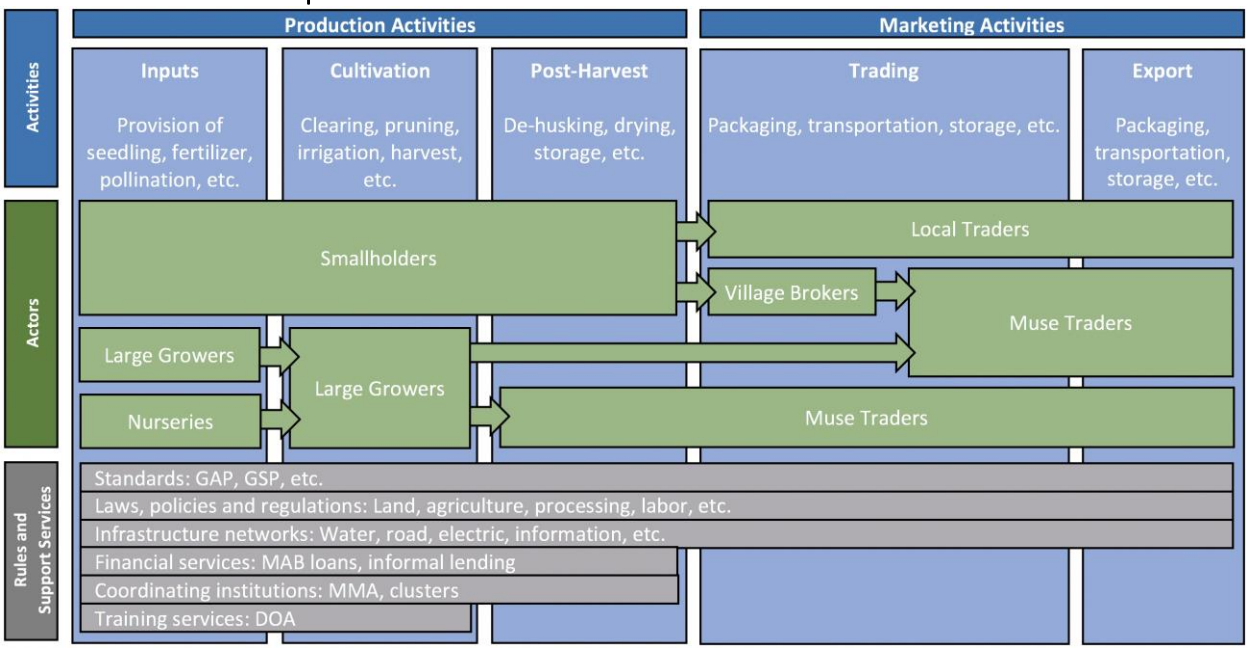
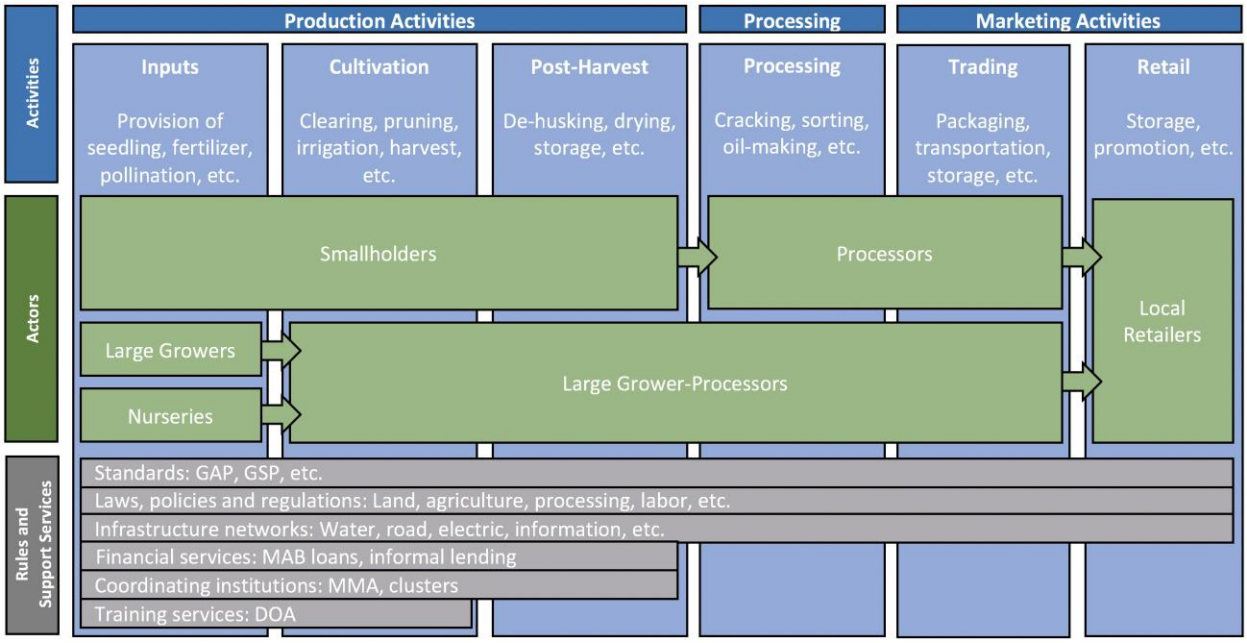


Chart 7. Value Chain Map: Kernel and Oil Products.



5.2 Value Chain Actors

5.2.1 Input Providers – Macadamia input providers include providers of planting material, fertilizer, irrigation, machinery and labor (pesticide is neither applied nor recommended).

- Seed and Seedling Suppliers – The main suppliers of planting material in Myanmar are large growers with surplus inventory and occasionally small nurseries. With respect to both seed and seedlings, growers are the main suppliers of planting material. Large growers distribute surplus seedlings while smallholders distribute surplus seed. Interviews suggest that this practice has become increasingly common in the past three or four years. The number of suppliers in Shan State probably numbers in the hundreds, but it is impossible to know without better estimates of the macadamia grower population.

  A handful of nurseries with dedicated supply of macadamia do exist in Myanmar, but these may number as few as three. The supply of macadamia seedlings is largely the domain of growers with surplus inventory, and it is rarely viewed as a business model in its own right.[41] Nonetheless, those which do operate have demonstrated scale and innovation. For example, one private nursery in Ywangan Township reports selling 3000-7000 plants annually, with a target of 10,000 in 2020. Another donor-funded nursery in Hsiseng Township has 3000-4000 seedlings but has yet to begin supplying to growers. Finally, the Nyaungkhio DOA operates a nursery which reportedly distributes 15,000-20,000 seedlings

[41] While ordinary nurseries in Pyin Oo Lwin do indeed carry small inventories of macadamia seedlings (among other plants) sales are negligible.

per year (both inside and outside of Shan State).[42] Besides these, a number of nurseries in Pyin Oo Lwin sell small volumes of macadamia as a shade tree for coffee.

There are just two known sources of grafted seedlings in Myanmar, although a third is expected to come online in 2020. First, one large grower in Pyin Oo Lwin is currently grafting seedlings and occasionally sells surplus inventory. Second, according to interviewees, Chinese traders on occasion distribute grafted seedlings imported from Yunnan Province. Third, the DOA nursery in Nyaungkhio has been cultivating scion and plans to perform its first grafting in May 2020.

There are no dedicated suppliers of seed for germination, and this is rarely performed as a business in Myanmar (nor is it recommended). Suppliers of seed generally consist of neighboring growers who provide seed for free, particularly in low-production areas. Interviews encountered only one instance of this process being commercialized (in southern Shan State).

- **Fertilizer Suppliers – Suppliers of fertilizer (chicken or cow manure) include the usual local input markets in town centers.**

- **Irrigation Sources – There are no active providers of irrigation solutions for macadamia growers in Myanmar.** In general, proper irrigation in winter is rarely applied by most growers (see Section 3.1 on Input Requirements). Although irrigation equipment (e.g. pumps, tubing) and installation expertise are indeed available in or near macadamia growing locations, the few macadamia growers implementing irrigation solutions have done so themselves rather than retain outside providers.

- **Machinery and Equipment Suppliers – Suppliers of machinery (de-husker, cracker, drier and roaster) are mainly manufacturers in Mandalay or China, and occasionally large growers in Pyin Oo Lwin in Nyaungkhio who rent excess capacity.** Most heavy machinery is purchased in Mandalay, although some growers have imported machinery from China, and one has imported machinery from Brazil. In the past four years it is increasingly common to have copycat products commissioned by a local manufacturer in Mandalay (see Section 3.1 on Input Requirements). It is unknown how many growers rent excess capacity for de-huskers and crackers, but this includes at least a handful of the largest growers in Pyin Oo Lwin and Nyaungkhio. Simple hand-operated crackers are also sometimes constructed at home.

5.2.2 Workers – Labor for macadamia production is generally the same seasonal workforce supporting other agricultural products. Labor is generally sourced locally, and no growers reported relying upon migrant labor from other townships or states/regions. The channels for recruiting paid labor are largely informal, consisting of social and professional networks. The peak in labor supply is during harvest. Smallholders rely on family and friends for labor, while large growers hire

[42] One interviewee also reported that DOA nurseries in Indaw and Namseng may distribute macadamia seedlings (ungrafted), however this could not be confirmed.

labor from nearby towns or villages. Very large landholders will also have a small dedicated workforce throughout the year for maintenance purposes.

5.2.3 Growers – The total population of macadamia growers in Myanmar is unknown, possibly numbering as few as hundreds or as many as thousands. Neither township DOA offices nor macadamia clusters keep formal records of the number of growers (see Section 4.2 on Output). The population of smallholders is the most difficult to estimate because they are more numerous and rarely specialize in macadamia. For example, consider one village of 150 households in Ywangan Township. Five growers currently harvest one acre of macadamia each, however reports suggest that up to 100 additional households (66% of the village) have planted macadamia in the past three years. Another village in Ywangan Township reports that 50 smallholders have recently planted macadamia, however many of these have as few as 20 trees which mainly provide shade for coffee or other crops. Large growers are much easier to count because they exist mostly in northern Shan State and are fewer in number. Interviews suggest that Nyaungkhio has 46 large growers cultivating between 5 and 300 acres each (most have around 50 acres), and In Pyin Oo Lwin has roughly 20 large growers cultivating up to 200 acres each. Nonetheless, complete population figures remain very incomplete.

The profiles of individual macadamia growers vary widely, and without better data it is impossible to generalize. Table 11 profiles 10 growers interviewed for this study, reporting acres, trees, intercropping and yields. All growers interviewed for the study have mature trees older than 10 years. Smallholders typically have one acre or less, while more advanced growers have anywhere from five to 300 acres.[43] As previously discussed, smallholders plant more densely than larger growers. Yields are variable, and total annual production ranges from 200kg to 20 MT of NIS. According to one expert, the largest and most productive orchards probably produce not more than 20-30 MT/year of NIS, while other large growers may produce as little as 5 MT/year.[44]

5.2.4 Processors – There are probably not more than a dozen Macadamia processors in Myanmar, defined here as actors who produce kernel, pieces, oil or other products beyond NIS. This study identified six producers of whole kernel and two producers of pieces (as baking ingredients); four of these companies produce oil (see Table 9). The input volumes for these processors range from as little as 0.3 MT of NIS to as much as 40 MT of NIS, with most on the lower end of this range. Processors either source NIS from their own orchards and/or via growers and traders. Their manufacturing operations are located both in production regions and in Yangon. Some growers process NIS on their property in Mandalay Region or Shan State while others transport NIS to Yangon and do so there. Most of these processors market their goods via small retailers, or in one case CityMart (Myanmar's largest grocery chain), while two supply to their own bakeries and cafes.

