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PALM OIL INDUSTRY IN SRI LANKA:
AN ECONOMIC ANALYSIS

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MAY 2023

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Acronyms

AER	Agro-ecological Region
CDA	Coconut Development Authority
CEA	Central Environment Authority
CRI	Coconut Research Institute
CVD	Cardiovascular Disease
FFB	Freesh Fruit Bunches
GHG	Greenhouse Gas
MUFA	Monounsaturated Fatty Acid
PKO	Palm Kernel Oil
POIA	Palm Oil Industry Association
POME	Palm Oil Mill Effluent
PUFA	Polyunsaturated Fatty Acid
RBD	Refining, Bleaching and Deodorisation
RPCs	Regional Plantation Companies
RSPO	Roundtable on Sustainable Palm Oil
SFA	Saturated Fatty Acid

Executive Summary

Palm oil is the main edible oil source consumed in the world. Sri Lanka began importing palm oil a few decades back mainly due to the increasing local demand driven by population and income growth, changes in food habits and developments in food and related industries. Considering the rising demand for imported palm oil and the potential suitability of climatic and soil factors in the country, oil palm was allowed to be cultivated on 20,000 hectares (ha) as part of a strategy to promote import substitution. Hence, regional plantation companies (RPCs) were permitted to cultivate oil palm in marginal rubber lands in selected districts. However, oil palm cultivation and consumption are globally criticised for its environmental and health impacts regardless of rewarding factors such as low cost and versatility in food and many other industries. Sri Lanka also paid attention to possible environmental hazards and health impacts of consuming palm oil as well as resistance from local environmental activists. As a result, oil palm cultivation was banned and a phase out within 10 years was proposed as a policy decision. Subsequently, the country took measures to restrict the importation of palm oil, considering its health hazards. Yet, alternatives to satisfy the local demand are limited. Hence, the decision was revised to keep the market open under licences. However, the industry investors claim that the criticism is unreasonable. Therefore, this study explores the economic aspects of the industry, such as costs and returns, contribution to the economy, tariff protection, market linkages etc., including potential environmental and social issues in the palm oil industry value chain in Sri Lanka.

The study uses the value chain analysis approach, which employs a mixed method comprising key informant surveys, email surveys and desk reviews to gather data. The findings reveal that the industry currently saves a foreign exchange outflow of United States Dollars (USD) 17 million (Mn) annually and caters to around 6% of the domestic edible oil demand. In addition, the generation of 33,390 employment opportunities and capital investments of Sri Lankan Rupees (LKR) 23 billion (Bn) are visible in the industry. It includes establishing two palm oil mills and two refineries for local plantations. The current land extent is nearly 10,330 ha, managed by eight RPCs. Considering the land and climatic suitability, oil palm is cultivated in the country's wet zone low country regions. Rainfall and the dry spell length are the major determinants of crop productivity, locally and globally.

The study finds that the productivity of oil palm estates is comparatively low (2.5 Mt/ha) to the best productivity levels observed globally (3.6 metric tonnes (Mt)/ha). However, the industry earns profits at the current market prices of imported palm oil and local coconut oil. The average profit margin from selling fresh fruit bunches (FFB) is nearly 59%. The profitability of local palm oil mainly depends on the world market price of palm oil, import tax level, exchange rate and land productivity, the latter of which varies over estates. Currently, the total tax is around 59% of the cost, insurance and freight (CIF) price, and the tax rate is highly volatile depending on the seasonality of coconut production. Maintaining a low tariff protection for palm oil would incentivise land productivity improvements and a shift away from unproductive lands. It would benefit both the economy and the environment. The coconut oil industry needs to adopt modern technologies for coconut oil production and for further value addition, such as lauric acid to reach the export market, maintain a favourable farmgate price for coconut growers and offer safe coconut oil to consumers. Due to the inherent properties and industrial demand, local coconut oil is not a perfect substitute for palm oil and its derivatives. The coconut production capacity is inadequate to meet the total oil demand with priorities given to

coconut export processing industries and local culinary consumption needs. The local edible oil supply meets approximately 26% of the demand and the per capita consumption is gradually rising locally and globally. Therefore, meeting the oils and fat demand in Sri Lanka will be challenging under the prevailing economic conditions, particularly amid the current foreign exchange constraints.

Environmental issues are common to any agricultural land use and are also observed in oil palm cultivation. However, this is of potential with varying degrees, mainly owing to its inherent high input consumption due to high oil productivity. Specific criticisms in the existing literature were groundwater depletion, water quality depletion, regeneration, siltation, floods and landslides, potentially influencing the surrounding community and the environment. Few studies in other countries supported these criticisms, while a few remain inconclusive. Therefore, further investigations and close monitoring of the above criticisms in the local context are essential to decide whether to remove the plantations or to internalise the environmental cost to mitigate the negative externalities. Hence, identifying the feasibility of adopting sustainable management practices to overcome such negative externalities is vital. If implemented, periodic monitoring is crucial, and an import Cess or a domestic levy could finance the cost.

The environment-economic trade-off is inevitable in sustaining the needs of the people. However, sustainable management to minimise environmental costs is crucial to protect the natural balance. Therefore, the decision making process should be backed by an unbiased proper technical analysis conducted by relevant experts. Techniques such as scientific land use planning and spatial analysis are recommended for selecting/revisiting suitable areas for oil palm cultivation. Further, it is observed that no policy provision is available for smallholder cultivation of oil palm. Thus, monitoring scattered smallholdings for the perceived environmental issues would not be feasible.

The health impacts of palm oil consumption literature remain mixed. This might be due to the context-specific nature of studies, and competition and lobbying power in the global edible oil market. However, local edible oil consumption (including both coconut oil and palm oil) has been criticised over serious health concerns owing to a lack of enforcement and monitoring for proper processing and storage. Additionally, to avoid adulteration with repeatedly used oils, stringent quality checks at importation and local edible oil production are mandatory. Therefore, these issues should be intially addressed to overcome the health hazards of edible oil consumption.

1. Introduction

Palm oil is the largest produced vegetable oil (71.5 Mt in 2018), with a market share of nearly 36% globally (FAO, 2021a). It is extracted from the fruit (mesocarp) of the "oil palm", botanically known as Elaeis guineensis. Oil palm is grown in tropical countries within 10 degrees of the equator and has the highest land productivity among other oil crops worldwide. The leading producers, Indonesia (57%) and Malaysia (27%) account for around 84% of global palm oil production (FAO, 2021a). The world market share of palm oil in the vegetable oil market has been growing gradually since 1975. Global vegetable oil production doubled during 2000-2018, while the world market share of palm oil grew from 24% to 36%. Due to palm oil's unique characteristics and its derivatives, its popularity has grown over several applications. For example, approximately 90% of the production goes for food processing such as baking, frying, cooking and confectionaries, particularly in chocolate manufacturing as a substitute for cocoa butter (Ogan, Marie-Josée, & Ngadi, 2015). The rest goes for non-food applications such as soap, toothpaste, detergents, cosmetics, waxes, lubricants, biofuel and oleochemical manufacturing (Edem, 2002). However, global environmental concerns are arising about clearing tropical rainforests for oil palm cultivation and its consequences on biodiversity, environment degradation and global warming. Moreover, health concerns of palm oil consumption over other vegetable oils are also mounting.

Sri Lanka began oil palm ("katu pol") cultivation in 1967 at Nakiyadeniya Estate located in Galle District. Records reveal about 9,000 hectares (ha) of oil palm lands by 2015. Meantime, Sri Lanka began palm oil and other vegetable oil imports in the early 1990s to meet the rising local demand from both domestic and industrial use. Hence, in 2015, the Ministry of Plantation Industries (MPI) initiated the expansion of oil palm cultivation up to 20,000 ha as an import substitution strategy. The aim was to locally supply 50% of the existing palm oil demand at the time. Regional plantation companies (RPCs) were advised to use abandoned and unproductive rubber lands in five districts, namely Kegalle, Ratnapura, Kalutara, Galle, and Matara, where favourable climatic conditions exist for oil palm (CEA, 2018). Under this policy initiative, the RPCs reached over 10,000 ha of new oil palm cultivation and related investments by 2021.

Then, the government decided to ban oil palm cultivation in the country, issuing an extraordinary gazette on 5 April 2021. The decision was based on the long-term environmental cost of cultivating oil palm owing to "soil erosion, drying of springs thus, affecting biodiversity and life of the community" (Presidential Secretariat, 2021). The policy further directs to systematically remove the existing plantations and nurseries at an annual rate of 10% and to replace these with rubber or any other cultivation favourable for water resources. Meantime, parallel to the global context, misapprehensions prevail among local consumers regarding the adverse health impacts of palm oil, which is a cheap substitute for domestically available coconut oil and an ingredient in processed food. Therefore, considering the potential health hazards of consuming crude palm oil (Presidential Secretariat, 2021), the government temporarily suspended palm oil imports in 2021 (Imports and Exports Control Department, 2021). Later, the import ban was revised with an import license scheme (Imports and Exports (Control) Regulations No. 04 of 2021) to meet the demand from several industry sectors (Government of Sri Lanka, 2021).

However, the decision to ban oil palm cultivation remains and the investors claim that the decision is irrational considering the benefits to the domestic economy, losses on their investment, and unreasonable conclusions on the environmental cost. Hence, the overall objective of this study is to revisit the reasons for the ban on oil palm cultivation and arguments against the ban, thereby focusing on the economic, environmental, health and social factors.

The study aims to achieve the below objectives to fulfil the overall objective.

1. To map the value chain actors, functions, and the enabling environment and to assess the economic significance of the palm oil industry in Sri Lanka

2. To revisit the possible environmental and social impacts of oil palm cultivation

3. To explore the possible human health issues of palm oil consumption

4. To make necessary recommendations for policy interventions

The rest of the study describes the data and methods used (Section 2), trends in the global vegetable oil market (Section 3), global environmental concerns of oil palm (Section 4), palm oil and human health (Section 5), palm oil industry value chain (Section 6) environmental sustainability (Section 7), socioeconomic aspects of oil palm (Section 8), and conclusions and recommendations (Section 9).

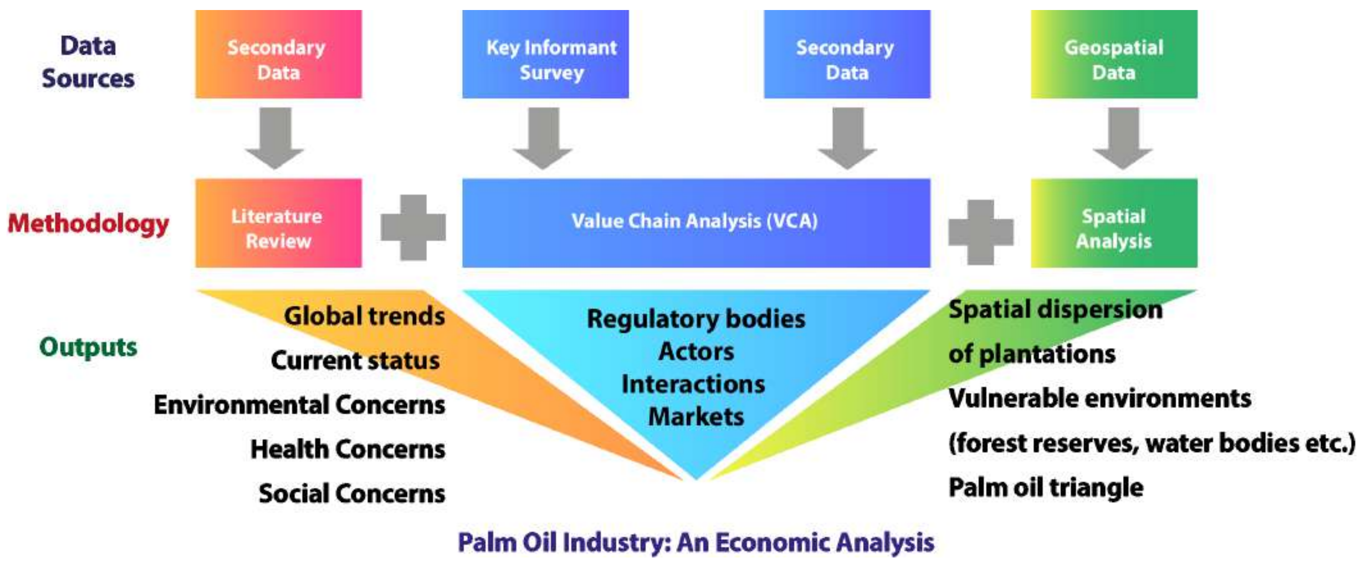
2. Data and Methodology

This study mainly employs a qualitative methodology. Given the inadequate and unsatisfactory empirical evidence of previous studies concerning the domestic palm oil sector, an in-depth analysis was necessary. Hence, the research methodology comprises a comprehensive literature review and value chain analysis (VCA) covering numerous palm oil stakeholders. After conducting an extensive literature review, the research team developed the methodology. The review consists of secondary data analysis to identify the current trends in the global vegetable oil market and in the country, environmental concerns of oil palm cultivation and health concerns of palm oil consumption. The VCA guided the study to understand the local context. The VCA is a broad framework with a sound theoretical foundation and scope for applying various empirical tools. It is beneficial in coherently analysing complex multi-market, multi-stakeholder value chains, organising different sets of information on production, trade flows, restriction measures, markets and consumer behaviour, and identifying targeted interventions and mitigation measures (Coulibaly, Arinloye, & Melle, 2010).