Table 9. Processors of Kernel in Myanmar

[43] There is rumored to be one 8000-acre plantation (1000 acres currently under production) in or near Nyaungkhio Township funded by Chinese investments, however this is unconfirmed.
[44] Interview.

Company	Processing Location	Kernel	Oil	Pieces	Output (MT NIS*)	NIS source	Sales Channel
Olive Moon Co.	Nyaungkhio				2.0	Also a grower	Local retailers
Green Triangle Co.	Yangon				< 1.0	Also a grower	Local retailers
Golden Triangle Co.	Unknown				40.0	Buys from traders	CityMart
Hsiseng Co.**	Hsiseng				< 1.0	Also a grower	NGO
Sithar Coffee Co.	Pyin Oo Lwin				< 1.0	Buys from traders	Local retailers
Kamayut Co.**	Unknown				Unknown	Unknown	Local retailers
Shwe Pazun Co.	Unknown				Unknown	Unknown	Bakeries
A&T Co.	Nyaungkhio				Unknown	Also a grower	Bakeries

**Kernel output is reported here in NIS equivalent.*

***Formal company name is unknown or does not exist.*

5.2.5 Village Brokers – Macadamia brokers are generally small, town- or village-based traders active primarily within local networks of smallholders. Brokers tend to move goods over short distances, sourcing inventory from growers at the farm gate and selling them to processers (e.g. in Pyin Oo Lwin) or traders arriving from Muse. As with many other crops in Myanmar, village brokers are not dedicated to particular products, rather they trade in various commodities throughout the year during the annual cycle of harvests (they are active in macadamia during August to October). As such, this is essentially the same network of local brokers that supports trade in other agricultural commodities in Myanmar. Often in Myanmar they number less than four within any particular village.[45] Many brokers in Myanmar report charging roughly 150 MMK/kg (on top of transport costs) for their services, and this is probably true for macadamia as well. According to growers they tend to buy in various, small volumes of 200kg or 300kg.

5.2.6 Traders and Exporters – Traders essentially function like brokers—they buy and sell NIS inventory, with a markup for transport and profit—although they are distinguished here as actors who export to foreign markets, namely Chinese buyers at Muse.[46] Virtually all macadamia traders are based in Muse and travel to Shan State and Mandalay Region to buy NIS or NIH at the farm gate.[47] The one known exception to this general model is a Ywangan-based trader who sources NIS locally and transports it to Muse for export. One respondent reported that as recently as 2018 there were only two Muse-based traders buying NIS in Nyaunghio, but as of February 2020 this has risen to five or six traders. Rather than make frequent trips, these traders aggregate 18 MT of NIS (i.e. one shipping container) by purchasing all available goods from multiple growers. Growers report that they may request at least a minimum of one metric ton of NIS from an individual grower. In recent years, some traders from Muse have begun performing functions beyond simple transportation. For example, several now purchase NIH and de-husking at or near the point-of-sale before returning to Muse to dry and/or export NIS.

[45] While macadamia brokers were mentioned by several interviewees, no brokers were interviewed for this study as they were note easily located outside of the macadamia harvest period.

[46] There are currently no other export countries for Myanmar macadamia besides China.

[47] Growers refer to these traders as "Chinese traders" although they are generally said to be based in Muse on the Myanmar-side of the border. None were interviewed for this study.

5.3 Actor Analysis: Challenges and Inefficiencies

5.3.1 Input Providers – The primary challenges and inefficiencies for input providers (i.e. nurseries) include: limited R&D, technical expertise, market research, and customer awareness.

- **Limited R&D.** Nurseries lack information about which varieties they should be cultivating and marketing. While some varieties have been identified as most promising, validation takes years and has yet to be conclusive. New nurseries may also require information on best practices on other aspects of nursery production (e.g. transplant age). Without adequate research and development (R&D) to acquire this information nurseries cannot provide the best products.

- **Limited Technical Expertise.** Nurseries lack technical expertise, particularly with respect to the grafting process to ensure this is performed correctly. Expertise borrowed from other industries like avocado may not be transferable to macadamia.

- **Limited Market Research.** Nurseries lack market research on the size and location of potential buyers, or growers willing to purchase seedlings. Without better understanding of their market, nurseries cannot develop business plans or effectively reach buyers.

- **Limited Customer Awareness.** Nurseries require an educated customer base familiar with the value seedlings offer. In other words, as long as growers are unaware of the benefits of seedlings, grafting and superior varieties, nurseries will not be able to grow a robust customer base.

5.3.2 Workers – Workers for macadamia growers face similar challenges to workers in other agricultural value chains in Myanmar (e.g. lack of sick leave, worker benefits, etc.). A more involved analysis of the role of workers is provided elsewhere in Section 8.1 on Labor.

5.3.3 Growers – The primary challenges and inefficiencies for macadamia growers (i.e. those who sell NIS) include: limited technical expertise, familiarity with product specifications, access to equipment, and availability of labor.

- **Limited Technical Expertise.** Many growers are unfamiliar with best practices for a variety of core functions, particularly de-husking period and drying / sorting processes. Without using improved processes, growers will continue to produce low yields and low-quality NIS.

- **Limited Familiarity with Product Specifications.** Growers lack information about optimal moisture content of NIS and kernel, often believing target moisture to be as high as 15% (rather than 3.5% for NIS).

- **Limited Access to Equipment.** Access to moisture-testing equipment and surplus de-husking machinery is limited. Large and small growers alike lack equipment for properly

testing the moisture content of NIS and kernel. Also, small growers in particular continue to de-husk with hammers (rather than automated machinery) which is slow and costly. In some cases, this incentivizes selling lower-value nut-in-husk rather than NIS. Small growers lack access to surplus de-husking machinery capacity (e.g. from nearby large growers) to make their processes more efficient.

- Limited Availability of Labor. Large growers at higher altitudes where two harvests are feasible (e.g. Pyin Oo Lwin and Ywangan) must compete with coffee production for labor during second harvest. Without timely harvest the product is susceptible to rancidity or cracking.

- Limited Customer Awareness. Growers struggle to market high-quality NIS as along as traders are unaware of optimal moisture content and/or unable to test for this.

- Limited Infrastructure. Poor communication and transportation infrastructure, between growers and traders, makes it difficult for growers to sell NIS at optimal dryness.

5.3.4 Processors – The primary challenges and inefficiencies for macadamia processors of kernel or oil include: limited technical expertise, familiarity with product specifications, quality equipment and customer awareness of their products.

- Limited Technical Expertise. Processors are unaware of best practices for producing macadamia oil and high-quality kernel products. Without this, processors cannot market high-quality products.

- Limited Familiarity with Product Specifications. Kernel and oil processers lack familiarity with product specifications for accessing global markets (e.g. optimal moisture content, thresholds for inclusion of broken kernels and foreign matter, etc.). Processors require better information in order to access export markets.

- Limited Access to Equipment. Macadamia processors lack access to quality equipment, including machines for cracking and oil extraction. This is particularly true with respect to cracking; currently most producers of kernel use poor-quality crackers manufactured in Mandalay which result in a large number of damaged kernels.

- Limited Customer Awareness. The domestic consumer market in Myanmar likely remains largely unaware of the value and health benefits of macadamia. Without better domestic marketing, processes will struggle to grow a strong domestic market for macadamia products.

5.3.5 Village Brokers – The primary challenges and inefficiencies facing village brokers include lack of awareness of products specifications and poor-quality or costly transportation infrastructure. Poor transportation options reduce margins for traders, and lack of clear product specifications

(e.g. optimal dryness) makes it difficult to market products. In general, the challenges for brokers in the macadamia value chain are probably not so different from other agricultural value chains in Myanmar.

5.3.6 Traders and Exporters – Because macadamia traders are Muse-based (i.e. unavailable for interview), it is difficult to identify with confidence their challenges and inefficiencies. These likely relate to logistical challenges resulting from geographically scattered suppliers of NIS, low-quality and insufficient supply from growers, and poor trade infrastructure (particularly transportation and communication).

SECTION SIX: Productivity, Output and Profit

This section compares summarizes what is known about productivity, output and profit margins in Myanmar's macadamia value chain. To the extent possible, productivity and output is benchmarked against international productivity and global output.

6.1 Productivity

6.1.1 NIS Yields – Australian macadamia growers generally achieve yields of 10-12.5 kg/tree for grafted trees at full maturity. As previously discussed, grafted trees begin producing about 0.5 kg/tree in year four and can reach a maximum of 10-12.5 kg/tree in year 11 (see Table 10).[48] This translates to roughly 1.3-1.6 MT/acre based on standard spacing. Furthermore, Australian growers currently aim to push yields to 15.5kg/tree (2 MT/acre) by 2022.[49] However, un-grafted trees probably offer a more appropriate benchmark for measuring productivity in Myanmar, as grafting is uncommon in Myanmar. As previously discussed, un-grafted trees—even under ideal growing conditions—offer much lower yields (see Section 3.1 on Input Requirements). Some un-grafted trees may yield as little as 10% of grafted trees (1-2 kg/tree, or <0.25 MT/acre), and in some cases they may never yield at all.[50]

Table 10. Macadamia Yields from Grafted Trees (125 trees/acre)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
Kg/tree	-	-	-	0.5	1.0	2.0	4.0	6.0	8.0	9.0	10.0	10.0	10.0
MT/acre	-	-	-	0.1	0.1	0.3	0.5	0.8	1.0	1.1	1.3	1.3	1.3

Table 11. Yields for Various Myanmar Growers (Single Harvest)

Township	Intercrop	Tree age	Acres	Tree/acre	Total (MT NIS)	Kg/tree	MT/acre
Ywangan*	Avocado	12	1.0	100	0.6	5.89	0.59
Ywangan*	Coffee, avocado	15	1.0	100	0.4	3.77	0.37
Nyaungkhio	Mango	16	25.0	40	8.8	8.75	0.35
Nyaungkhio	-	15	60.0	40	5.0	1.04	0.08
Nyaungkhio	Mango	16	300.0	40	20.0	1.66	0.06
Pyin Oo Lwin*	Coffee	12	2.5	300	2.1	2.74	0.82
Pyin Oo Lwin	Mango	16	220.0	60	3.0	0.23	0.13
Hsiseng*	Turmeric, ginger, EFY	14	1.0	100	0.3	3.00	0.30
Ywangan	Coffee, avocado	12	0.5	40	0.2	8.15	0.32
Ywangan	Mango, avocado	12	0.5	60	0.2	5.43	0.32

**Grower reported a second harvest is also possible.*

Macadamia yields in Myanmar are highly variable, but they are certainly much lower on net than those in Australia. With respect to yield-per-tree, growers report yields from 3-10 kg/tree for mature trees, or as low as 30% of yields in Australia. Among large growers, the top end of the most

[48] Interview

[49] Cooperative Research Center for Developing Northern Australia. 2019. Capturing the ASEAN Agricultural Opportunity for Northern Australia.