The study utilised various data collection methods and stakeholder engagement processes. Primary and secondary data were used in the study. Primary data were gathered through key informant surveys conducted with sector stakeholders like RPCs, refineries, and professionals to map the value chain. A mixed method comprising telephone surveys and email surveys was used for this purpose. Secondary data was gathered through literature, stakeholder records and official statistics. In addition, spatial data, such as geolocation, was collected when developing the maps.

The geographic location data generated the maps presented in this report. The geospatial analysis conducted using the QGIS software enabled the research team to unearth the palm oil triangle in Sri Lanka.

Figure 2.1: Conceptual Framework



Source: Authors' elaboration (2021).

A systematic literature review and secondary data sufficed to analyse the health hazards of palm oil consumption and global trends and to compare the pros and cons of coconut and oil palm cultivation.

Four aspects are to be concerned in understanding the value chain dynamics to assist in decision making: contribution to economic growth, inclusiveness, social acceptance and environmental sustainability (EU, 2018).

2.1 Value Chain Analysis

As explained previously, VCA is a strategic tool that allows researchers to systematically evaluate a particular industrial value chain to identify value chain actors, interactions, processes and activities. The value chain covers entire actions necessary to bring a product or service from conception through the various stages of production (including a mix of physical transformation and the input of various producer services), distribution to ultimate consumers, and final disposal. This simple example demonstrates that manufacturing is merely one of many value-added relationships. Moreover, each link in the chain has a variety of activities.

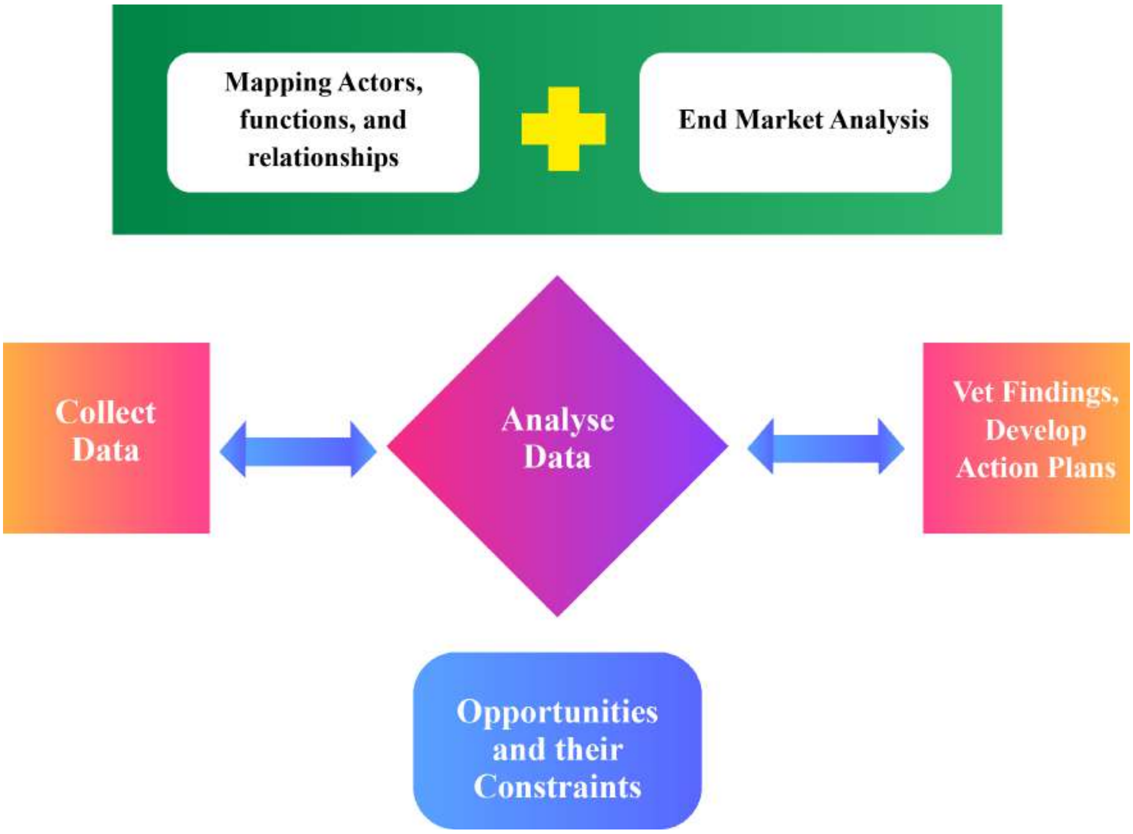
Kaplinsky and Morris (2002) describe value chains as "the full range of activities required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers and final disposal after use" (p. 4).

Two essential parts of VCA enhance comprehension of the upgrading challenge. It helps illustrate how competition is not just determined by the activities of a single company, but also by the suppliers and purchasers that eventually provide the product to the end client. As a result, it gives a taxonomy for upgrading that encompasses the activities of several interconnected businesses and areas of upgrading activity. It introduces agency and underlines the crucial role performed by leading enterprises that assume responsibility for strengthening systemic chain competitiveness.

Creating value chains has become a dependable instrument for encouraging sustainable agriculture investments. An agricultural value chain is a set of operations that add value to a final product, starting with the creation of raw materials, connecting to processing, obtaining the final product, marketing, sale to the ultimate user or customer, and concluding with waste disposal. The VCA, however, begins with the end market to decide the items they want and how the most value may be distributed along the chain as the players work to manufacture those goods.

The palm oil value chain was analysed using both qualitative and quantitative approaches. The quantitative study involved mapping the pattern of value-added distribution along the chain, measuring profitability, productivity, and production capacity, and comparing the performance of a firm, value chain, or value chain actor to that of its competitors. Figure 2.2 illustrates the standard VCA model proposed by Nang'ole, Mithöfer, & Franzel (2011).

Figure 2.2: Standard Value Chain Analysis Model



Source: Nang'ole, E., Mithöfer, D., & Franzel, S. (2011). *Review of Guidelines and Manuals for Value Chain Analysis for Agricultural and Forest Products.* Kenya: World Agroforestry Centre.

3. Global Vegetable Oil Market Trends

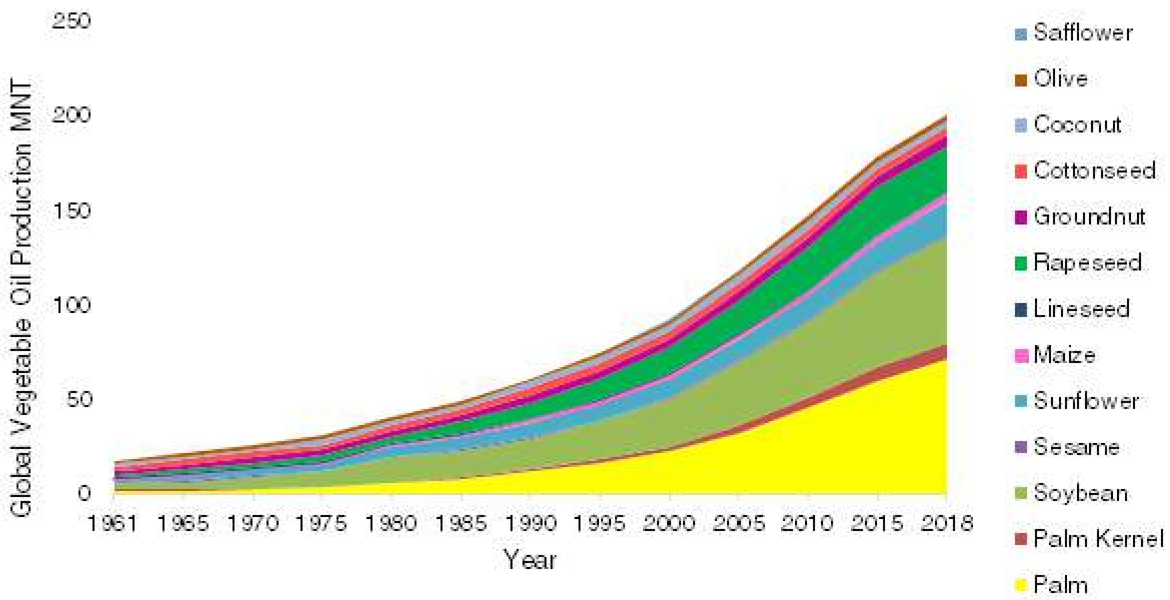
Edible oils are cooking oils of a plant, animal, or microbial origin, which are liquid at room temperature and are suitable for food use (United States Patent and Trademark Office, 2018). It plays a vital role in human nutrition, disease prevention and healing (Kumar, Sharma, & Upadhyaya, 2016). Around 75% of the global oil and fat requirement is met by edible vegetable oils (List, 2018). With the rising global population and income levels, changes in consumption patterns and multiple uses at the industry level, vegetable oil production has escalated over the past decades. Sri Lanka is a net importer of edible oils and is directly influenced by the global edible oil market behaviour.

"Sri Lanka is a net importer of edible oils and is directly influenced by the global edible oil market behaviour."

3.1 Global Production

Palm oil, soybean oil and rapeseed oil (canola) dominate the global market and volumes are surging over the last decades (Figure 3.1). Palm oil is the world's largest vegetable oil (36%) and accounted for 2.3 Mn Mts of production in 2020 (Murphy, Goggin, & Paterson, 2020). Indonesia and Malaysia are the leading producers of palm oil, accounting for 85-90% of total palm oil produced (FAO, 2021a). Nearly 82% of palm oil exports in 2019 were from these two countries (Harvard Trade Atlas, 2020; Murphy, Goggin, & Paterson, 2020).

Figure 3.1: Production of Major Vegetable Oils in the World



Source: Food and Agricultural Organization. (2021). *Food and Agricultural Organization Statistics, 2020*. Rome: Food and Agriculture Organization.

The second largest produced oil is soybean (28%). Almost 55% of the soybean oil production is supplied by Argentina, followed by the United States of America (USA) and Brazil. Hence, more than 50% of the vegetable oil is from the Southern hemisphere. As main suppliers, Canada, Germany and Russia account for around 58% of the global rapeseed oil exports (Figure 3.2).

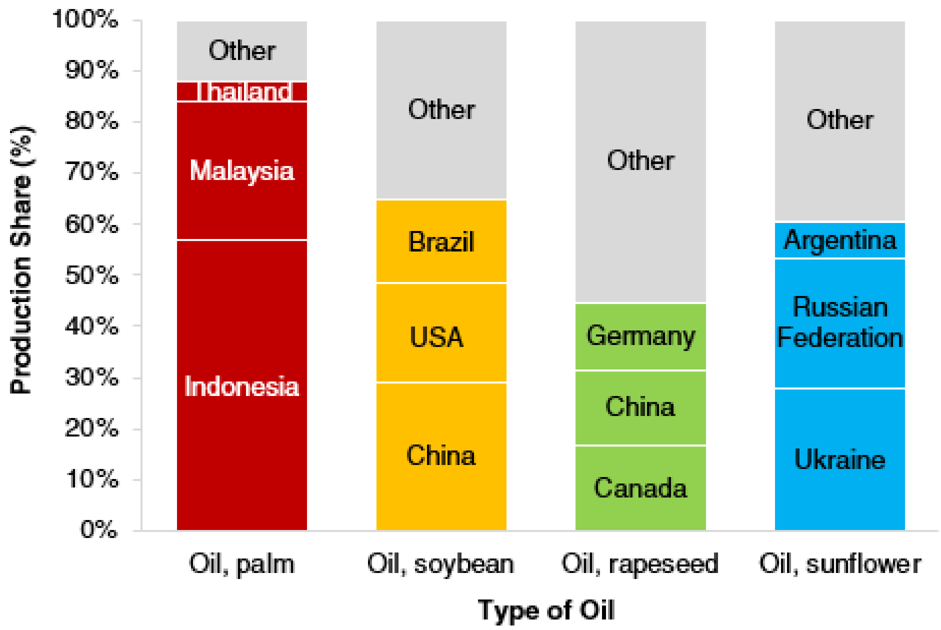
3.2 Global Consumption

Statistics reval that global consumption of each type of vegetable oil has gradually increased (209.14 Mn Mt in 2020/2021) (Food and Agricultural Organization, 2021). Equally, per capita consumption figures have been rising from 18.6 Kilogram (kg) in 2000 to 26.8 kg in 2019 (List, 2018). Nearly 75% of the production goes to food, 5% to feed and 20% to biodiesel. According to the OECD-FAO Agricultural Outlook 2019-2028 statistics,[1] per capita vegetable oil consumption is predicted to increase by 0.9% per annum. Individual consumption patterns evolve over time due to the influence of diverse social and economic factors such as income, price of foods, personal preferences, cultural differences, and environmental and geographical elements (OECD/FAO, 2019).

Nearly 40% of the production of vegetable oil is traded. China (10.25%) and India (9.43%) are the world's largest palm oil importers (Harvard Trade Atlas, 2020).

Figure 3.3 shows the behaviour of price indices for vegetable oils, seeds, and oil meals (by-product), which are ingredients in animal feed. Prices are steadily increasing after 2020.

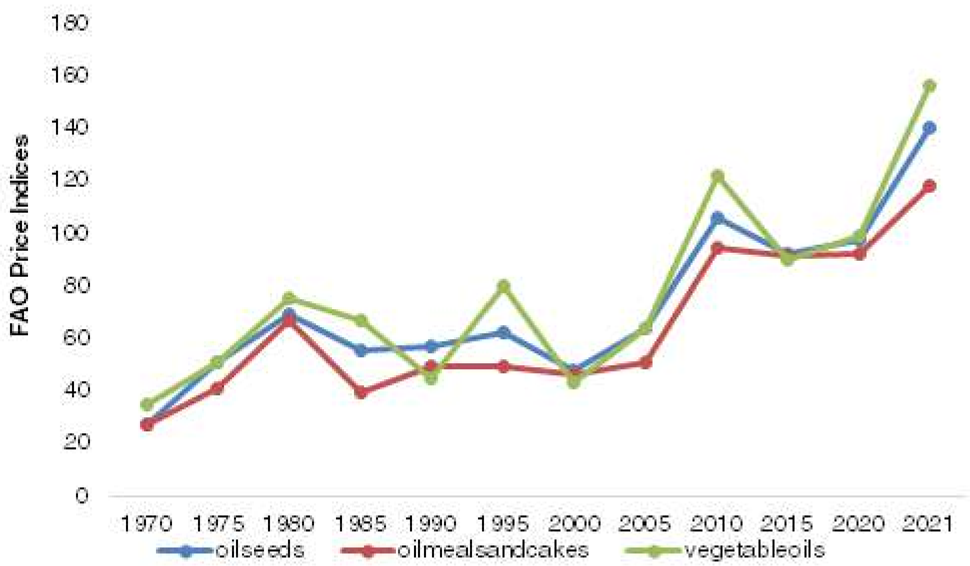
Figure 3.2: Production of Major Vegetable Oils in the World



Source: Food and Agricultural Organization. (2021). *Food and Agricultural Organization Statistics, 2020*. Rome: Food and Agriculture Organization.

[1] This report is a joint effort by the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO) of the United Nations.

Figure 3.3: International Price Indices for Oil Seeds, Vegetable Oils and Oil Meals



Source: Food and Agricultural Organization. (2021). *FAO Price Indices for Oilseeds, Vegetable Oils and Oil Meals.* Rome: Food and Agricultural Organization.

3.3 Future Projections

According to the Organisation for Economic Co-operation and Development (OECD), the consumption of vegetable oils was expected to increase at a lower rate compared to the 2010-2019 period. The demand for bio-diesel production will increase at a lower rate. Urbanisation in developing countries will raise the demand for processed food with high vegetable oil content. India's per capita consumption will grow up to 14 kg by end 2025. The development of new hotel and restaurant chains in city areas in developing countries can be identified as a new strategy to boost the utility of edible oils. Future global edible oil market value is projected to reach USD 119.57 Bn by end 2025. An annual growth rate of 0.9% p.a. is projected due to innovative new flavours and the rising consumer demand for healthy diets from unprocessed, organic edible oils.

However, owing to the disruptions created by the COVID-19 pandemic, recovery of economic activities will mainly determine the future consumption levels, which are directly linked to the countries' economic growth. Mobility restrictions have considerably reduced away-from-home food consumption during the pandemic. Further, environmental concerns are rising for soybean (Brazil & Argentina) and palm oil (Indonesia & Malaysia) cultivation area expansions. Instead, incentivisation is proposed to increase the productivity of the cultivated lands. Certification schemes feed free of genetically modified content (for soybean), labelling and deforestation needs by importing countries may curb the supply growth.

3.4 Local Context

Oils and fats are a major constituent of the typical Sri Lankan diet and raw material in manufacturing, particularly in the food manufacturing industry. The industry survey 2019 show that around 4,297 establishments employ 360,937 workers in the formal food manufacturing sector, generating an annual output of approximately Sri Lankan Rupees (LKR) 1.6 Bn (Department of Census and Statistics, 2019).

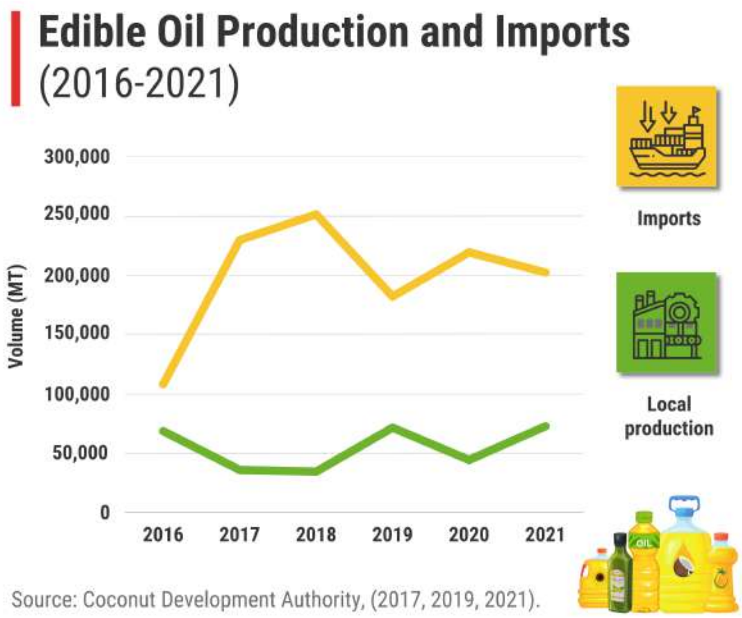
The demand for domestic edible oils comes from two segments: households and industries. Data from the Household Income and Expenditure Survey (HIES) 2019 of the Department of Census and Statistics (DCS) show that an average household consumes 1.8 litres of fats and oils per month (excluding margarine). Here, the annual consumer demand was around 111,953 Mt, with coconut oil being the main source of edible oil. Industrial demand in 2021 can be approximated to 163,086 Mt. Total demand in 2021 was around 275,039 Mt.

The country's demand for edible oils is met by locally produced and imported fats and oils. Coconut oil and palm oil are the main local edible oil sources. In 2021, total edible oil production was 72,769 Mt. Coconut oil production was 43,038 Mt, depending on annual coconut production. Crude palm oil and palm kernel oil production were 29,731 Mt, according to the Coconut Development Authority (CDA). The rest (74%) of the demand is met by imports.

According to CDA statistics, the volume of imported fats and oils in 2021 was 202,270 Mt. A range of edible oils are imported to meet industrial demand and partially to meet household demand. The foreign exchange outflow for fats and oils imports in 2021 was LKR 56.7 Bn, while in 2020, it was around LKR 37.4 Bn.

The available data show that it is challenging to meet the edible oil demand from the local supply. The average annual coconut production in the last five years was 2,792 Mn nuts. Nearly 65-70% of the produce is consumed as fresh coconuts (1,800 Mn nuts). Processing industries utilise the remaining coconuts (around 1,000 Mn). Around 108,108 Mt of coconut oil can be produced from 1,000 Mn nuts at the expense of export industries, yet 166,931 Mt of excess demand has to be met. Palm oil is cultivated in approximately 10,000 ha, which is expected to produce around 24,000 Mt-40,000 Mt depending on the productivity. Together, coconut and palm oils can be expected to supply a maximum of 148,108 Mt, which is still short of 126,931 Mt of oil required to meet the household consumer and industry demand. The extra land requirement to supply this gap at the current productivity level for palm oil would be 52,888 ha. The extra coconut production requirement is 1,174 Mn. A productivity improvement of nearly 42% (6,272 nuts/ha-8,919 nuts/ha) required to meet this gap for coconut production is moderately possible. Nevertheless, the trade-off between

Figure 3.4: Fats and Oil Production and Imports Over Time



coconut export industries and edible oil substitution is not economically sensible. For example, the export value in 2021 was LKR 166 Bn, while oil imports were equivalent to around LKR 30 Bn. Further, the composition of fats and imported oils shows that local oils are not perfect substitutes for imported oils. Hence, Sri Lanka remains a net importer of edible oils and fats. Therefore, global market behaviour will directly influence the local availability of edible oils.

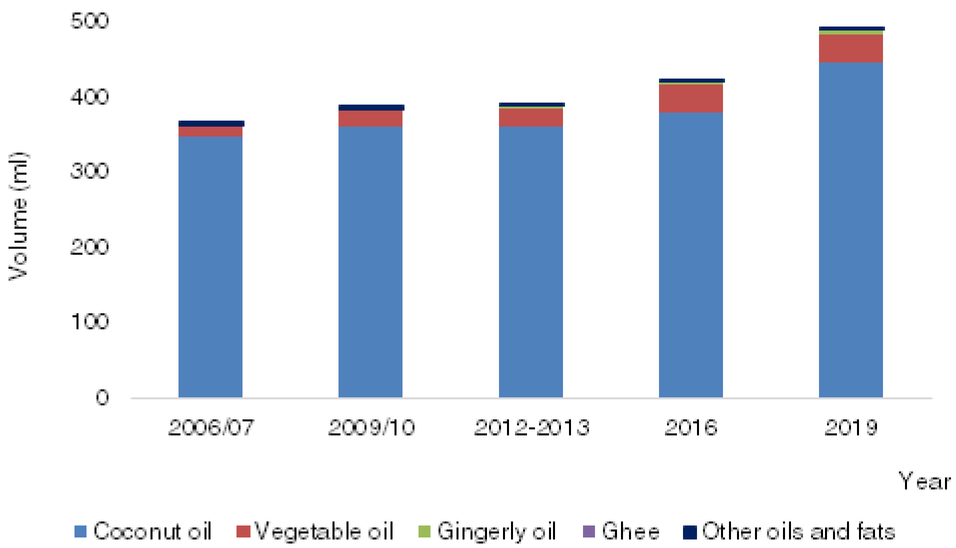
Per capita consumption figures show a slightly increasing behaviour over time (Figure 3.5). The per capita volume has increased from 367 ml to 492 ml in 2006-2019, showing a 2.6% average annual demand growth from households.

Currently, Sri Lanka is amidst a severe economic crisis owing to a foreign exchange shortage and a widening budget deficit to afford government expenditure. Therefore, the uncertainties in the world market, such as supply chain disruptions and price hikes, lack of foreign currency and local currency depreciation, would significantly affect the country's affordability of oils and fats. Hence, the situation is challenging domestic food security.

Allocating more land to cultivate local oil crops is not feasible, given the limited land availability. Therefore, strategies to enhance the productivity of local edible oil sources would be of utmost importance to secure domestic food needs.

> “Strategies to enhance the productivity of local edible oil sources would be of utmost importance to secure domestic food needs. ”

Figure 3.5: Change in Per Capita Edible Oil Consumption Over Time



Source: Department of Census and Statistics. (2007, 2013, 2016 and 2019). *Household Income and Expenditure Survey*. Colombo: Department of Census and Statistics.