[50] Interview.

reasonable estimates place yields at 7-10 kg/tree, which is still significantly below Australian growers.[51] Among smallholders, Myanmar yields are much lower (see Table 11). Smallholders cultivating just one acre report yields around 3-4 kg/tree. With respect to yield-per-acre, large and small growers alike report producing roughly 0.3-0.4 MT/acre for fully mature trees aged >10 years (just 25-30% of per-acre yields in Australia).[52]

Box 1. Procedures for Estimating Myanmar Yields

Importantly, yield estimates from Myanmar growers—particularly those of large growers—are highly unreliable due to poor record keeping and the mixture of trees that differ in variety and age. Accurate yields cannot be reported without proper record keeping, particularly for large growers. For instance, most growers do not keep reliable data on their inventory of trees by variety and age, which are perhaps the two main drivers of yield. Growers do not record yields on a per-tree basis; rather, they produce yield estimates by recording total output (for all trees of various age and variety) and dividing this by the total number of trees or acres. However, because growers likely have both high- and low-yielding trees—due to both variety and maturity—an average yield across all trees or acres is fairly misleading.[53] Estimated yield must also be adjusted for other factors. For example, most large growers equate total output with total sales volume, however sales volumes have been (or should be) adjusted for theft (20% removed before harvest, according to one large grower), pest damage (10-15% removed at harvest, for some growers), and size (10% of removed at sale, according to several growers). This estimation challenge is less problematic for smallholders, who may plant only once and have fewer acres or trees to monitor.

6.1.2 Kernel Recovery – Total kernel recovery (TKR)—or the ratio of kernel to NIS from which it is obtained—typically varies from 28% to 45%, and it is estimated to be 33% in Myanmar. TKR is driven largely by the variety of macadamia tree cultivated, rather than farm-management practices.[54] Studies suggest that TKR typically peaks around 38% in trees aged 8-19 years before declining to around 34%.[55] TKR is further divided into Saleable Kernel Recovery (SKR) and Reject Kernel Recovery (RKR), with a typical breakdown of roughly 97% and 3%, respectively. In Myanmar, there is no precise data on kernel recovery, although processors usually have a rough idea of this. Processers all report TKR of 33% (i.e. 3:1 ratio of NIS to kernel), although such estimates are likely very imprecise. Processors do not report SKR or RKR, however observation of processor operations suggests that RKR likely exceeds the 3% standard.

[51] Some growers report impossibly large yields—sometimes as high as 20-30 kg/tree—which have been excluded.
[52] Large and small growers report similar per-acre yields despite having different per-tree yields. This is possible because smallholders plant many more trees per acre.
[53] For instance, it is entirely possible that an individual acre contains 10 mature high-yielding trees (10kg/tree), 10 immature high-yielding trees (0kg/tree), and 20 mature low-yielding trees (3kg/tree). In this situation, the above calculation method would incorrectly suggesting that all trees have low yields.
[54] Macadamia Industry Benchmark Report. 2019. Queensland Government.
[55] Ibid.

6.1.3 Oil Recovery – Macadamia is a high-oil nut, containing 68-79% oil content, and Myanmar processors report achieving 66% extraction.[56] Oil producers in Myanmar generally report a 3:2 ratio of kernel to oil extracted. For example, processors report producing 1kg of oil from 1.5kg of macadamia kernel. However, these estimates are likely very imprecise.

6.2 Output

6.2.1 Global Output – Macadamia is among the rarest nuts in the world, but global production has grown significantly in recent decades. In 2019, global production of macadamia kernel stood at 59,307 MT of kernel (equivalent to just over 200,000 MT NIS). This is amounts to just 5% of almond production (1,200,000 MT) and 7.5% of walnut production (800,000 MT) by volume. Although output is small compared to other nuts, Macadamia is among the fastest-growing. Production rose 112% in the 10-year period from 2009 to 2019 (57% increase over the previous decade), and it increased 18% from 2018 to 2019.[57] Chinese production in particular has grown recently, rising 114% in 2018-2019 alone. By some estimates, China could be the largest producer by 2035.[58] However, African growers may also change the profile of macadamia production in the coming decade. A 2019 study suggests that production increases in South Africa and Kenya could triple global output by 2030.[59]

Australia and South Africa are by far the largest producers of Macadamia. Most macadamia production is located in Africa and Oceana, followed by North America and Asia.[60] South Africa and Australia are the largest producers, accounting for 29% and 25% of production, respectively.[61] Other large producers include Kenya (13%), China (10%), U.S. (7%), Guatemala (4%), Malawi (3%) and Brazil (3%). In Southeast Asia, the largest producer is Vietnam, which began planting in the 1990s. Total output volumes by country are listed in Table 13.

6.2.2 Myanmar Output – Total macadamia output in Myanmar is unclear, but it is estimated to be 300-500 MT of NIS, or much less than 1% of global production. Neither township DOA offices nor the Myanmar Macadamia Association keep formal records of production. One estimate given for 2019 production in Pyin Oo Lwin and Nyaungkhio was 200 MT of NIS each.[62] However, even if accurate, these figures almost certainly exclude other growing regions which mainly consist of smallholder growers and coffee growers growing macadamia as a shade tree (see Section 5.1 on Value Chain Actors).[63] Kernel production does not add substantially to this figure, as it likely

[56] International Tree Nut Council. 2018. Technical Information Kit - Macadamias.
[57] International Tree Nut Council. 2019. Nut and Dried Fruits Statistical Yearbook - 2018/2019.
[58] Deloitte Access Economics. 2017. Market Opportunities for Queensland Agribusiness from FTA with China.
[59] Cooperative Research Center for Developing Northern Australia. 2019. Capturing the ASEAN Agricultural Opportunity for Northern Australia.
[60] Ibid.
[61] Ibid.
[62] According to some interviewees, these two townships have roughly the same output, with Nyaungkhio leading in production area and Pyin Oo Lwin leading in yields.
[63] The figures here are based on informal, rough estimates from DOA and cluster representatives.

accounting for no more than 10% of all NIS produced.[64] Estimates from processors indicate that at most 15 MT/year of macadamia kernel is produced in Myanmar, or less than 0.03% of global kernel output.

Chart 8. Tree Nut Production: 2019 (MT of Kernel) [65]

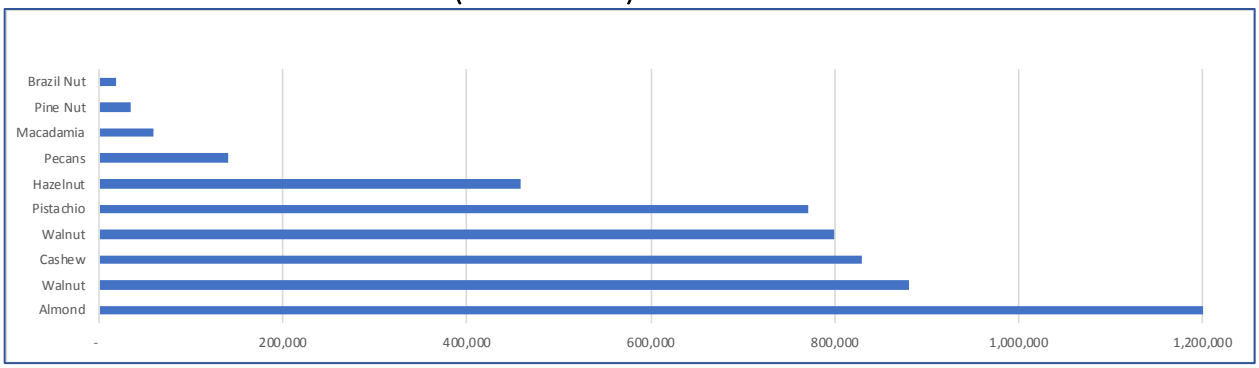


Chart 9. Global Macadamia Output: 2009 – 2019 (MT of Kernel)[66]

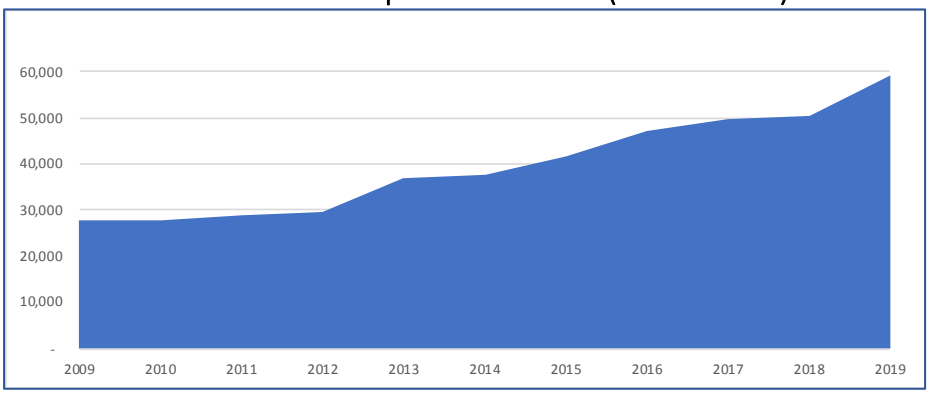


Table 12. Output

Year	MT
2019	59,307
2018	50,394
2017	49,813
2016	47,256
2015	41,687
2014	37,497
2013	36,907
2012	29,484
2011	28,714
2010	27,639
2009	27,951

Geographically, macadamia growers are located in at least five states and regions in Myanmar, including: Shan State, Mandalay Region, Chin State, Kachin State and Kayah State. These regions may be divided into three groups: those with large growers, those with mostly smallholders, and those which have yet to begin harvesting. The first group consists primarily of Nyaungkhio and Pyin Oo Lwin and accounts for most production (though not necessarily the majority of growers). Ywangan Township in southern Shan State may also be in this group. The second group consists mostly of townships in southern Shan State where smallholders are more common. Townships reported to have growers include Pinlaung, Pindaya, Hoppone, Lawksawk, Indaw and Hsiseng. Areas outside of southern Shan State which may fall into this group include Kentung Township (eastern Shan State), Namseng (northern Shan State), and Minbu (Magway Region). The third group consists of regions of Chin State, Kachin State and Kayah State which have reportedly begun planting macadamia in recent years. Shan State nurseries have sold seed or seedlings to growers from these locations in the last four years, although none are confirmed to have begun harvesting.

[64] Based on production volumes of the largest kernel producer in Myanmar.
[65] International Tree Nut Council. 2019. Nut and Dried Fruits Statistical Yearbook - 2018/2019.
[66] Ibid.

Table 13. 2018 Macadamia Output by Country (MT of Kernel) [67]

	South Africa	Australia	Kenya	China	U.S.	Guatemala	Malawi	Brazil	Myanmar	Other	Total
MT	16,965	14,800	7,750	6,000	4,239	2,150	1,619	1,550	15	4,234	59,322
% Total	29%	25%	13%	10%	7%	4%	3%	3%	0%	7%	100%

Chart 10. 2018 Macadamia Output by Country (MT of Kernel) [68]

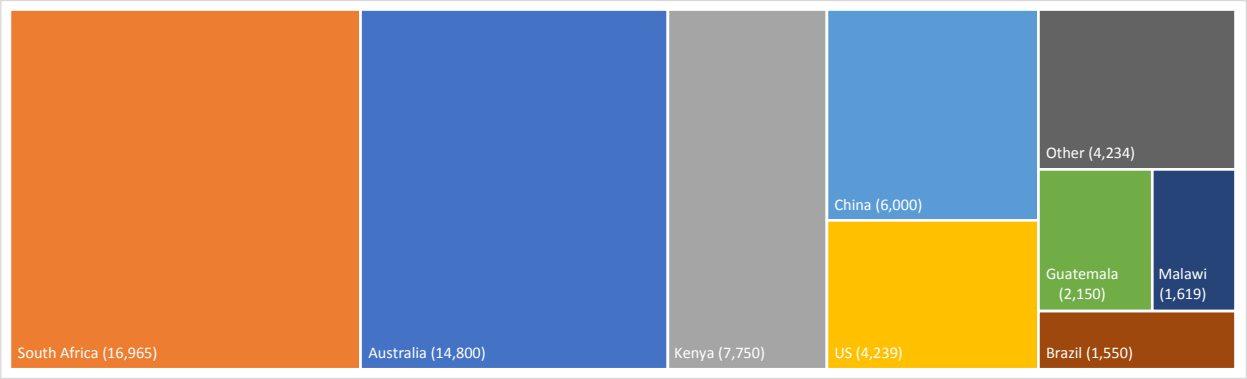


Table 14. Myanmar Townships Reportedly Growing Macadamia

State/Region	Township	Now Growing	Now Harvesting	Land Type	Grower Size
Shan State	Nyaungkhio	Confirmed	Yes	Forest	Large
Shan State	Ywangan	Confirmed	Yes	Agricultural	Small
Shan State	Hoppone	Confirmed	Yes	Agricultural	Small
Shan State	Lawksawk	Not Confirmed	Unknown	Unknown	Unknown
Shan State	Pinlaung	Not Confirmed	Unknown	Unknown	Unknown
Shan State	Indaung	Not Confirmed	Unknown	Unknown	Unknown
Shan State	Namseng	Not Confirmed	Unknown	Unknown	Unknown
Shan State	Pindaya	Not Confirmed	Unknown	Unknown	Unknown
Shan State	Kentung	Not Confirmed	Unknown	Unknown	Unknown
Mandalay Region	Pyin Oo Lwin	Confirmed	Yes	Agricultural	Large
Mandalay Region	Mogoke	Not Confirmed	Unknown	Unknown	Unknown
Magway Region	Minbu	Not Confirmed	Unknown	Unknown	Unknown
Kachin State	Unknown	Not Confirmed	Unknown	Unknown	Unknown
Kayah State	Unknown	Not Confirmed	Unknown	Unknown	Unknown
Chin State	Unknown	Not Confirmed	Unknown	Unknown	Unknown

Total acreage devoted to macadamia in Myanmar is also unclear, with estimates of total planted area ranging from 3,000 to more than 10,000 acres.[69] Importantly, one must distinguish between acres *planted* and acres *producing*. For example, the Nyaungkhio DOA estimates that in Nyaungkhio Township 1000 acres of macadamia have been planted but only 500 acres are currently under production. Other townships for which total acreage has been estimated included Yet Sauk (600 acres), Pinlaung (200 acres) and Pindaya (150 acres), although these estimates may not be reliable.[70]

[67] International Tree Nut Council. Nut and Dried Fruits Statistical Yearbook. 2018/2019.

[68] Ibid.

[69] Both large growers and the DOA provided estimates which are almost certainly inaccurate.

[70] The DOA in Nyaunghio also reported 8000 acres planted by a Chinese investor in areas of Shan State to which DOA does not have access because it is contested land (of which 1000 acres is reportedly being harvested). However this was not confirmed.

6.3 Profitability and Value Capture

6.3.1 Profitability of Cultivation – The profitability of macadamia cultivation in Myanmar is highly variable at present due to wide differences in inputs and outputs among growers. For example, inputs differ greatly because some growers invest far more than others in labor and fertilizer, and all growers cultivate a unique mix of trees by variety and maturity. Outputs—or the quality of the product sold—also differ significantly. For example, some growers pick aggressively from trees while others allow NIS to languish on the ground, essentially forfeiting value by harvesting inferior goods. The challenge of accurately measuring profitability is further amplified by poor record-keeping among growers.

Calculations provided by one Nyaungkhio case study suggest that NIS production in Myanmar can offer significant returns for growers. Financial calculations for this grower are presented in Table 15. In this instance, the grower reported investing $82 USD/acre in order to generate $230 USD/acre in revenue, or $147 USD/acre in gross profit. This amounts to a return on investment of 179%. These figures also suggest that labor is the major cost-driver, accounting for 96% of the cost structure for macadamia production. Key drivers of labor include field preparation (mostly weeding and clearing) at 73% and harvest at 27%. These figures are based on plant spacing of 40 trees/acre, a relatively low productivity of 1.6 kg/tree of NIS and a sale price of 5000 MMK/kg (as of October 2019). The data is also based on a single harvest and excludes costs and revenue from intercropping additional products on the same land (e.g. coffee, avocado).[71]

6.3.2 Value Capture – About half of the value created in the Macadamia value chain is captured by growers (45%) while the remainder is split almost evenly between workers (25%) and traders (30%). Myanmar NIS receives a price markup of about 2500-3000 MMK/kg between the farm gate and export to China. In 2019, NIS typically sold for 5000 MMK/kg at the farm gate and 8000 MMK to Chinese importers at Muse (see Section 6.1 on NIS Markets and Prices). Based on this and estimates of the costs borne by value chain actors (including labor costs from the above Nyaungkhio case study), it is possibly to roughly estimate the value-capture (i.e. the profit, roughly speaking) of various actors in the macadamia value chain. For each kg of NIS exported Muse at a price of 8000 MMK ($5.51 USD), the profit accrued to various actors is 50 MMK ($0.03 USD) for input providers, 1900 MMK ($1.31) for workers, 3500 MMK ($2.41 USD) for growers, and 2300 MMK ($1.59 USD) for traders.[72] These figures again point to the profitability of macadamia for growers, owing in part to the low input requirements of cultivation.

[71] Growers estimate that a second harvest can increase output by up to 80%.

[72] In fact, the cost-structure for Input providers and traders is unknown. Here, NIS shipping costs for traders is estimated at 200 MMK/kg. Markup by input providers is assumed to be 20-50% (although the resulting amount is negligible relative to overall price per kilogram).

Table 15. Nyaungkhio Case Study: Annual Cost, Revenue and Profit (per acre of NIS)[73]

Non-Labor Cost		MMK	USD
	Fertilizer	867	$ 0.60
	Pesticide	-	$ -
	Irrigation (electricity)	1,800	$ 1.24
	De-husking (electricity)	1,333	$ 0.92
	Subtotal	4,000	$ 2.76
Labor Cost			
	Fertilizer	12,000	$ 8.28
	Weeding	52,500	$ 36.21
	Pruning	18,000	$ 12.41
	Harvest	15,000	$ 10.34
	Collect	15,750	$ 10.86
	De-husking	1,313	$ 0.91
	Packing/etc	700	$ 0.48
	Subtotal	115,263	$ 79.49
Total Cost		119,263	$ 82.25
Revenue		333,333	$ 229.89
Gross Profit		214,071	$ 147.64

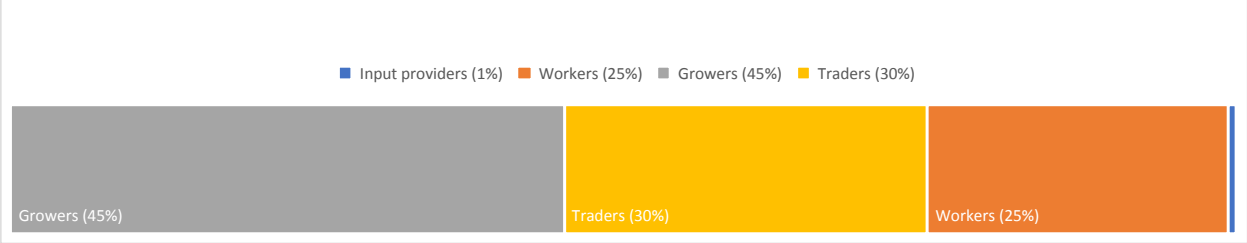
Table 16. Value Capture Among Actors

Actor	Direct Costs (MMK)	Revenue (MMK)	Profit (MMK)	Value Capture (%)	Value Capture (USD/kg)
Input Providers	100	150	50	1%	$ 0.03
Workers*	0	1900	1900	25%	$ 1.31
Growers	2000	5500	3500	45%	$ 2.41
Traders**	5700	8000	2300	30%	$ 1.59

**Based on Nyaungkhio case study.*

***Based on export of NIS to China at 8000 MMK ($5.50 USD).*

Chart 11. Distribution of Value Capture Among Actors (per one kg of NIS)



[73] Excludes fixed costs such as equipment, land, etc.

SECTION SEVEN: Rules and Supporting Functions

This section looks at the rules and supporting functions for the macadamia market system in Myanmar. This includes policies, laws, regulations and standards, as well as support institutions (infrastructure, information networks, financial services, training service and coordinating institutions). It also includes an analysis of relevant constraints and opportunities.

7.1 Rules, Regulations and Standards

7.1.1 Policies, Laws and Regulations. The following outlines macadamia industry's regulatory environment in Myanmar relating to food safety, agricultural production and land use.

- **Food Safety – Laws and institutions related to food safety have been outlined elsewhere, but in general they involve several key ministries.[74]** In general, the key government bodies related to food safety in Myanmar include the Ministry of Health (MOH), the Department of Food and Drug Administration (FDA) under MOH, the Ministry of Industry (MOI) and the Food Industries Development Supporting Laboratory of the Myanmar Food Processors and Exporters Association (MFPEA).[75] The FDA is responsible for registering and certifying food manufacturers according to the 1997 National Food Law. The other three bodies each have laboratories or other resources for conducting testing and analysis of products.

- **Agricultural Production – The key government body related to agricultural production in Myanmar is MOALI, and under this the Department of Agriculture (DOA).[76]** As outlined elsewhere, key laws include the 1990 Pesticide Law, 1993 Plant Pest Quarantine Law, 2011 Seed Law and 2015 Fertilizer Law.

- **Land – Myanmar land policy and law have been effectively outlined elsewhere, but for the purposes of this study it is worth noting that macadamia production can occur on both on forestry and agricultural land.[77]** Key laws relevant to agricultural land include the 2012 Farmland Law and 2012 Vacant, Fallow and Virgin Lands Management Law, while key laws and regulations related to forestry land include the 2018 Forest Law and 2019 Draft Forest Rules. Furthermore, each of these should, in theory, agree with the 2016 National Land Use Policy (NLUP). Meanwhile, responsibility for agricultural land management falls under the Ministry of Agriculture, Livestock and Irrigation (MOALI), particularly the Department of Land Management and Statistics (DALMS), while forest land management falls under the Forestry Department (FD) of the Ministry of Natural Resources and Environmental Conservation (MONREC).

[74] Lambert, D. and Bird, J. 2016. Chilli Value Chain Analysis and Upgrading Strategy: Southern Shan State and Mandalay Region, Myanmar. International Labour Organization.
[75] Ibid.
[76] Ibid.
[77] Ingalls, M.L., et. al. 2019. State of Land in the Mekong Region.

The administration of land laws and regulations can be complicated or inadequate in Myanmar, and this is true for land in macadamia growing areas. For example interviewees report lingering land disputes in some macadamia production areas despite procedures for resolving these (see Section 8.3 on Conflict). Additionally, jurisdiction can sometimes be unclear, particularly with regard to concessions.[78] In such cases, interviews with DOA suggest that DOA has authority over land while FD has authority over the trees on that land. This is relevant to macadamia production in Nyaungkhio, where in 2004 growers acquired 20-year leases from the Forestry Department for planting macadamia trees; these leases are expected to be renewed in 2024 for up to 30 years.