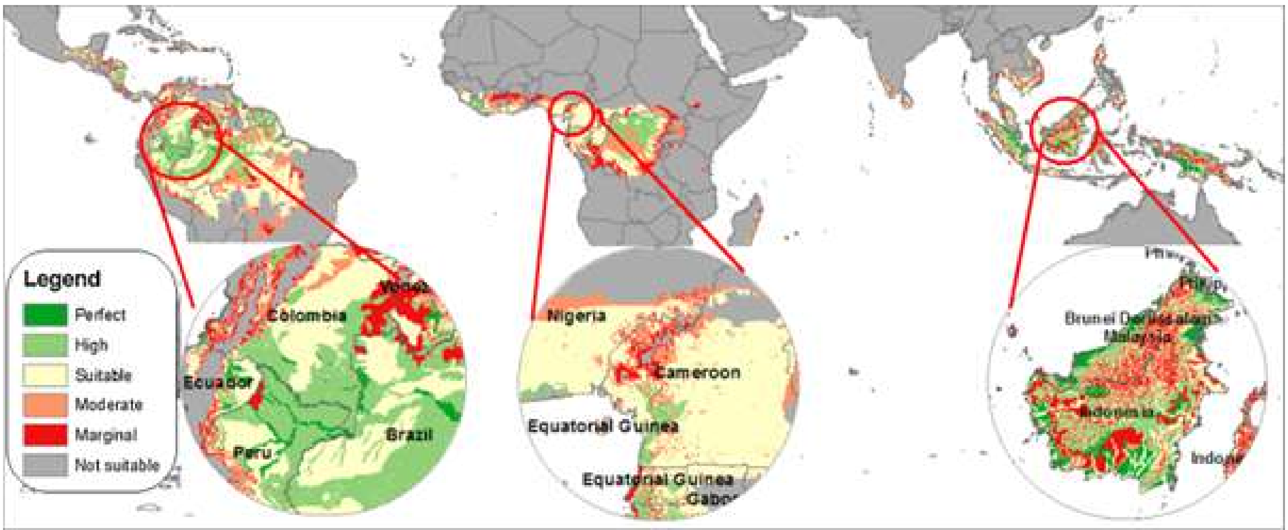
4. Environmental Concerns of Oil Palm Cultivation

Globally, oil palm cultivation has severe environmental concerns due to the conversion of forest lands in the main producing countries. Oil palm is widely grown in the tropical belt 5-10 degrees from the equator. The region is often weak in the monsoon, with rainfall averages of 200 mm per month in the most favourable growing regions (European Union, 2018). Between 1990 and 2010, with the growing demand worldwide for palm oil, cultivation area expanded from 6 to 16 Mn ha, accounting for approximately 10% of the world's permanent farmland (Pirker, Mosnier, Kraxner, Havlik & Obersteiner, 2016). Malaysia and Indonesia have been at the forefront of this fast development: over the previous decade, oil palm cultivated area in these two countries has risen by 150% and 40%, respectively, and these now account for over 80% of worldwide palm oil output (European Union, 2018). The world harvested area in 2019 for palm oil accounted for 28,312,612 ha (FAO, 2021). Figure 4.1 illustrates the favourable locations for optimal growth of oil palm.

"Globally, oil palm cultivation has severe environmental concerns due to the conversion of forest lands in the main producing countries."

These areas comprise of rich ecological diversity, and oil palm cultivation has threatened the local biodiversity and the global climate (European Union, 2018; Pirker, Mosnier, Kraxner, Havlik, & Obersteiner, 2016). Deforestation; loss of biodiversity (partly due to forest degradation); peatland conversion; greenhouse gas (GHG) emissions from land-use change; the use of palm oil for biodiesel; mill effluent; and other plantation activities; fire use and its consequences; air pollution (including haze); and water pollution are some detrimental environmental impacts.

Figure 4.1: Area Suitable for Planting Oil Palm



Source: Pirker, J., Mosnier, A., Kraxner, F., Havlik, P., & Obersteiner, M. (2016). What Are the Limits to Oil Palm Expansion? *Global Environmental Change, 40*(1), 73-81.

4.1 Deforestation

Palm oil's major source of controversy is deforestation (Russell, 2020; European Union, 2018; Cramb & McCarthy, 2016). Globally, around half of the present oil palm acreage was grown at the expense of forests, while the other half was grown to replace pastures, shrubland, and other land uses (IUCN, 2018). Increased output needs additional area for new plants (Russell, 2020).

According to scientific research, oil palm plantations cover 45% of formerly wooded land, a considerably higher percentage than other oilseed crops like soybean (8%), and between 2008 and 2011, palm oil caused 4,300 km2 of newly grown areas (European Union, 2018). As global demand rises and available land in traditional production centres becomes increasingly scarce, governments of developing countries such as Brazil, Peru, and Central and Western Africa are increasingly promoting oil palm cultivation as a significant component of poverty alleviation and food and energy independence (Kongsager & Reenberg, 2012). Future development of oil palm cultivation may result in deforestation patterns that highly differ from those observed in the past (European Union, 2018). Globally, an estimated 234 Mn ha of appropriate and accessible lands are available for oil palm agriculture, with the Amazon accounting for a sizeable percentage of this (Pirker, Mosnier, Kraxner, Havlik, & Obersteiner, 2016). Oil palms can be grown on degraded soil or land previously used for other crops; thus, forest removal isn't always necessary (Russell, 2020).

Similar to oil palm, expansion estimates suggest that rubber plantations were expanding rapidly in Laos, Vietnam and Myanmar, replacing the natural forest cover (Fox & Jean-Christophe, 2013). For numerous reasons, deforestation is a significant issue (European Union, 2018).

Oil palms contain less than 20% of the above-ground biomass of rainforest trees and have a reduced potential to absorb carbon dioxide from the atmosphere (European Union, 2018). *Equally, one research in Xishuangbanna, China, revealed that above-ground carbon in rubber plantations was less than half of what was found in surrounding forests* (Li, Youxin, & Mitchell, 2008).

Ziegler, et al. (2012) revealed that the above-ground carbon levels in mature rubber plantations vary significantly in Southeast Asia, ranging from 25 to 143 megagrams per hectare (Mg/ha). Further, estimated above-ground carbon in palm oil plantations ranges from 37.76-42.07 Mg/ha (Ni'matul, Meine, & Harti, 2015).

4.2 Biodiversity

Human actions cause an unparalleled pace of species extinctions throughout the planet (European Union, 2018). Commercial agriculture is the primary cause of species extinction (Rudel, Defries, Asner, & Laurance, 2009). The lowland tropics, where oil palm is grown, are the most species-rich forests on the planet (Corley & Tinker, 2003; Whitmore, 1998). Southeast Asia is among the most biodiverse regions, with high degrees of endemism and charismatic and endangered wildlife such as orangutans, Asian elephants, Sumatran tigers, birds of paradise, and three rhinoceros species (Whitmore, 1998). The Amazon is one of the most biodiverse ecosystems on the planet. This rainforest is home to approximately 3 Mn species, and over 2,500 tree species (or one-third of all tropical trees on earth) combine to produce and sustain this diverse ecosystem (Thomson, 2020).

Lenzen, et al., (2012) suggest that *developing countries experience tradeoffs between biodiversity and agricultural export earnings*. In contrast, 35% of domestically documented species concerns are connected to export output among net exporters. *This percentage is around 50-60% in Madagascar, Papua New Guinea, Sri Lanka, and Honduras.*

The loss of species caused by the transformation of tropical forests to agriculture, plantations, and other land uses are well known and undisputed (Brook, Sodhi, & Ng, 2003). Ashortage of data on how palm plantations impact biodiversity (Petrenko, Paltseva, & Searle, 2016). However, studies show that removing forests (i.e. deforestation), regardless of the cause has a significant detrimental impact on biodiversity (European Union, 2018; Petrenko, Paltseva, & Searle, 2016; WWF, 2021).

Oil palm plantations sustain just a fraction of rainforest animal diversity (Petrenko, Paltseva, & Searle, 2016). These threaten biodiversity by encroaching into the habitats of critically endangered species, such as the orangutan and the Sumatran tiger, as well as countless smaller species in Indonesia (Voigt & Wich, 2018). Peh et al. (2006) discovered a 77% decrease in bird species richness when primary forests were converted to plantations and a 73% decrease when secondary forests were selectively removed in Indonesia.

Oil palm plantations sustain fewer species than rubber, cocoa, or coffee plantations (Fitzherbert, Struebig, & Morel, 2008). *The conversion of rubber fields to oil palm, for example, led to a 14% decrease in bird diversity in Indonesia* (Peh, Sodhi, Jong, & Sekercioglu, 2006).

Plantations feature a consistent tree age structure, reduced canopy height, and *minimal undergrowth*, making them far less complicated than tropical rainforests (Yaap, Struebig, & Paoli, 2010). The above-ground biomass of older palm trees is less than 20% of the original forest, which has implications for *microclimate and shade-adapted species* (Saxon & Roquemore, 2011). Species with specific *diets*, those requiring habitat features such as tall trees, and those with narrow ranges and the highest conservation concerns are among those lost.

Accelerated deforestation jeopardises Indonesia's internationally significant biodiversity and contributes to the country's status as one of the world's biggest GHG emitters (Austin, Schwantes, Gu, & Kasibhatla, 2019). Between 2005 and 2015, oil palm cultivation was responsible for at least 50% of all deforestation in Borneo island (IUCN, 2021).

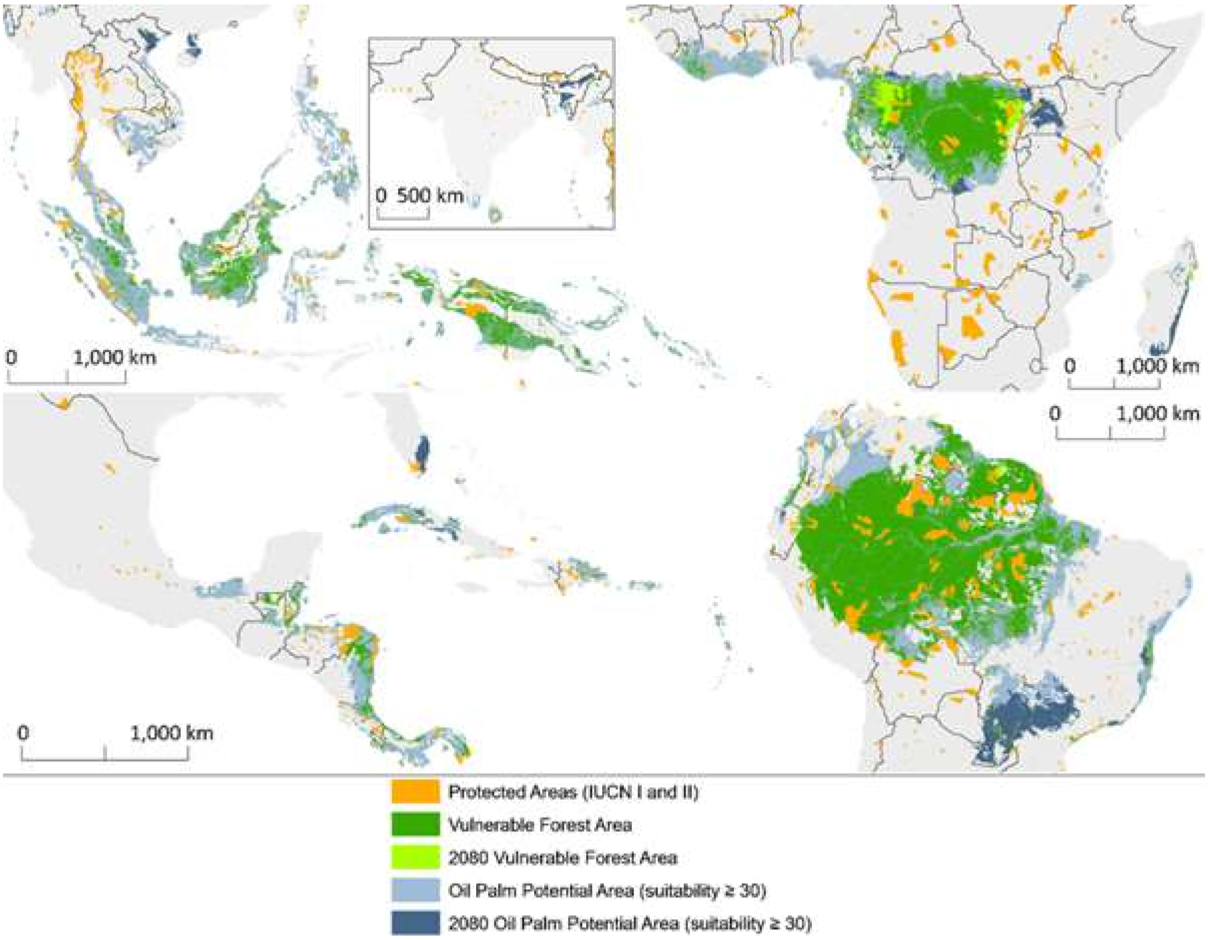
Figure 4.2 illustrates regions at risk of deforestation due to oil palm up to 2080. Figure 4.2 exhibits that Borneo, Indonesian Papua, Papua New Guinea, portions of Central America, and vast swaths of West Africa and South America are the most vulnerable to deforestation (Vijay, Pimm, Jenkins, & Smith, 2016).

According to the authors, Sri Lanka has been identified as a vulnerable country for oil palm cultivation associated with deforestation, by 2080.

“Oil palm plantations sustain fewer species than rubber, cocoa, or coffee plantations (Fitzherbert, Struebig, & Morel, 2008).

The conversion of rubber fields to oil palm, for example, led to a 14% decrease in bird diversity in Indonesia (Peh, Sodhi, Jong, & Sekercioglu, 2006).”

Figure 4.2: Vulnerable Forest Area by 2080



Source: Voigt, M., & Wich, S. (2018). Global Demand for Natural Resources Eliminated More Than 100,000 Bornean Orangutans. *Current Biology*, 28(5), 761-769.