7.1.2 Standards – A variety of international standards are relevant to various links in the Myanmar's macadamia value chain, including several listed below. Several of these are endorsed by international macadamia producer associations.[79] Recent studies have identified roughly 10 companies in Yangon capable of providing training and/or certification for standards below.[80]

- Good Agricultural Practices (GAP) – To minimize pathogens, contaminants and pest-management materials during on-farm production and post-production processes.
- Good Manufacturing Practices (GMP) – To ensure product quality during processing, packing, storage and transportation.
- Good Storage Practices (GSP) – To control moisture, temperature, fungi (e.g. aflatoxins) and insects during post-harvest, processing and transport.
- Hazard Analysis Critical Control Point (HACCP) – To reduce risk of biological, chemical and physical hazards during production.
- Good Hygiene Practices (GHP) – To prevent food contamination during processing and food preparation.
- ISO 22000 – To ensure adequate food safety management systems during various stages of the value chain.
- FSSC 2200 – To ensure adequate food safety management systems during various stages of the value chain.

7.1.3 Informal rules – Informal rules and cultural norms mostly impact macadamia value chain through informal financing and gender roles. For example, this includes customs and informal agreements related to lending (see Section 7.2 on Supporting Functions). It also includes the widespread practice of dividing labor functions between women and men and paying women lower day wages based on the belief that their work is less laborious (see Section 8.2 on Gender).

[78] Ibid.
[79] International Tree Nut Council. 2018. Technical Information Kit - Macadamias.
[80] Lambert, D. and Bird, J. 2016. Chilli Value Chain Analysis and Upgrading Strategy: Southern Shan State and Mandalay Region, Myanmar.

7.2 Supporting Functions

7.2.1 Infrastructure Networks – Road and electrical infrastructure is generally sufficient for macadamia production in Myanmar, but irrigation is insufficient. Most macadamia production is in Pyin Oo Lwin and Nyaungkhio area on the well-established Mandalay-Muse corridor; nor is this far from the modern Yangon-Mandalay highway. As such, the macadamia value chain relies heavily on the most developed sections of Myanmar's transport infrastructure. However, if production expands into other areas of Shan State, Chin State and Kachin State, road infrastructure will be far less suitable. Furthermore, processors report that the electricity demands of macadamia production are not overly burdensome, and most are able to operate de-husking and cracking machinery with generators during harvest season. Irrigation infrastructure, on the other hand, is badly wanting as most growers have little or no access to irrigation in the dry winter months.

7.2.2 Information Networks – As with most agricultural production in Myanmar, information systems in the macadamia value chain are slim to nonexistent. Actors in the macadamia value chain typically telephone one another in order to acquire the latest price information or arrange sales; however even this communication channel is not used most effectively. It is not uncommon for traders to provide growers little notification before arriving to make purchases (sometimes arriving weeks before or after expected). Available information on product specifications is also poor, as the ideal specifications for NIS are at best unclear and at worst fluid. Different traders accept NIS with varying levels of moisture (requested targets range from 5-15%), leaving growers uncertain about appropriate targets. Finally, perhaps the key deficit in information flow in the macadamia value chain is not between growers and traders but between growers and nurseries (or private growers conducting researcher). As previously discussion, macadamia growers all acknowledge that the best growing varieties in Myanmar remain unknown, leaving growers guessing as to the varieties they should plant (see Section 3.1 on Input Requirements).[81]

7.2.3 Financial Services – The great majority of macadamia growers probably self-finance or finance through informal institutions. Although government loans are available through the Myanmar Agricultural Bank (MAB), the smallest growers which operate on just 0.5-1 acre often lack the resources to access these formal financial institutions. On the other hand, the largest macadamia growers typically operate on forest land and are therefore ineligible for such agricultural loans. As mentioned previously, three large growers in Nyaungkhio have accessed Responsible Business Fund (RBF) grants funded through the Danish government in order to install solar-powered pumps and irrigation systems on their property (see Section 3.1 on Input Requirements).

7.2.4 Training Services – There is currently limited training or support available to most macadamia growers and processors in Myanmar. Several valuable trainings and consultancies have been provided to Myanmar growers and nurseries on a very small scale. This includes private consultations with international experts retained by the Nyaungkhio DOA and at least one large growers, as well as a study on cultivation techniques produced with funding from Winrock

[81] Several good studies on cultivation techniques for Myanmar have been produced both by Myanmar and international experts.

International.[82] That said, several of the nurseries previously mentioned—in Nyaungkhio and Hsiseng—although not designed as training facilities, nonetheless serve as information resources for growers in their localities. Importantly, several growers and producer associations do aspire to provide such assistance in the near future (see below).

7.2.5 Coordinating Institutions – The associative bodies relevant to macadamia in Myanmar include several regionally-based "grower clusters", the Myanmar Macadamia Association (MMA), Myanmar Fruit and Vegetable Producer Association (MFVPA) and the Union of Myanmar Federation of Chambers of Commerce and Industry (UMFCCI). The macadamia clusters are largely informal associations of growers within a given locality which have existed for not more than a few years. These are known to exist in Pyin Oo Lwin and Nyaungkhio, and another plans to form in Ywangan. In a sense, they are proto-associations informally organized at a subnational level. The MMA was recently founded in November 2019 as a broader and more formal institution, although it remains in its formative stages and has yet to lay out a formal vision. The MMA is in turn a member of both the MFVPA—Myanmar's overarching association of producers across various agricultural products—and the Yangon-based UMFCCI, which is Myanmar's national chamber of commerce.

7.3 Analysis: Constraints & Opportunities

7.3.1 Rules, Regulations and Standards: Constraints & Opportunities – Myanmar's system of formal and informal rules present opportunities related to adoption of food safety standards as well as constraints related to land management, regulatory capacity and gender roles.

- Policies, Laws and Regulations – Perhaps the key constraint on macadamia production with respect to law and policy involves inadequate land dispute procedures and instability surrounding the relative jurisdictions of the DOA and FD *vis a vis* macadamia production on forest land. Such instability may pose a significant political risk for investors in the macadamia sector (although it appears relevant primarily to production in Nyaungkhio). The other notable constraint related to the regulatory functions of government involves the limited technical, laboratory and overall resource capacity of the FDA, MOHS and other institutions. These are important for ensuring the safety of products and suitability for export, yet these institutions have limited capacity to cover Myanmar's many agricultural commodities let alone less-common products such as macadamia.

- Standards – Growing familiarity with international health and safety standards among growers in Myanmar's broader agricultural sector presents the opportunity to incorporate such standards in macadamia production while the sector is still in its infancy. Standards such as GAP, GMP, GSP and HACCP are by no means widely adopted in Myanmar, yet there is growing familiarity with them with respect to other agricultural products (e.g. coffee, tea) which may spillover to macadamia production via coordinating institutions. This is particularly true with respect to coffee, mango and avocado where there is much overlap in growers due to intercropping.

[82] Thomas, M. Myanmar Macadamia Industry Guide to Orchard Best Management Practices. 2017.

- Informal Rules – Gender-based division of labor in macadamia production presents perhaps the most notable constraint related to informal rules and norms in Myanmar. In short, rigid labor roles for women and men may significantly limit work and income employment opportunities for women within the value chain (see Section 8.2 on Gender).

7.3.2 Supporting Institutions: Constraints & Opportunities – With respect to support functions, opportunities lie in sufficient road infrastructure and the existence of actors and institutions currently able and willing to aid in value chain development, while constraints exist with respect to infrastructure, financial services, technical support and value chain coordination.

- Infrastructure Networks – Relative to many other regions of Myanmar, Shan State macadamia growers are relatively well-supported by transportation infrastructure. The position of major macadamia growing locations—between Mandalay and the Chinese border post at Muse—presents a significant opportunity for ensuring future growth can access export markets. On the other hand, the lack of irrigation infrastructure is a significant obstacle for even the very largest macadamia growers. While poor availability of irrigation is not as dire a constraint as say improper selection of plant varieties, it will eventually impose a low ceiling on the growth potential of Myanmar macadamia production.

- Information Networks – As with most agricultural commodities in Myanmar, the lack of a centralized source of information for product standards and prices is a significant constraint. In the absence of more formal information systems, growers and traders in particular are susceptible to sudden and unexpected price fluctuation or difficulties in price negotiation. In order for actors in the value chain to plan effectively, they need access to current information and therefore means to communicate effectively among one another (e.g. input providers with growers, growers with buyers, etc.); this is not currently the case.

- Financial Services – Financial services for MSMEs and smallholder growers are notoriously limited in Myanmar and constitute a serious constraint in the macadamia value chain. On the positive side, smallholders cultivating macadamia generally do so on agricultural land—rather than forest land—rendering them eligible for MAB loans (the same is not true for large growers in Nyaungkhio). However, MAB loans are far from sufficient to satisfy the financial needs of many MSMEs and smallholders.

- Training Services – Although macadamia-related trainings are currently very limited in Myanmar, existing resources in Nyaungkhio and Pwin Oo Lwin present the opportunity to serve as the building blocks for expanded offerings to value chain actors. On the one hand, the role of the Nyaungkhio DOA in researching macadamia varieties, establishing a nursery and experimenting with grafting provides a useful starting point and government counterpart for expansion of trainings and services to MSMEs and small growers. On the other hand, a small number of larger growers who have privately retained international experts to support their macadamia operations may also play a valuable role as well.

Whether training services are provided by government, private sector or nonprofit actors, these private sector actors could facilitate a spillover of technical expertise and best practices within the sector and provide effective coordination. The same is true for large processors of kernel or oil, who can play an important role in the dissemination of drying practices and standards to growers who supply to them. Perhaps the key challenge is ensuring collaboration among private sector actors who may alternatively perceive themselves as competitors.

- Coordinating Institutions – Recent coordination efforts between macadamia producers and processors offer notable opportunities for multiple positive transformations in Myanmar's macadamia value chain. In particular, the establishment of the MMA and regional clusters—modeled as they are on existing coffee, mango and tea associations in Shan State—could facilitate a variety of upgrading activities, including the sharing of market information, facilitation of trainings and possibly even business-matching and market access. As a member of UMFCCI (which has a role in approving products for export) the MMA is also in a position to promote export opportunities and the industry in general. Of course, the key constraint is the newness of the MMA and its informality relative to more-established institutions for coffee, tea and mango. The MMA is currently very small and has little reach beyond the very largest growers, therefore it will require resources and time in order to grow into an institution that effectively incorporates and benefits MSMEs and small growers.

SECTION EIGHT: Cross-Cutting Issues

This section addresses cross-cutting issues relevant to macadamia production in Myanmar, including issues related to labor, gender, the environment and armed conflict.

8.1 Labor

8.1.1 Labor Profile – Based on the Nyaungkhio case study, year-round care and cultivation account for 70% of labor hours in macadamia cultivation, with the remaining 30% required during harvest. According to the financial profile provided above, macadamia production requires roughly 20 worker-days per acre per year (see Section 4.3 on Markup and Profitability).[83] Weeding and land-preparation account for 45% of this, followed by pruning (15%), collection (15%), picking (13%) and application of fertilizer (10%). Post-harvest activities like de-husking and drying together make up just 1.9% of total labor hours. Of the 30% of labor hours required for harvest, 15% is spread over a three-month period (i.e. collecting), and the other 15% is condensed into a one-month period. Of course, this picture may differ for smaller growers or growers which intercrop heavily. For instance, smaller growers are more likely to invest in harvest labor but neglect year-round labor (e.g. weeding, clearing). Furthermore, heavy intercropping may reduce the required labor-hours for clearing and weeding macadamia, as these inputs are distributed across multiple crops grown on the same land.

Chart 12. Nyaungkhio Case Study: Percent Labor Hours for NIS Production, by Activity

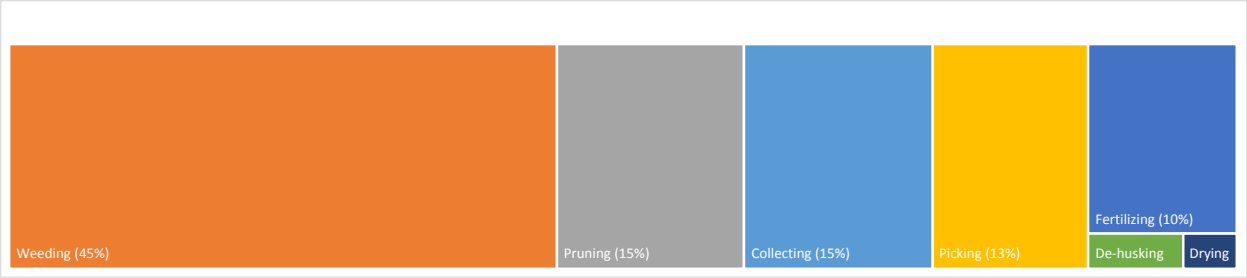


Table 17. Nyaungkhio Case Study: Percent Labor Hours for NIS Production, by Activity

Activity	Days/acre/year	% Total labor	Gender profile
Fertilizer application	2.00	10%	Men
Weeding and clearing	8.75	45%	Men
Pruning	3.00	15%	Men
Picking	2.50	13%	Men
Collecting	3.00	15%	Women
De-husking	0.23	1%	Men and women
Drying	0.13	1%	Mostly women
All activities	**19.62**	**100%**	**Both**

[83] There is reason to believe that in fact more labor is required. These calculations are based on labor required for 300 acres of macadamia. However, the actual acreage under harvest is probably less than 300, meaning per-acre labor requirements are higher than the figures reported here.

8.1.2 Financial Impact on Labor – Macadamia production has a small financial impact on Myanmar's labor force relative to other agricultural commodities, but it is likely to grow. Based on the Nyaungkhio case study, workers may capture 25% of value generated from NIS exports to China; this amounts to roughly $1.31 USD/kg, or $1,310 USD/MT (see Section 4.3 on Markup and Profitability). Based on estimates of total NIS output in Myanmar, this amounts to $353,000 to $589,000 USD/year in total worker wages from macadamia (see Sections 4.2 on Output).[84] Conditional on the reliability of these figures, macadamia production may currently generate between 86,000 and 145,000 worker-days per year, or the equivalent of 300-500 full-time, year-round jobs in the agricultural sector. These figures are far from extraordinary relative to more common agricultural products, however macadamia production is also growing quickly. If nothing else, these figures offer a baseline for more reliable future measurements of job and wage growth for workers in Myanmar's macadamia industry.

8.1.3 Occupational Safety and Health – Few significant risks associated with work were reported by actors within the macadamia value chain. Most focus of this study was placed on the experience of workers during cultivation, which probably make up the majority of labor in the value chain. At present, pesticide use is virtually nonexistent, and the use of chemical fertilizers is rare as well, limiting the potential negative impacts of agrochemical use. Labor activities on macadamia orchards are generally considered safe by growers, and harvest does not require climbing of trees as is sometimes the case with other tree crops in Myanmar. Provided a suitable work environment and proper equipment, the main post-harvest activities of de-husking and drying are considered by growers to be relatively safe for workers as well. There are also potential occupational safety hazards related to processing—for instance with respect to operating machinery (e.g. cracking and drying machinery)—however this will vary by processor.

8.1.4 Child Labor – Child labor is present in agricultural activity throughout Myanmar, therefore it is possible that child labor is used by some actors in the macadamia value chain. There were no reports from growers or other value chain actors of activities or functions reserved for children. However, individual businesses and smallholder growers in particular may use child labor. As such, any interventions must be careful to consider the potential impacts on child labor.

8.2 Gender

8.2.1 Gender Roles – Both women and men have important roles in the macadamia value chain, some of which overlap and some of which are distinct. For starters, some labor categories are skewed more heavily toward men. For instance, brokers and traders of agricultural commodities in Myanmar are generally (although not always) men.[85] Among the five processors interviewed for this study, four owners were men and one was a woman. Currently, women are most involved in the macadamia value chain as laborers employed by growers and processors. Although gender roles could be somewhat more fluid for smallholders, large growers describe fairly distinct roles

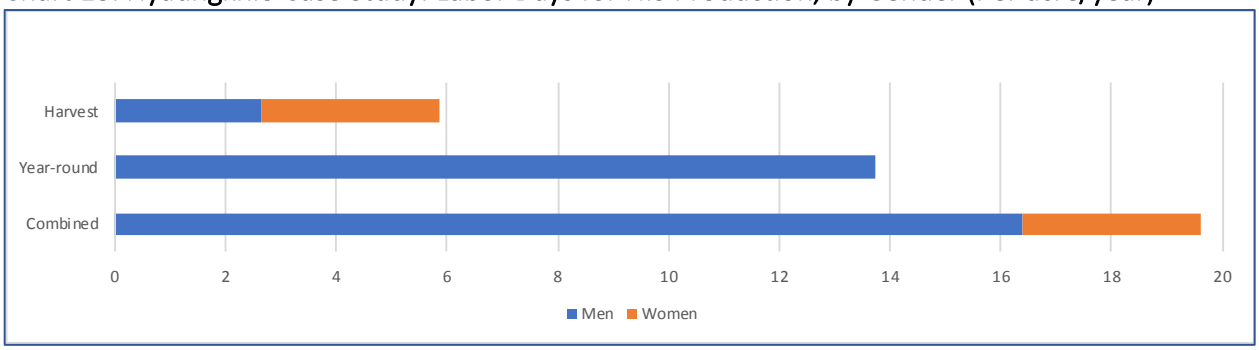
[84] As much as 90% of macadamia output is estimated to be bound for export to China.

[85] Trading houses which provide storage and brokerage of agricultural products—such as those in Aungban—are often operated by women, but none are known to be active in the macadamia value chain.

for men and women during cultivation and harvest (see Table 17). Women are often largely responsible for collecting macadamia nuts during harvest as well as management of the indoor drying process. Men are often largely responsible for fieldwork, including fertilizer distribution, weeding, pruning and picking nuts from trees (if this is done). De-husking is performed both by men and women when it is done manually with a hammer, however when it is automated with machines it is typically performed by men. As such it is possible that additional automation could further erode the role of women within the macadamia value chain.

8.2.2 Job-Creation Differentials – Based on the Nyaungkhio case study, macadamia production generates far more work for men than for women, due largely to year-round land preparation. Based on the above division of labor and the labor requirements outlined earlier, men supply roughly 84% of labor hours and women supply 16% of labor-hours during cultivation and harvest (see Table 17). Labor required during three months of harvest are roughly evenly divided between men and women, with women contributing 53%. However, this is more than offset by year-round land preparation which is performed entirely by men. Additional processing—to produce either kernel or oil—is likely to further skew workload toward men, as machinery operation is typically their jurisdiction. However, the gender dimension would likely look very different if macadamia growers were more productive. Higher yields—because they are tied largely to variety selection—would mean far more harvest and post-harvest activity (relative to fieldwork) and therefore greatly increase the involvement of women.

Chart 13. Nyaungkhio Case Study: Labor Days for NIS Production, by Gender (Per acre/year)



8.2.3 Earnings Differentials – As with much work in Myanmar's agricultural sector (not just macadamia production) women are typically paid less than men. Macadamia growers report paying women 5000-5500 MMK/day and paying men 6000 MMK/day for on-farm labor. The rationale for this difference as provided by growers is that women's labor is less "physical" or "laborious." This pay differential of 500-1000 MMK/day amounts to paying women 10-20% less than men. This would further skew toward men the financial benefits accrued to labor suggested by the Nyaungkhio case study above. Whereas women account for 16% of labor hours in that case study, they would account for just 14% of wages from labor. As stated above, this gender division would look significantly different were Myanmar growers seeing higher yields and therefore requiring more harvest and post-harvest labor.

8.3 Environment

8.3.1 In general, the negative environmental impacts of macadamia production generally relate to water management, chemical use, carbon emissions and soil impact. At present, the negative environmental impacts of macadamia cultivation appear to be few relative to many other agricultural products in Myanmar. Several of the above concerns—such as agrochemical use (pesticides and fertilizers) and soil erosion from unsustainable irrigation practices—do not pertain to Myanmar macadamia production in its current form (see Section 3.1 on Input Requirements). Perhaps the greatest immediate environmental risk from Myanmar's macadamia production is the husk and shell byproduct left by growers. As discussed above, it is not uncommon for husk and shell to be disposed of through burning (see Section 2.3 on Byproducts). In order for the industry to achieve sustainably at scale, better disposal methods for these byproducts is needed.

Byproducts and other environmental impacts are likely to grow along with the macadamia industry in coming years. In particular, the use of irrigation will certainly increase with industry growth, and solutions to unidentified pests and poor yields could lead to greater adoption of agrochemical products. Therefore, while macadamia is currently a relatively low-impact agricultural commodity in Myanmar, the environmental footprint from discarded husk and shell could change substantially in the next five years.

Macadamia production in Myanmar may also present opportunities for carbon sequestration as growth leads to the planting of new trees. A 2019 study suggests that macadamia trees may fix up to 3.35 tons of carbon per hectare per year (or 100 kg/tree).[86] If planting is carried out in conjunction with a system of carbon offset certificates, this may also have the potential to provide additional income opportunities for growers planting new macadamia trees. However, no such efforts were encountered during this study.

8.4 Conflict

8.4.1 The major macadamia production areas in Myanmar are not currently threatened by active conflict, however the impact of conflict on all macadamia production areas is not well understood. Neither of the Myanmar's largest macadamia producing areas—Pyin Oo Lwin and Nyaungkhio Townships—have ongoing armed conflict issues at present. Among the other macadamia-producing townships in Shan State (Yet Sauk, Pinlaung, Hoppone, Indaung, Nam Seng, Pindaya), Mandalay (Mogoke) and Magway (Minbu), there is some history of armed conflict but no immediate conflict at the time of writing. However, without better understanding all macadamia production regions it is difficult to know for sure if or how macadamia production is intertwined with conflict in Myanmar. Furthermore, without knowing exactly where production is taking place

[86] Timilsina, A.P. et al. 2019. Estimation of Carbon Sequestration of Macadamia Nut in Kaski District, Nepal.

in Chin State, Kayah State and Rakhine State, it is also impossible to know for sure whether there are conflict-related issues there as well.[87]

Macadamia trade routes in Myanmar must also be considered from a conflict perspective, since 90% of macadamia is believed to ship northward through Shan State and onward to China. There are some risks posed to macadamia traders, who ply the road from Pyin Oo Lwin up to the the Muse border crossing, by way of cities like Hsipaw and Lashio. While this is one of the most highly-trafficked trade routes in Myanmar, various locations along the route have been impacted periodically by armed conflict in recent years. For example, reports of unrest near Muse and Hsipaw are not unheard of and such events—while not necessarily immediately adjacent to the transportation corridor itself– can inevitably disrupt trade and endanger individuals.