4.3 Conversion of Other Agricultural Lands

Palm oil production is claimed to have mainly expanded on logged-over forest and former rubber and coconut plantations in Malaysia, but natural rainforest and peatlands have frequently been converted to oil palm cultivation in Indonesia (Kongsager & Reenberg, 2012). The extensive oil palm expansion has compromised Borneo's rice production systems (Koh & Ghazoul, 2010). However, in Latin America, it was estimated that 79% of oil palm development occurred in areas that had previously been under some agricultural system (predominantly cattle ranching), while 21% occurred on territory that previously had forest cover (European Union, 2018; Fox & Jean-Christophe, 2013). Similarly, Brazil promoted oil palm cultivation in degraded lands (Branda?o & Schoneveld, 2015), while Thailand facilitated the expansion of oil palm into previously abandoned agricultural lands (Dallinger, 2011).

In Sri Lanka, oil palm cultivation expanded through degraded unproductive lands under rubber cultivation (Central Environmental Authority, 2018). *Therefore, rubber plantations are highly vulnerable for conversion into oil palm cultivations in Sri Lanka* (Central Environmental Authority, 2018).

> "In Sri Lanka, oil palm cultivation expanded through degraded unproductive lands under rubber cultivation."

4.4 GHG Emissions

Greenhouse gas emissions from palm oil production and processing are primarily caused by two factors: land-use change (with extra emissions if the fire is used to clear land for cultivation) and plantation and mill operations (Petrenko, Paltseva, & Searle, 2016; European Union, 2018).

The differential in carbon sequestration between the oil palm plantation and the land use it replaces is the most crucial factor of oil palm cultivation's contribution to GHG emissions via land-use change (LUC) (Chase & Henson, 2010). Tropical forests store around 46% of the world's live terrestrial carbon, while deforestation may account for 25% of total net global carbon emissions (Skutsch, Bird, & Trines, 200). Unlogged Asian tropical forests store up to 400 tonnes of carbon per ha above ground, with additional carbon stored in mineral soils that has yet to be measured, accounting for up to four times the amount of above-ground carbon stored by a fully mature oil palm plantation (Lucey, Hill, & Meer, 2014; European Union, 2018).

Bhagya, et al., (2017) revealed that coconut had sequestrated 51.14 tonnes of carbon per ha above ground and 47.06 tonnes of carbon per ha below ground. Estimates suggest that rubber plantations store 82.1-128.4 tonnes of carbon per ha above ground (Simon, Nuthammachot, Titseesang, & Okpara, 2021; Petsri, Chidthaisong, & Pumijumnong, 2013) while the below-ground biomass ranges from 16-105.73 tonnes per ha (Brahma, Nath, & Das, 2016). *Nevertheless, forests comprise 3-10 times more carbon biomass than rubber and oil palm plantations* (Kotowska, Leuschner, Triadiati, & Meriem, 2015), transforming forests into oil palm plantations resulted in net GHG emissions (Petrenko, Paltseva, & Searle, 2016; Lucey, Hill, & Meer, 2014). In addition, the conversion of grassland sight results in a net carbon dioxide intake (Germer & Sauerborn, 2007; Petrenko, Paltseva, & Searle, 2016; European Union, 2018). Moreover, clear-felling rubber plantations emit 135 Mg ha-1 carbon, which is less than forests (384 Mg ha-1) (Brahma, Nath, & Das, 2016). *Yet, the conversion of formerly rubber plantations to oil palm plantations in Malaysia is estimated to result in a 20% increase in carbon savings*, *ensuring that the environmental advantages of palm oil-based biofuel production are maintained* (Kusin, Akhir, & Mohamat-Yusuff, 2017).

In addition to land-use change, GHG emissions from the palm oil industry include those from the treatment of palm oil mill effluent (POME), fertiliser usage, energy inputs to mills, and the use of fossil fuels for transportation, machinery, and energy use during day-to-day operations (European Union, 2018). According to the European Union's research data, the first two are likely to create the most emissions. In Thailand, palm oil mills emitted an average of *1,198 kgCO2e/MT of total crude palm oil* (Kaewmai, H-Kittikun, & Musikavong, 2012). The primary sources of GHG emissions were cultivating and harvesting fresh fruit bunches (FFB) and the wastewater treatment system. Total emissions from manufacturing concentrated latex, block rubber, and ribbed smoked sheet were *0.54, 0.70, and 0.64 tonnes CO2-eq/ton product, respectively.* (Jawjit, Kroeze, & Rattanapan, 2010).

Nitrous oxide (N2O) is another potential source of GHG emissions from oil which is released due to the use of nitrogen fertiliser (including the use of nitrogen-fixing cover crops) (Loh, Nasrin, &

Mohamad, 2017; Fowler, Nemitz, & Misztal, 2011). Further, N2O emissions from fertilised palms have been calculated at 4.4 kg N2O-N per ha per year; however, the authors acknowledge that this finding is subject to substantial uncertainty (Fowler, Nemitz, & Misztal, 2011). Apart from these, van Noordwijk, et al., (2017) revealed that the N fertiliser rate used in Indonesia is 344–394 kg N ha"1 with a mean of *141 kg N ha"1 yr"1*. The estimated N fertiliser use rate for rubber in China is *75 kg N ha"1 yr"1,* which accounts for 2.5 kg N ha"1 yr"1 of N_2O emissions (Wen-Jun, Hong-li, Jing, & Yi-Ping, 2016).

Mills get significantower from burning oil palm crop leftovers (Hosseini & Wahid, 2014). While land-use change is expected to be the most crucial source of GHG emissions linked with palm oil production and processing in many situations, plantation management and mill activities emit GHG regardless of previous land use (European Union, 2018).

4.5 Impact on Local Water Quality and Availability

Oil palm plantations have a significant impact on air and water quality in local and regional areas (Qaim, Sibhatu, & Siregar, 2020). Therefore, significantly deteriorated water quality has now been added to the risks of oil palm cultivation (Carlson, Naumann, & Vazire, 2012; Carlson & Curran, 2014). *Large-scale oil palm production also has an impact on regional water quality, mostly due to excessive fertiliser application, which causes nitrate contamination* (Comte, Colin, & Whalen, 2012) *and water flow redistribution, which can result in periodic water scarcity in communities near oil palm plantations* (Merten, Röll, Guillaume, & Meijide, 2016). Furthermore, some mills discharge millions of tonnes of POME—a toxic combination of crushed shells, water, and fat *residues—untreated* into waterways each year (Comte, Colin, & Whalen, 2012).

Pollutants emitted by agrochemicals used in fertilisers, pesticides, and rodenticides negatively influence terrestrial and aquatic ecosystems (Verdade, Piña, & Rosalino, 2015). *During heavy rains, POME, which is microbially processed in open ponds, frequently spills into rivers* (Sheil & Casson, 2009). Moreover, POME and heavy metal poisoning of fish may be linked, and excessive nitrogen fertiliser promotes the eutrophication of streams (Sheil & Casson, 2009). However, studies that quantify exact leach rates from oil palm plantations are limited. *Similarly, fertiliser used in rubber plantations (N, P, K, Ca and Mg) losses through leaching* wherein a study in Sumatra estimated leaching rates as 4, 3, 8, 4 kg ha"1 year"1 for N, K, Ca, and Mg, respectively (Vrignon-Brenas, et al., 2019).

The nutrient leaching rate of coconut plantations is 50, 6, 106 and 14 kg ha"1 year"1 for N, P, K and Mg, respectively (Gunathilakem & Manjula, 2006). *Oil palm cultivations in Sri Lanka use high agrochemical levels for crop protection and inorganic fertilisers that are-10 times greater per ha of rubber* (Central Environmental Authority, 2018).

Wetlands and lakes are also at risk from oil palm cultivation since decreasing oxygen levels and increased nitrate loading (eutrophication) have been linked to the expanding oil palm sector (Petrenko, Paltseva, & Searle, 2016). Large-scale commercial plantings have been reported to reduce ecosystem evapotranspiration, resulting in hotter and drier climatic conditions, while mature plantations (age > 8-9 years) transpire more water (up to +7.7%) than the forests these have replaced (Manoli, Meijide, Huth, & Knohl, 2018). *Reduced infiltration in oil palm plantations lowers water storage and increases surface runoff, putting access to useable water at jeopardy and raising the danger of flooding* (Comte, Colin, & Whalen, 2012).

According to facts, established oil palm plantations on each side of the waterfall in

Sri Lanka cause soil erosion on slopy fields degrading local water quality and the possibility for landslides (Central Environmental Authority, 2018).

One study by Manoli, et al., (2018) conducted using sites from Papua New Guinea, Malaysia and Indonesia suggest that *oil palm plantations are water extensive, with farmers and villagers in oil palm-dominated areas reporting water shortage issues, such as decreased water levels in wells during the dry season as well as changes in streamflow levels and water quality*. Estimates suggest that a palm oil mill in Thailand produces 14% of grey water from its total water footprint (Suttayakul, H-Kittikun, Suksaroj, Mungkalasiri, & Wisansuwannakorn, 2016).

Depletion of water levels in water bodies and wells adjacent to oil palm plantations was significantly observed in the Kalutara and Galle districts of Sri Lanka (Central Environmental Authority, 2018).

Agusta, et al.,(2019) suggest that the *oil-palm coarse root and fine roots distribution at the position of 10-30 cm soil depth significantly affects the moisturising capacity in the upper soil layer during the dry season as well as reduces groundwater levels by preventing water infiltration.*

Similarly, in Sri Lanka, runoff and sedimentation, nutrient leaching from fertilisers, pesticides, other agrochemicals, and effluent discharge are all possible variables that influence water quality and can be important consequences of oil palm farming (Central Environmental Authority, 2018).

5. Palm Oil and Human Health

5.1 Composition and Processing of Palm Oil

Palm oil is extracted from the mesocarp (pulp) (Pande, Akoh, & Lai, 2012) of the fruit, whereas palm kernel oil (PKO) is derived from the seed kernel. Palm oil has a unique fatty acid (Edem, 2002) and triacylglycerol (TAG) profile and contains 50% saturated fatty acids (SFAs), 40% monounsaturated fatty acids (MUFAs) and 10% polyunsaturated fatty acids (PUFAs). Compared to other types of vegetable cooking oils, palm oil and PKO are *highly saturated* in nature (Table 5.1). Palm oil and its fractions, such as palm olein (liquid fraction), palm stearin (solid fraction), super olein, mid olein, super stearin and mid stearin (Pande, Akoh, & Lai, 2012) are extensively used and subjected to refining, bleaching and deodorisation (RBD) processing and interesterification to diversify the applications. *Palm oil contains a high proportion of* palmitic acid, which is a *SFA* (Edem, 2002). Compared to all other types of cooking oils, considerable quantities of oleic and linoleic acids give it a higher unsaturated fatty acids (UFA) content than coconut oil and PKO. Palm olein and super olein contain high levels of oleic and linoleic acids (Edem, 2002) but less palmitic acid than palm stearin. *Palm oil is high in* physiologically and biologically active substances such as *tocopherols, carotenoids and phytosterols* (Sundram, Sambanthamurthi, & Tan, 2003), promoting human health.

Uses of Palm Oil in Relation to its Composition and Properties

Around 90% of palm oil (Ogan, Marie-Josée, & Ngadi, 2015) and its derivatives are used for food applications such as baking, frying, cooking and confectionaries. Palm oil is highly suitable for producing margarine and shortening, mainly because it is semi-solid at ambient temperature; it has a melting point range of 32–40°C, which is very close to body temperature. Palm oil and its fractions produce beta prime fat crystals that mainly impart a firm texture, glossy appearance, and smooth mouth-feel (Pande, Akoh, & Lai, 2012) to use in shortening and baked products successfully. *Palm stearin* is the most extensively used fraction in producing *trans-free margarine*. A comparatively low amount of unsaturated fatty acids (UFAs) and a high proportion of tocopherols and tocotrienols compared to other vegetable oils make *palm oil resistant to oxidation, polymerisation, foaming, and maintains the quality of food and suitable for deep fat frying*. It *extends the shelf life of fried products*, producing no gummy or sticky residues in the equipment and no waxy or greasy mouth feel in fried products.

Palm mid fraction has a steep melting and crystalising profile similar to coco butter (Pande, Akoh, & Lai, 2012), thus used as the *cocoa butter equivalent*. Hence, it is used for chocolate manufacturing (E.g. Dairy Milk, Cadbury's Roses, Mars, Aero, Ferrero Rocher, Kinder, Nutella) and sustainably produced palm oil is a concern of these brands. Bioactive compounds obtained from palm oil can be used for the *fortification of foods and dietary supplements*. Palm oil fractions' emulsifying properties (Ogan, Marie-Josée, & Ngadi, 2015) are used *to produce milk formulas and other malted beverages*. The remaining 10% of palm oil (Edem, 2002) is used for non-food products such as *soap, toothpaste, detergents, cosmetics, waxes, lubricants, biofuel* and *oleochemical* manufacturing. In addition, it is used as a *traditional antidote to cyanide toxicity*.

5.2 Palm Oil and Human Health

Scientific studies on the health impacts of palm oil and its derivatives are *mixed*. Consumption of high amounts of SFAs (Gesteiro, et al., 2019) leads to increase low-density plasma lipoprotein

(LDL) levels while reducing high-density lipoprotein (HDL), resulting in cardiovascular diseases (CVDs) like atherosclerosis. Since palm oil contains more SFAs than other cooking oils, some clinical studies reported a significant relationship between palm oil consumption and higher mortality from ischemic heart disease (Kadandale, Mart, & Smith, 2019). Also, it is reported that consuming palm oil in more than 30% of the diet (Edem, 2002) is directly associated with a *risk of CVDs*. Compared to other vegetable oils, the high proportion of SFAs in palm oil (Ismail, Maroof, Ali, & Ali, 2018) has led to the assumption that palm oil contributes to the increased prevalence of CVDs globally. Diet, Nutrition and Prevention of Chronic Diseases: 2003, the joint report of the WHO and the FAO (World Health Organisation, 2002) stated with convincing evidence that palmitic acid abundant in palm oil consumption leads to *a raised risk of developing CVDs*.

> "Scientific studies on the health impacts of palm oil and its derivatives are mixed."

The latest guidelines of the American Heart Association recommend decreasing the intake of saturated fat to 5-6% (Sacks, et al., 2017) of the total daily energy intake, especially for individuals with elevated LDL levels and <10% for the general population (Sacks, et al., 2017) and to replace saturated fats with more unsaturated fats. Scientific prospective and observational studies on many populations stressed that a lower intake of SFAs (Mensink, 2016) replaced with a higher intake of mono and polyunsaturated fatty acids, is associated with reduced CVDs and related mortality (Ornish, et al., 1990).

But *palm oil contains a considerable amount of MUFAs like oleic acid, which highly promotes human health.* The balanced fatty acid profile and its metabolism are similar to olive oil (Sundram, Sambanthamurthi, & Tan, 2003) ; its adequacy to result in lipoprotein-cholesterol profile against CVDs by inhibiting endogenous cholesterol biosynthesis, and lower platelet aggregation and blood pressure (Sundram, Sambanthamurthi, & Tan, 2003) have been highly proved. Palm oil contains bioactive compounds rather than any other cooking oils; ã–tocotrienol; physiologically active as vitamin E and carotenoids in palm oil detoxify highly reactive free-fatty peroxy radicals, *protecting against oxidative damage to body cells*. Moreover, palm oil is a very rich source of phytosterols which increase the excretion of cholesterol and acts *anti-cancer and anti-inflammatory components* (Sundram, Sambanthamurthi, & Tan, 2003).

A significant and growing body of scientific evidence indicates that *palm oil's effect on blood cholesterol is relatively neutral* (Aravie, Oyekale, & Emagbetere, 2015) compared to other fats and oils. The main dietary SFAs with medium chains (Mensink, 2016), such as lauric and myristic acids, are abundant in coconut oil and PKO, and may be higher contributors in increasing serum cholesterol levels, which increases the risk of CVDs than palmitic acid. However, it is evident in other research studies that saturated medium-chain fatty acids (lauric acid) are directly absorbed into the intestine and do not participate in the "biosynthesis and transport of cholesterol" which is considered a cardio-protective property of coconut oil (Boateng, 2016). Some critique draws up the assumption that industry-driven global campaigns on "anti-saturated fats" began in the late 1950s from the USA (such as American Soybean Association, Corn Products Company and Center for Science in the Public Interest) have influenced coconut oil consumption globally (Enig, 1999).

According to several meta-analysis (Aravie, Oyekale, & Emagbetere, 2015) on palm oil and CVDs, it is proved that *palm oil in a balanced diet adequately results in lipoprotein-cholesterol profile against heart diseases by inhibition of endogenous cholesterol biosynthesis* (Aravie, Oyekale, & Emagbetere, 2015) *reducing low-density lipoprotein (LDL);"bad cholesterol" and improve high-density lipoprotein (HDL);"good cholesterol*" leads to a healthy lipid profile, reducing CVDs and lowering platelet aggregation and blood pressure.

Most PUFAs containing vegetable oils are subjected to a hydrogenation process in margarine and shortening manufacturing (Pande, Akoh, & Lai, 2012). This results in the production of trans fatty acids (TFAs) associated with numerous adverse health effects such as an increase of LDL, reducing HDL, and promoting cancer and platelet aggregation. Due to its high solid fat content, palm oil is semi-solid at room temperature and has less or no need to undergo a hydrogenation process, thus *minimising the risk of producing TFAs*. Palm oil and its fractions are *extensively used as a potential replacement for TFAs in ultra-processed foods,* which were banned in 2018 by the WHO and the FAO due to adverse health effects like cancer_(Kadandale, Mart, & Smith, 2019).

5.2.1 Palm Oil Frying Dynamics and Human Health

Palm oil is extensively used by fast food chains, hotels and eateries due to its affordable/cheap price (Edem, 2002) and desirable appearance to fried products. Though it has excellent oxidative stability, heating to a higher temperature for a prolonged duration causes a significant reduction of antioxidants (Khor, et al., 2019). This results in oxidation, polymerisation and hydrolysis of fatty acids rendering unwanted products harmful to health. Most of these bioactive compounds are removed during RBD processing (Pande, Akoh, & Lai, 2012).

Palm oil becomes oxidised and dark in colour when repeatedly heated to a temperature above 150 0C (Edem, 2002). However, unfortunately, in Sri Lanka, roadside "*wade*" and snack sellers (fast food sellers/outlets) use the same oil around 40 repeating frying cycles. Some organised groups (Jayawardena & Madhujith, 2013) collect repeatedly used oils and resell these at very lower prices after simply filtering and bleaching. Clinical evidence report (Gesteiro, et al., 2019) that consumption of oxidised palm oil induces adverse lipid profiles, reproductive toxicity and toxicity in the kidney, lung, liver, heart and other organs etc., occur due to produced cytotoxic products.

5.2.2 Ensuring Food Safety in Palm Oil

Though the composition of fresh palm oil and its derivatives are extremely safe and multi-beneficial to human health and the food industry, alarming food safety issues remain due to its inappropriate usage and malpractices. In Sri Lanka, adulteration of fresh palm oil with used oils, (Khor, et al., 2019) repeated usage for frying, high heating and inappropriate storage (Almeda, Vina, Costa, Silva, & Feitosa, 2018) are common misuses which adversely affect the human health. Strict regulations and laws should be adhered and enforced against palm oil adulterations; in addition, frequent monitoring should be conducted, especially targeting roadside food vendors and fast-food producers.

To raise consumer awareness on unhealthy processed foods, particularly for ultra-processed foods, policies should be in place and enforced for a strict labelling requirement to display (Kadandale, Mart, & Smith, 2019) the ingredients and their potentially harmful effects. Palm oil can be enriched and fortified with antioxidants (Aleman, et al., 2010) after RBD processing to prevent oxidation. Therefore, adhering to better strategies would ensure the food safety of this miracle cooking oil.

"In Sri Lanka, adulteration of fresh palm oil with used oils, (Khor, et al., 2019) repeated usage for frying, high heating and inappropriate storage (Almeda, Vina, Costa, Silva, & Feitosa, 2018) are common misuses which adversely affect the human health."

5.3 Sri Lankan Palm Oil Regulations

Manufacturing, importation, sales and distribution of palm oil, its derivatives and food produced using those as ingredients or additives are mandatorily regulated under Sri Lanka Food Act No. 26 of 1980 (Food Act No 26 of 1980, 1980), Food (Standards) Regulations of 1989 (Food (Standards) Regulations, 1990) and its amendments and Food (labelling and Advertising) Regulation 2005 for packaging, labelling and advertising (Parliament of the Democratic Socialist Republic of Sri Lanka, 2005). Sri Lanka Standards (SLS) on palm oil and its derivatives are developed and revised with the assistance of the publications of the Codex Alimentarius Commission, Department of Standards Malaysia, and International Organization for Standardization (ISO). Standards for Named Vegetable Oils (CODEX STAN 210-1999) (Food and Agricultural Organization, 2019) would facilitate the harmonisation of national legislations with international standards; it can thus reduce impediments to international trade of palm oil and palm kernel oil which are used as the main reference in the development of Sri Lankan legislations.

Separate SLS specifications are maintained for palm oil, PKO and its derivatives; SLS 720 specification of palm oil, SLS 961 specification of palm olein, SLS 960 specification of palm stearin and SLS 862 specification for PKO, prescribe the requirements and methods of sampling and testing. These standards are subject to the restrictions imposed under the Sri Lanka Food Act No. 26 of 1980 and the regulations framed thereunder, wherever applicable. According to SLS 720, palm oil is graded as crude palm oil (CPO), neutralised palm oil (NPO), neutralised, bleached palm oil (NBPO) and neutralised, bleached, and deodorised palm oil (NBD)/RBD based on the processing method. As general requirements, the product shall be clear on melting and free from adulterants, sediments, suspended and other foreign matter, water separated, added colouring substances, and added flavouring substances. The odour and taste of each product shall be characteristics of the designated product. It shall be free from foreign and rancid odour and taste. Colour is different from specific palm oil derivative to derivative and should adhere to the specifications.

However, a lack of enforcement, awareness and a monitoring system made those regulations (storage, labelling, adulteration with repeatedly fried oil) ineffective.

"Lack of enforcement, awareness and a monitoring system made those regulations (storage, labelling, adulteration with repeatedly fried oil) ineffective."

6. Palm Oil Industry Value Chain

This section covers an industry overview, palm oil industry value chain map, value chain activities and the environmental sustainability context of the local palm oil industry.

6.1 Industry Overview

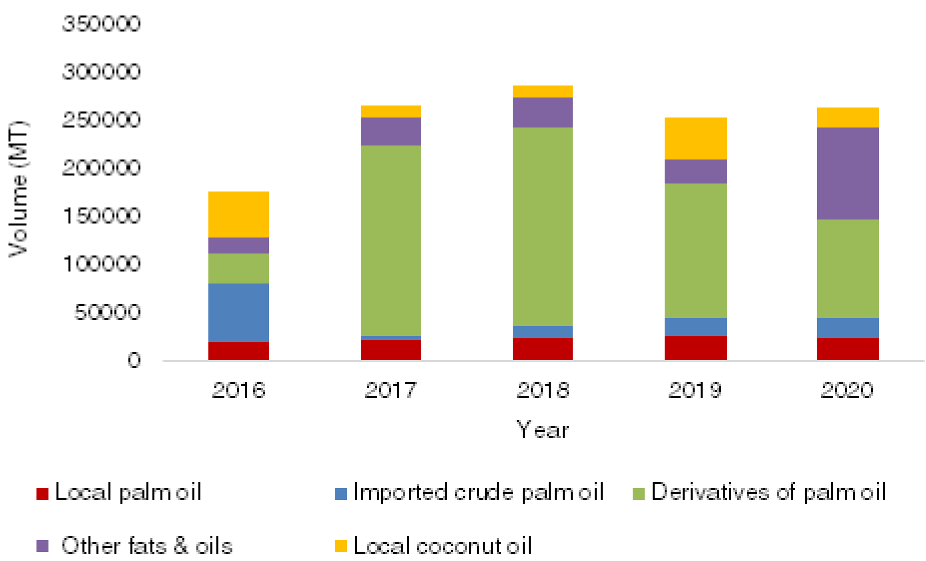
Oil palm cultivation in Sri Lanka began in 1967 with 20 ha of land in the Galle district and expanded to around 10,000 ha. The government approved for RPCs to cultivate oil palms in five selected districts with suitable agro-ecological conditions. These lands exist in Kegalle, Ratnapura, Kalutara, Galle and Matara districts. According to the CDA statistics (Coconut Development Authority (b), 2021), the production of crude palm oil and palm kernel oil in 2020 was 24,567 Mt, a slight drop from 2019 production (see infographic), while 2021 production was 29,731 Mt. It has an average annual supply share of 6% in 2016-2020. The average land productivity was around 2.4 Mt/ha in the period 2016-2020. In other words, 1 ha of land could produce 2.4 Mt of palm oil, which was comparatively low to the best global productivity level of 3.6 Mt/ha.

6.2 Palm Oil Industry Value Chain Map

Local palm oil industry stakeholders include RPCs, millers, refineries, distributors, wholesalers, retailers, and end-users. Other than these, imported palm oil and its derivatives connect this chain through refineries and the sales network.