The conflict-related dimensions of macadamia production in Myanmar could change as macadamia production expands into new areas of Kachin State or northern and eastern Shan State. Because Chinese demand for macadamia currently outstrips supply in Myanmar, and growth is premised on planting new and better tree varieties, there is a high likelihood of expansion of production into new regions of Shan State and Myanmar generally. Such expansion may present new concerns related to ongoing armed conflict in Myanmar.

8.5 Land Rights

8.5.1 Land Rights - Land rights issues are a legitimate concern in areas where macadamia is currently grown, and these issues could grow if/when production expands to new areas of Myanmar. As discussed previously, unresolved land disputes are a significant concern with respect to agricultural land in Myanmar (see Section 7.1 on Rules, Regulations and Standards). Interviews suggest that in macadamia-producing areas of northern Shan State there are issues of contested land ownership which remain unresolved. Of course, land rights issues are by no means limited to northern Shan State, and could become more of an issue as macadamia production expands into new regions. In southern Shan State, studies have already highlighted land-confiscations as a significant issue for farmers of other agricultural products in that region.[88] These same concerns apply to expansion in Kachin State, Chin State and other areas of Myanmar. As such, any interventions must be careful not to support activities that might legitimize past or future land confiscations.

[87] It should be noted that in at least one instance in Nyaungkhio, there are cases of contested land ownership related to land on which macadamia is currently cultivated. It was also suggested by one interviewee that the unusually high reports of theft of NIS in this area are related to such land disputes, although this could not be confirmed.
[88] Burke, A. 2015. What Holds Vegetable Farmers Back? Conflicts, Governance and Market Assessment.

SECTION NINE: Value Chain Upgrading Opportunities

This section briefly summarizes potential "upgrading opportunities" to help develop a macadamia value chain in Myanmar that benefits MSMEs by improving the product quality and output within the macadamia value chain. This section first summarizes six categories of upgrading opportunities before exploring specific action points within each of these.

9.1 Summary of Main Upgrading Opportunities

9.1.1 Improved Inputs – Improving NIS yield and quality in Myanmar requires better inputs. This includes R&D to plan growing locations and varieties, technical support for grafting, and financial and technical support for expanding nurseries and improving access to irrigation.

9.1.2 Improved Cultivation and Post-Harvest Practices – Improving NIS yield and quality in Myanmar requires improved cultivation practices. This includes R&D to plan growing locations and varieties, technical support for grafting, and financial and technical support for expanding nurseries and improving access to equipment and irrigation.

9.1.3 Improved Kernel and Oil Processing – Producing high-value, export-quality macadamia kernel and oil requires additional technical expertise and processing inputs. In particular, processors require familiarity with product standards and specifications for high-value macadamia products as well as access to imported cracking and oil-making machinery.

9.1.4 Better Value Chain Coordination – Product quality may be improved if better coordination within the macadamia value chain (particularly NIS) leads to spillover of information and expertise. This includes coordination among Myanmar growers, coordination between growers and Chinese importers, and coordination between processors and other foreign importers in markets such as the U.S., Japan, Korea and EU.

9.1.5 More Business and Financial Services – Growing viable MSMEs in the macadamia value chain requires improved business services and financial support. This includes financing for needed investments in inputs and machinery, as well as improved record-keeping and business strategy.

9.1.6 Better Marketing and Market Linkages – Marketing higher-value goods like macadamia kernel and oil requires accessing foreign and domestic markets. This includes establishing market linkages with foreign importers as well as actively promoting the consumer benefits and uses of macadamia in order to grow the domestic market in Myanmar.

9.2 Detailed Value Chain Improvements

9.2.1 Improved Inputs.

- R&D: Cultivation areas – Myanmar's current macadamia output is far less than 1% of global supply, yet output potential remains unknown because of lack of data on suitable agro-ecological zones. Further research is needed to identify geographic regions (and therefore potential grower populations) in which macadamia cultivation is most suitable. The optimal places to begin this research include Shan, Kachin and Chin States.
- R&D: Macadamia varieties – Planting location-appropriate macadamia varieties is essential to achieving profitable yields, however the best varieties for Myanmar remain unknown. Several promising varieties have been trialed in recent years, and the results of these trials should become known in the next three to five years. The results of varietal trials must be recorded, assessed and distributed to growers and nurseries to ensure propagation of superior varieties.
- Technical Support: Grafting – Grafting is essential to improving macadamia yields, yet this process is virtually nonexistent in Myanmar. Growers and nurseries require technical support to understand best practices for grafting and its impact on profitability.
- Technical Support: Improved pollination – Improving pollination either through the use of pollination services or keeping honey bee hives on the orchard can improve yields. Growers and/or imput providers require technical support to establish and maintain honey bee hives for this purpose.
- Financial and Technical Support: Expansion of nurseries – Widespread adoption of improved planting material requires strong institutions for sourcing and distributing grafted seedlings, yet macadamia nurseries in Myanmar are rare, small and inexperienced. Technical, financial and operational support for nursery expansion is needed to ensure growers can access suitable inputs for achieving better yields and quality.
- Financial Support: Improved irrigation systems – Irrigation is important to ensure optimal yield, size and quality of macadamia, yet irrigation is rarely available to growers in Myanmar. Delivering irrigation is location-dependent and will require significant investment if Myanmar yields are to reach their full potential. Investments should be focused in production regions receiving less than 1200 mm/year in rainfall.

9.2.2 Improved Cultivation and Post-Harvest Practices.

- Technical Support: Optimized cultivation practices – Macadamia can be cultivated with relatively little care, but most smallholders and many large growers fall well short of employing best practices that could improve yield and quality. This includes proper spacing, pruning, pollination, fertilization, harvest and more. Smallholders in particular require training and Myanmar-language versions of existing resources outlining best practices.
- Technical and Operational Support: Optimized post-harvest practices – Proper de-husking and drying is the critical step in producing quality NIS, and yet Myanmar growers adopt a variety of approaches that fall short of established best-practices. This results in poor-

quality and low-value NIS. Growers require training and access to local-language versions of existing resources outlining proper drying methods and periods.

- Operational Support: Machinery rental – Most smallholders de-husk with manual labor, yet this can be costly and lead to delays that reduce product quality. To ensure proper de-husking after harvest, smallholders will benefit from access to excess local capacity of automated de-husking equipment.

9.2.3 Improved Kernel and Oil Processing.

- Technical Support: Kernel and oil-making standards and processes – Macadamia kernel and oil are high-value products with rigorous international product specifications, yet even large Myanmar processors are often unaware of these specifications let alone familiar with the technical requirements needed to achieve them. Processors require training and access to local-language versions of existing resources outlining product specifications and standard equipment.
- Financial Support: Improved processing equipment – Kernel integrity is essential to producing high-value macadamia products that are competitive on international markets, yet Myanmar processors use inferior cracking and oil-making equipment. Cracking machinery manufactured in Mandalay results in a high proportion of damaged kernels, and peanut oil machinery may be ill-suited for macadamia. Processors who seek to export macadamia kernel or oil require access to imported cracking and oil-making machinery which reduces kernel damage and produces export-quality oil.

9.2.4 Better Coordination in Value Chain.

- Operational Support: Strengthened institutions for coordination among growers – Increasing overall product quality and output will require information-sharing among Myanmar nurseries, growers and processors and a strategic plan for the industry, yet few platforms exist to achieve this (bulk-buying may also be explored). The nascent macadamia association, regional clusters, and interested government offices (e.g. DOA) may serve as platforms for sharing best practices and facilitating sales, provided suitable growth in engagement and capacity. Such efforts would require technical support, funding and outreach to value chain actors.
- Technical and Operational Support: Market standards familiarization – Existing research clearly defines optimal target moisture content for NIS (approx. 3.5%), yet Myanmar growers and traders exchange NIS at varying levels of dryness, leading to inconsistent product quality. Fixing product standards can formalize value capture and enable better business planning, but this requires awareness on the part of both growers and traders. Growers and traders alike require training and access to local-language versions of existing resources outlining product standards.
- Operational Support: Improved grower-trader coordination – Marketing quality NIS to Chinese buyers requires efficient planning and coordination to supply NIS at optimal dryness, yet relationships between Myanmar growers and Chinese buyers are typically

informal and weak. Growers require reliable channels of communication with Chinese buyers to ensure product quality.

9.2.5 More Business and Financial Services.

- Technical and Operational Support: More business / training services – Improving yield and quality of Myanmar's macadamia products requires more widespread provision of technical and administrative expertise to growers and processors, yet there are few market actors currently offering this. The required expertise includes technical aspects of cultivation and post-harvest activities as well as administration like accounting (i.e. proper records and book-keeping) and business planning and strategy.
- Financial Support: More financial services – Increasing and improving Myanmar's macadamia output requires significant investment, yet most growers and smallholders in particular lack access to affordable financing to expand production (e.g. savings and credit groups). Smallholders require capital to invest in proper planting material and post-harvest activities, while processors require capital to invest in proper machinery.

9.2.6 Better Marketing and Market Linkages.

- Operational Support: Increased export market linkages – In order to meet export standards for macadamia kernel Myanmar processors must coordinate with foreign buyers, but few Myanmar processors have established such relationships. Myanmar kernel processors require business-matching and field-visits with kernel importers in the U.S., Japan, Korea and EU in order to develop a strategy to access these markets.
- Technical Support: Improved marketing to domestic consumers – In order to grow domestic consumption of processed goods like macadamia kernel and oil (serving as a stepping stone to producing export-quality products), the macadamia industry will benefit from a concerted marketing strategy aimed at publicizing the benefits to Myanmar consumers and increasing domestic macadamia consumption.

ANNEX

Annex A. Example Industry Resources

Image A-1. Examples of Various Chemical / Microbiological Standards for Macadamia Kernel

	Australian Macadamia Society (AMS) [1]	Southern African Macadamia Growers' Association (SAMAC) [2]	Brazilian Macadamia Association (ABM)
Chemical			
Moisture	Not to exceed 1.8%	Maximum 2%	1.5% ± 0.3%
Free fatty acids	≤ 0.5%	≤ 0.5%	≤ 1.0%
Peroxide value	≤ 2 meq/kg (2 years shelf life); 2< X <3 meq/kg (1 year shelf life)	≤ 3 meq/kg	≤ 3 meq/kg or ≤ 5 meq/kg (some markets)
Microbiological			
Total plate count	< 30,000 cfu/g	< 20,000 cfu/g	< 30,000 cfu/g
Yeast and mold	< 20,000 cfu/g	< 20,000 cfu/g	< 20,000 cfu/g
Coliforms		< 300 cfu/g	< 350 cfu/g
E. coli	< 3/g (AS 5013.15 - 2006 test method)	Not detected (BS 5763 method)	< 3 cfu/g
Salmonella	Not detected /250 g (AS 5013.10 - 2009 test method)	Not detected in 25 g (ISO 6579 or BAM method)	Negative in 250 g

Source: Australia Macadamia Society.

Image A-2. Examples of Various "Styles" of Macadamia Kernel

Style II

Description	Size
Wholes and halves: shall consist of at least 50% whole kernels, with the remaining percentage consisting of pieces	of which no more than 2% will pass through a 7.8 mm (5/16 inch) square opening.

Style III

Description	Size
Cocktail: shall consist of at least 90% half or larger kernels, included therein at least 15% whole kernels, with the remaining percentage consisting of pieces	of which no more than 2% will pass through a 6.25 mm (¼ inch) opening.