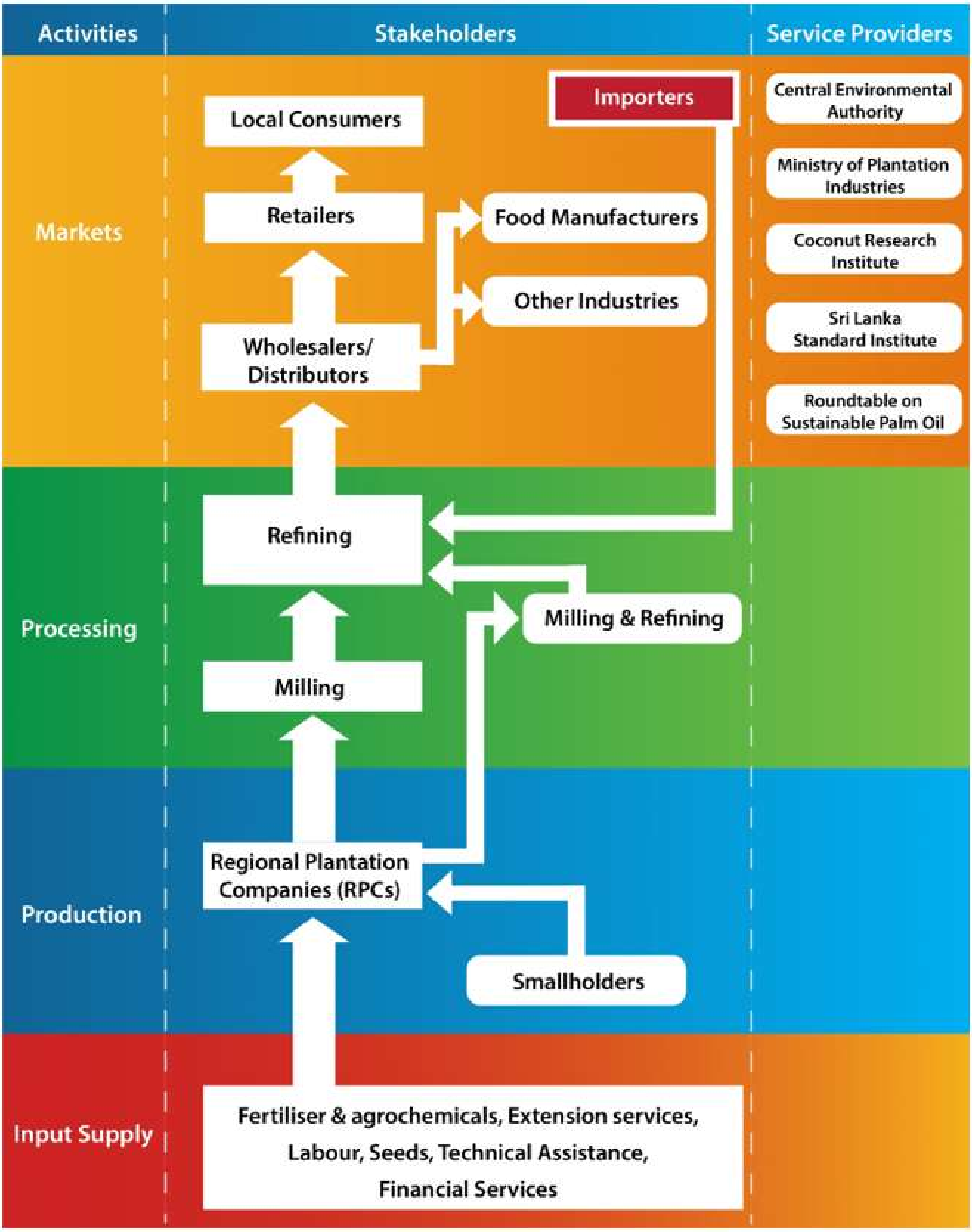
Figure 6.1 illustrates the value chain map of the palm oil industry in Sri Lanka. The palm oil value chain activities are categorised into four; input supply, production, processing, and markets. The value chain map depicts stakeholders and the service providers of each activity in the value chain and their relationships.

Production and Imports of Palm Oil and its Derivatives in the Local Fats & Oil Market (2016-2020)



Source: Coconut Development Authority. (2020). Sri Lanka Coconut Statistics 2020. Colombo: Coconut Development Authority.

Figure 6.1: Value Chain Map of the Palm Oil Industry in Sri Lanka



Source: Authors illustration (2021).

6.3 Value Chain Activities and Players

6.3.1 Bunch Production

Currently, eight RPCs engage in oil palm cultivation. The total area cultivated as of June 2021 is 10,310 ha (Table 6.1), around 0.8% of the arable lands in the country. Previous land use of the planted area is mostly rubber, while some tea cultivation is also reported. The total investment in establishing these estates and mills is approximately LKR 26 Bn (Daily Mirror, 2021).

Watawala, Namunukula, Elpitiya and Agalawatte Plantations each exceed 1,000 ha of cultivation extent. Those four RPCs own nearly 85% of the land. With the MPI approval, each RPC was allowed to expand up to 20% of the leased lands for cultivating oil palm. The Watawala Plantations PLC maintains smallholders, which account for around 7% of its bunch production (Watawala, 2022). Further, their plantations in Galle are under a joint venture with Sunshine Holdings PLC and Pyramid Wilmar Pvt. Ltd.

The planting density of the estates varies from 130 to 145 palms/ha. Planting density in Malaysia ranges from 136-185 palms/ha (Nazeeb, Tang, Loong, & Syed Shahar, 2008) and in Indonesia, it varies between 128-160 palms/ha (Riyanto, Sartini & Nasution, 2020).

Harvesting takes place every 7-10 days interval. The land productivity of FFBs varies across the RPCs, as indicated in Table 6.1. Considering the bearing land extent, the annual average FFB productivity is 9.77 Mt/ha. Only two RPCs produce above the average productivity level and another two are closer to the average, while the rest face very low productivity. Four large-scale estates show comparatively a higher productivity level.

The average cost of production (COP) is LKR 32.29/kg of FFB varies from LKR 9.21 to 71.03. Comparatively lower rates of COP are observed in highly productive RPCs. Horana Plantations shows low productivity and low cost of production, while other low productive plantations show a high cost of production owing to new plantations in Lalan RPC.

The average sales price of 1 kg of FFB is LKR 52.98. Therefore, the average profit margin is LKR 19.69 for a kg of FFB, with a 59% margin. The average profit of selling FFB is around LKR 192,371/ha, which varies between LKR (-38,608) and LKR 323,874, excluding Watawala Plantations PLC. These companies sell crude palm oil and palm kernel oil to refineries.

"The total area cultivated as of June 2021 is 10,310 ha (Table 6.1), around 0.8% of the arable lands in the country."

The average productivity is 9.77 FFB/ha. The average profit margin is LKR 19.69/kg of FFB which is nearly a 59% margin. Average profit is LKR 192,371/ha.

Other than the scale of operation, agro-climatic factors (such as rainfall, temperature, and soil), age of the plantation, experience, genetics, and management practices influence the oil palm crop productivity. Figure 6.2 provides the geographical distribution of cultivated lands of each RPC in Sri Lanka and agro-ecological regions (AER). According to Figure 6.2, all the plantations are in the wet zone, particularly in low country wet zone AERs.

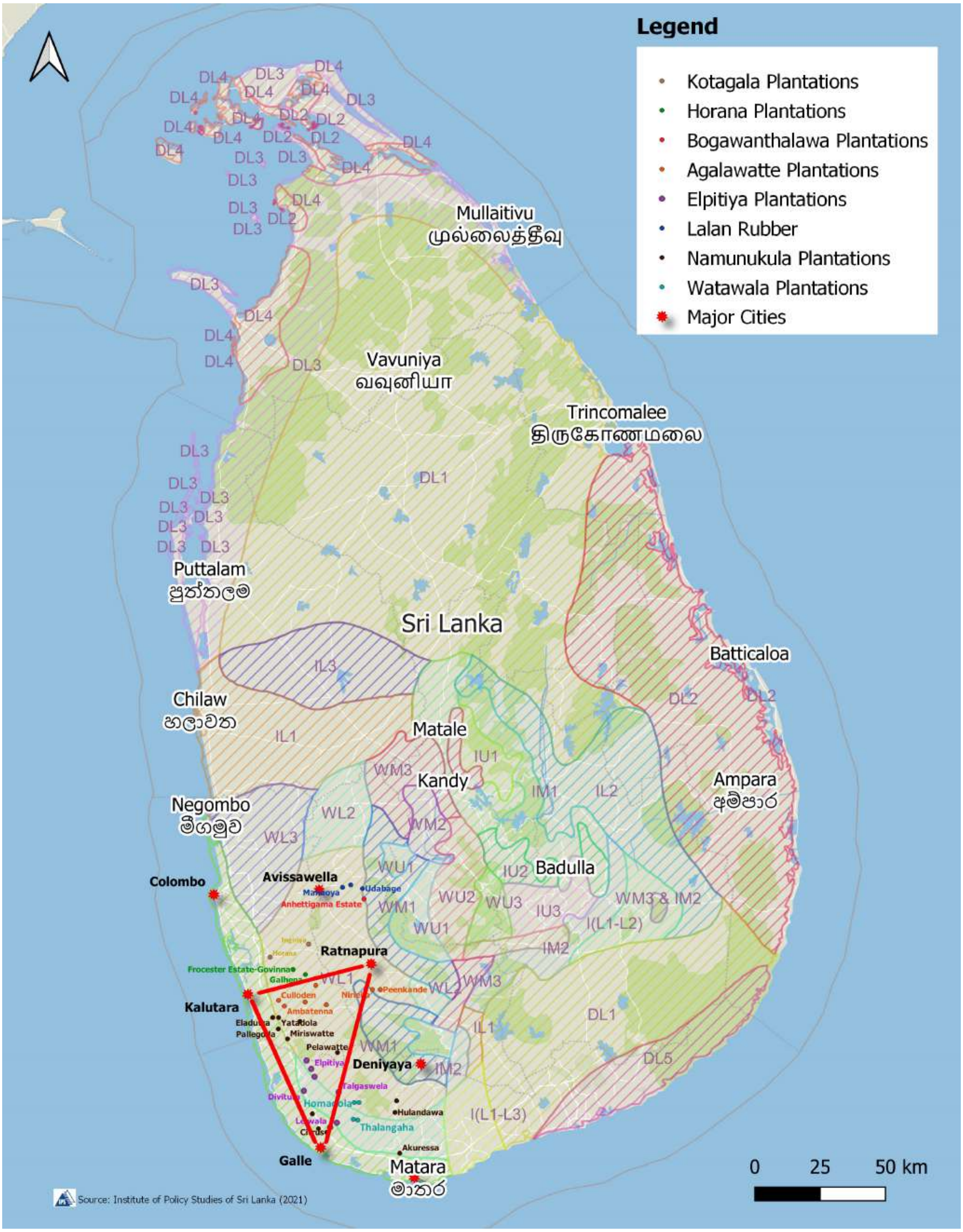
Table 6.1: Cultivation Details of the RPCs

RPC	Cultivated Area (Ha)	Annual FFB*** Production (Mt)	FFB Productivity (Mt/ha)	COP LKR/kg	Average Sales Price LKR/kg	Profit/ha LKR	Seeds
Agalawatta	1,262.6	8,953	7.09	25.13	53.14	198,617	Malaysia
Bogawanthalawa	206.59	399	1.93	71.03	51.04	-38,608	Thailand
Elpitiya	1,616.33	16,555	10.24	33.27	57.39	247,045	Malaysia & PNG
Horana	358.45	1,174	3.28	9.21	46.77	123,017	Malaysia
Lalan*	446.31	952	4.88	52.00	59	34,127	Thailand
Watawala	3,396.06	46,408	13.67	21.00	282****		Malaysia, Thailand
Kotagala	525.88	2,482	4.72	35.00	46	51,917	Indonesia / Malaysia / PNG/ Thailand
Namunukula	2,498.1	21,387	8.56	19.69	57.52	323,874	Malaysia & PNG
Total	**10,310.32**	**98,310**	**9.77**	**33.29**	**52.98****	**192,371**	

Notes: *Mature extent (195.27 ha) was used to calculate the productivity ** Excluding Watawala Plantations PLC ***Fresh fruit bunch (FFB) **** Price of crude palm oil

Source: From the survey of RPCs, Palm Oil Industry Association (POIA), 2021.

Figure 6.2: Oil Palm Plantations in Sri Lanka



Source: Authors illustration (2021).

6.3.2 Processing

The harvested FFB are transported for processing. Milling and refining are the two basic processing activities in the palm oil value chain. Two processing facilities are established among the eight RPCs. Watawala Plantations PLC has both facilities, a palm oil processing mill and a refinery. However, at the time of the study, only the milling facility is in operation.

AEN Palm Oil Processing (Pvt.) Ltd in Baduraliya is a joint venture of Agalawatte, Elpitiya and Namunukula RPCs with both milling and refining facilities. They do milling and refining for all the RPCs except Lalan Plantations and Watawala Plantations PLC. The Lalan Plantations sell their produce to the mill owned by the Watawala Plantations PLC in Nakiyadeniya. The total production of Crude palm oil in 2020 was nearly 25,000 Mt and suppliers are AEN Palm Oil Processing (Pvt.) Ltd (12,000 Mt) and Watawala Plantations PLC (13,000 Mt). Considering the FFB production, the average conversion factor of the FFB to palm oil was around 3.9 Mt; To produce 1 Mt of palm oil, 3.9 Mt of FFB was needed in 2020.