Style IV

Description	Size
Halves and pieces: shall consist of at least 50% half kernels, with the remaining percentage consisting of pieces with no more than 5% larger than half kernels	**Style IV L**: kernel size is larger than 16 mm (round caliber). **Style IV M**: kernel size is between 14-16 mm (round caliber). **Style IV S**: kernel size is between 10-14 mm (round caliber).

Style V

Description	Size
Large diced: shall consist of units which are smaller than half kernels	of such size that no more than 5% will pass through a 7.8 mm x 25 mm (5/16 inch x 1 inch) opening, included therein not more than 2% that will pass through a 2.34 mm (3/32 inch) square opening.

Style VI

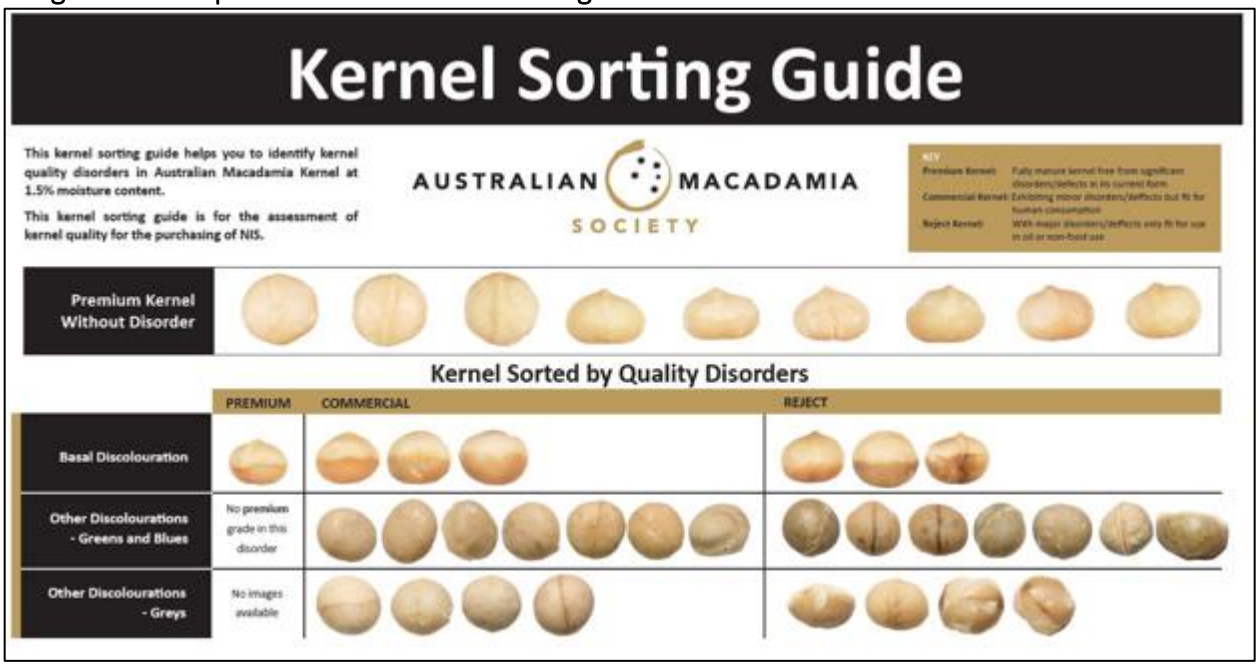
Description	Size
Chips: shall consist of units	that at least 95% will pass through a 7.8 mm x 25 mm (5/16 inch x 1 inch) opening but no more than 2% will pass through a 2.34 mm (3/32 inch) square opening.

Style VII

Description	Size
Bits and diced: shall consist of units	smaller than half kernels and of such size that at least 95% will pass through a 7.8 mm (5/16 inch) square opening but no more than 10% will pass through a 2.34 mm (3/32 inch) square opening.

Source: Australia Macadamia Society.

Image A-3. Example Macadamia Kernel Sorting Guide



Source: Australia Macadamia Society.

Image A-4. Annual Macadamia Consumption, Various Countries

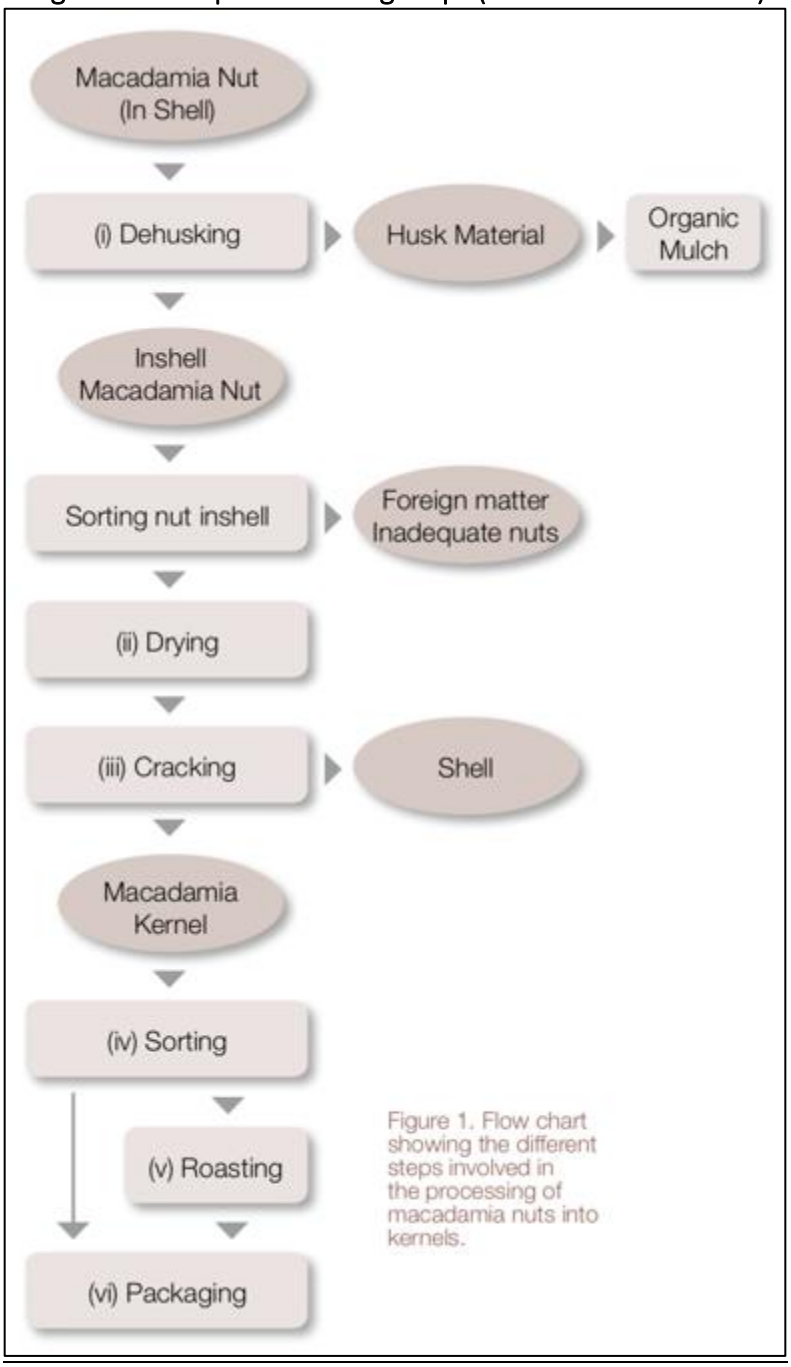
WORLD MACADAMIA ESTIMATED CONSUMPTION (Kernel Basis)

COUNTRY	2013			2014			2015			2016			2017		
	Consumption (MT)	Cons. per capita (kg/year)[1]	Estimated Cons. per capita (kg/year)[2]	Consumption (MT)	Cons. per capita (kg/year)[1]	Estimated Cons. per capita (kg/year)[2]	Consumption (MT)	Cons. per capita (kg/year)[1]	Estimated Cons. per capita (kg/year)[2]	Consumption (MT)	Cons. per capita (kg/year)[1]	Estimated Cons. per capita (kg/year)[2]	Consumption (MT)	Cons. per capita (kg/year)[1]	Estimated Cons. per capita (kg/year)[2]
USA	9,370	0.030	0.121	10,269	0.033	0.133	9,907	0.031	0.123	8,829	0.027	0.110	11,319	0.035	0.140
China	3,333	0.002	0.025	2,401	0.002	0.018	1,619	0.001	0.012	4,055	0.003	0.028	4,131	0.003	0.029
Australia	3,328	0.149	0.298	3,157	0.136	0.272	3,255	0.136	0.272	3,374	0.140	0.280	3,250	0.133	0.266
Japan	2,001	0.016	0.047	1,976	0.016	0.047	2,250	0.018	0.054	3,233	0.025	0.077	3,116	0.024	0.074
Germany	1,206	0.015	0.074	1,222	0.015	0.075	1,869	0.023	0.116	2,011	0.025	0.123	1,219	0.015	0.074
Canada	960	0.028	0.056	2,130	0.060	0.121	991	0.028	0.055	1,001	0.028	0.055	1,066	0.029	0.058
Brazil	1,064	0.006	0.055	1,054	0.005	0.052	1,328	0.006	0.064	1,431	0.007	0.069	797	0.004	0.038
Korea Rep	196	0.004	0.040	306	0.006	0.061	504	0.010	0.100	667	0.013	0.131	663	0.013	0.130
Spain	236	0.005	0.017	358	0.008	0.025	284	0.006	0.021	613	0.013	0.044	519	0.011	0.037
UK	294	0.005	0.024	472	0.007	0.037	639	0.010	0.049	436	0.007	0.033	504	0.008	0.038
France	112	0.002	0.007	173	0.003	0.010	205	0.003	0.013	157	0.002	0.010	285	0.004	0.018
Malaysia	123	0.004	0.017	138	0.005	0.018	185	0.006	0.024	225	0.007	0.029	267	0.008	0.034
Thailand	25	0.000	0.004	27	0.000	0.004	77	0.001	0.011	209	0.003	0.030	255	0.004	0.037
Switzerland	131	0.017	0.022	121	0.015	0.020	142	0.017	0.023	213	0.025	0.034	241	0.029	0.038
Italy	211	0.003	0.014	146	0.002	0.010	244	0.004	0.016	198	0.003	0.013	162	0.003	0.011
Poland	86	0.002	0.011	223	0.006	0.029	74	0.002	0.010	140	0.004	0.018	123	0.003	0.016
Saudi Arabia	66	0.002	0.024	106	0.004	0.036	80	0.003	0.025	139	0.004	0.043	121	0.004	0.037
Singapore	123	0.024	0.097	341	0.062	0.248	206	0.037	0.147	170	0.030	0.121	110	0.019	0.077
Norway	101	0.021	0.103	121	0.024	0.119	87	0.017	0.083	94	0.018	0.089	89	0.017	0.084
Israel	110	0.014	0.096	29	0.004	0.024	110	0.014	0.091	127	0.016	0.104	74	0.009	0.059
WORLD TOTAL	**37,092**	**0.005**		**46,617**	**0.006**		**47,306**	**0.006**		**50,360**	**0.007**		**49,697**	**0.007**	

[1] Total consumption expressed in Kg per person. Population data from United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision.
[2] Based on the estimated percentage of population consuming the specific product.

Source: Australia Macadamia Society.

Image A-5. Example Processing Steps (Advanced Production)



Source: Australia Macadamia Society.