> "The average land productivity is around 2.4 Mt palm oil /ha. This is comparatively low to the best global productivity level of 3.6 Mt/ha in Malaysia."

As previously shown, the estimated land productivity is around 2.4 Mt of palm oil/ha.

The average land productivity is around 2.4 Mt palm oil /ha.This is comparatively low to the best global productivity level of 3.6 Mt/ha in Malaysia.

Watawala Plantations PLC deliver the extracted crude oil to local refineries (Pyramid Wilmar Lanka (Pvt.) Ltd, Sena Mills Refineries (Pvt.) Ltd, NMK Holdings (Pvt.) Ltd, and AEN Palm Oil Processing (Pvt.) Ltd).

AEN Palm Oil Processing (Pvt.) Ltd sells the refined oil in bulk form to other refineries (Pyramid Wilmar Lanka (Pvt.) Ltd, Sena Mills Refineries (Pvt.) Ltd, Narada Agro Industries (Pvt.) Ltd & Unilever).

Due to investment needs, most activities in the value chain are vertically and horizontally integrated at the processing stage. For example, the local two mills do the initial processing (milling) of FFBs produced by the RPCs. Then the refineries process both locally and imported crude palm oil (and crude palm olein). These handle the importation, refining and distribution, while some refineries are involved in value addition and re-exports.

6.3.3 Markets

The refineries handle the wholesale of refined oil (both locally produced and imported). They check the quality, make bulk purchases and distribute the produce to the local market.

The refined oil is mainly distributed to wholesalers in bulk form, who in turn distribute to retailers and industries. The refineries do no branding except for further processors such as Narada Agro Industries (Pvt) Ltd (part of the (NMK Holdings (Pvt) Ltd) and Pyramid Wilmar Lanka (Pvt) Ltd. They produce a range of value-added products for the local and export markets. Occasionally, the refineries sell directly (in bulk form) to industries such as bakeries, bazaar markets and food/confectionery manufacturers like Ceylon Biscuits Limited and Maliban Biscuits Limited.

6.3.4 Input Supply

The main inputs of the sector consist of fertiliser and agrochemicals, seeds and labour.

Chemical fertilisers and agrochemicals are used in cultivation. The fertiliser suppliers are CIC Fertilisers, Hayleys' Agro Chemicals, Agstar Ltd, Dimo Agri Fertiliser, Polychem, and Bogawantalawa. Ceylon Petroleum Corporation, Hayleys Agro Chemicals, and C & W Chemicals Ltd are the agro-chemical suppliers.

Seeds are mainly imported from Malaysia, followed by Thailand, Papua New Guinea (PNG), and Indonesia. In 2020, the estates employed 33,390 employees in oil palm estates. The average labour requirement is 3.7 employees/ha.

6.3.5 Service Providers

The Ministry of Plantation Industries (MPI), Ministry of Environment, Department of Plant Quarantine, Ministry of Provincial Councils, Local Government & Sports, State Ministry of Company Estate Reforms, Coconut Research Institute of Sri Lanka (CRI), Central Environment Authority (CEA), and Local Pradeshiya Sabhas are the government institutes regulating different aspects of oil palm cultivation.

The MPI is the apex body of the oil palm industry which provides permission for seed imports, planting and importation of palm oil etc.

The CRI is involved in seed importation and nursery management under strict quarantine guidelines provided by the Department of Plant Quarantine.

When a mill or a refinery is established, an 'Environmental protection license' should be obtained from the CEA for waste disposal. The CEA provides guidelines for the safe disposal of by-products and energy generation.

The manufacturers are registered under the 'National Dangerous Drugs Control Board' (to use chemicals) in processing activities.

Public and private institutes and local and foreign consultants and internal staff provide technical assistance. The CRI, the Tea Research Institute, CIC Fertilisers and individual consultants from Sri Lanka and Malaysia are part of this.

Commercial banks have provided finance facilities for plantations other than Bogawanthalawa, Elpitiya, and Namunukula Plantations, which were self-financed.

Imported oils are checked for the required quality standards at Sri Lanka Customs with the involvement of the Sri Lanka Standards Institute (SLSI). Here, samples are checked to release the same for refining. Certification is required from the SLSI for imported oils and ISO certifications (ISO 22716:2007 - the international standards for Good Manufacturing Practices -GMP).

The roundtable on sustainable palm oil (RSPO) is a globally established entity to assure a sustainable palm oil industry worldwide. The Watawala Plantations PLC has obtained certification from the RSPO. The RPCs have formed Palm Oil Industry Association (POIA), connecting plantation companies, processors, and importers.

7. Environmental Sustainability

An understanding of environmental sustainability and social acceptance of a value chain is essential for necessary decision making. However, oil palm, an exotic crop in Sri Lanka draws environmental and social criticisms. As a result, the current ban on oil palm cultivation and phasing out of existing plantations was imposed on 5 April 2021 (Presidential Secretariat, 2021). This section provides insights into the current environmental concerns of the palm oil value chain in Sri Lanka based on local and international literature.

7.1 Geographical Location of the Plantations

Optimum climatic conditions for oil palm prevailing in the best yielding areas (Indonesia and Malaysia) of the world are shown below (Lim, 2011; Carr, 2011).

- Annual Rainfall – minimum 2,000 mm, evenly spread during the year
- Mean maximum and minimum air temperatures of 29-33 ^{o}C and 22-24 ^{o}C
- Relative humidity >85% (equivalent to saturation deficits <0.6 kPa)
- Bright sunshine averaging 5h d^{-1} throughout the year, rising to 7h d^{-1} in some months (or solar radiation of 16-17 MJ m^{-2} d^{-1})

Considering the favourable climatic factors for oil palm cultivation, areas of wet zone AERs have been recommended for establishing oil palm plantations. Lands of RPCs with marginal rubber cultivation were transformed into oil palm cultivation in line with the government policy decision.

Some critiques against oil palm cultivation are based on location or the landscapes selected for cultivation. Proximity to environmentally sensitive areas such as rainforests and catchment areas, uncovering slopy lands prone to landslides, heavy soil erosion and siltation of water streams and rivers causing floods are among those. However, any agricultural land use (tea and rubber) in this area may incur the same issues but with varying degrees. Therefore, identifying the accurate locations of the lands is crucial for making necessary decisions.

Figure 7.1 illustrates the spatial distribution of oil palm plantations against the AERs of Sri Lanka. A unique combination of natural factors such as climate, soil, and terrain defines an AER. When an agro-climatic map overlaps soil and topography, the resulting map indicates AERs. Agro-climatic maps are places where the combined influence of climate is uniform throughout the area for crop production. Each AER reflects consistent agro-climate, soil, and terrain characteristics. As such, it would support a particular agricultural system where a specific variety of crops and farming techniques would thrive.

According to the spatial distribution, plantations are confined to the Western region (Figure 7.1) mostly within Kalutara, Galle and Ratnapura districts, where the low country wet zone area is located. Most oil palm plantations can be observed in the WL1 sub-region, wherein several plantations were identified within WL2, while a few locations were unavailable.

Annual rainfall and rainfall distribution throughout the year is key determinants of water availability for crop cultivation and productivity. The volume and distribution of Southwest monsoon (SWM) and the first inter-monsoon (FIM) rains were significant in establishing the five agro-ecological

Figure 7.1: Spatial Distribution of Oil Palm Plantations in the Western Region - 2021

Source: Authors illustration (2021).

Table 7.1: Rainfall in the Oil Palm Cultivated AERs

AER	Annual Rainfall (mm)	Dry Months (<100 mm)
WL1a	>3,200	January, February
WL1b	>2,800	January, February, March
WL2a	>2,400	January, February, March
WL2b	>2,200	December, January, February, March

Source: Department of Agriculture. (2008). *Rainfall and Agro-ecological Regions of Sri Lanka*. Peradeniya: Department of Agriculture.

sub-regions in the low country wet zone. Meanwhile, the months of July, August, and December to February are of comparatively less rainfall which aligns with the bimodal rainfall pattern of the country. Table 7.1 shows the annual rainfall and dry months (less than 100 mm rainfall) in the oil palm grown AERs.

7.2 Groundwater Depletion

As oil palm is an efficient oil crop with high productivity, it needs comparatively high amounts of inputs for high productivity. Oil palm is criticised for its high intake of inputs, including water (Pinzi, Leiva, López?García, Redel?Mací, & Dorado, 2014; Dayang Norwana, et al., 2011; Mol, 2007). The daily water requirement of a mature tree is 300-350 litres during the summer seasons (Carr, 2011). Areas selected for cultivating oil palm in Sri Lanka are in the wet zone. However, the distribution of rainfall patterns in each AER shows some dry spells in the region. Most plantations are in WL1a region, where annual rainfall is 3,200 mm and a dry spell of two months is prominent (less than 100 mm rainfall) from December to January.

WL1b is a small area compared to WL1a. Rainfall is 2,800 mm and the dry spell is three months (DOA, 2006). Therefore, plantations located in WL1b AER can be less productive and may contribute to groundwater depletion in the absence of irrigation during the dry months.

WL2a and WL2b regions get less rainfall (2,400 mm and 2,200mm, respectively) compared to WL1 regions and dry spells that vary from 3-4 months. Therefore, revisiting locations selected based on site-specific information, including the AERs, may be necessary to avoid potential groundwater depletion issues.

Land suitability classification provided by the Department of Land Use Planning shows (Table 7.2) that less than 2,500mm rainfall receiving lands are marginally suitable for oil palm cultivation. Hence, areas receiving less than 2,500mm of rainfall would not be favourable for the investors and the environment.

The Land Use Policy Planning Department has introduced land requirements for oil palm cultivation (Land Use Policy Planning Department, 2022). These requirements are based on climatic and soil factors.

Areas receiving less than 2,500mm annual rainfall with more than two months dry spells may not benefit the investors and the environment.

"Areas receiving less than 2,500mm annual rainfall with more than two months dry spells may not benefit the investors and the environment."

In studies done in other countries, oil palm plantations have been identified as a possible cause for periodic water deficits in surrounding villages due to soil water redistribution. Oil palm has a horizontal and vertical root system, with the majority located at a depth of 1m (100 cm). However, in the absence of any obstacles (deep soils), the vertical roots grow up to 5m (500 cm) deep (Carr, 2011). It shows the potential for groundwater depletion during dry periods. However, the studies reveal that the stomatal conductance is low when the air is dry (Carr, 2011). Therefore, the outcome is non-conclusive, but the local context must be carefully monitored.

Oil palm has a horizontal and a vertical root system. Majority of the roots are located at 100 cm depth. In the absence of any obstacles (deep soils), the vertical roots grow up to 500 cm. However, the stomatal conductance is low when the air is dry.

Table 7.2: Land Requirements for Oil Palm

Land Quality	Land Characteristics	Limiting Values for Land Characteristics			
		Most Suitable	Moderately Suitable	Marginally Suitable	Not Suitable
Temperature regime	Elevation (m)	0-300	300-600	600-900	>900
	Mean annual temperature (°C)	25-28	23-25	20-23	<20
Radiation regime	Total sunshine hours/yr	>1,600	1,400-1,600	1,200-1,400	<1,200
Growing period	Days	>330	300-330	270-300	<270
Water availability	Mean annual rainfall (mm)	>3,000	3,000-2500	2,000-2,500	<2,000
	75% probability of rainfall (mm)	>2,300	1,900-2,300	1,400-1,900	<1,400
	Soil depth (cm)	>150	150-100	100-75	<75
	Soil texture	C, ZC, ZCL, ZL	L,SC,SCL,CL, C,ZC,ZCL	L,SC,C, ZC, ZCL,SCL,SL	All
Drainage	Soil drainage class	Well drained	Well-drained to imperfectly drained	Poorly drained	Excessively or poorly drained
	Depth to groundwater	>100	75-100	50-75	<50
Nutrients and toxicities	Soil PH at 50cm	5,5-6	6.0-7,5.0-5.5	7-7.5,4-5	>7.5,<4
	Soil type Sri Lanka	24	18,21,22,24	17,19,23	1-16,20-25, 27-31
Salinity	ECe, mS cm-1, at 1m	<2	2-4	4-6	>6
Erosion hazard	Slope angle (%)	<5	5-10	10-25	>25
	Previous erosion	Nil	Slight	Moderate	Severe
Ease of land preparation	Rocks and Stones (%)	Nil	1-5	5-10	>10

Notes: *Key to the soil types is in Annex II.

Source: Land Use Policy Planning Department. (2022). *Land Requirements for Oil Palm*. Colombo: Land Use Policy Planning Department.

> "Oil palm has a horizontal and a vertical root system. Majority of the roots are located at 100 cm depth. In the absence of any obstacles (deep soils), the vertical roots grow up to 500 cm. However, the stomatal conductance is low when the air is dry."

Table 7.3 shows the proposed climatic suitability for oil palm in Malaysia, indicating the importance of rainfall distribution throughout the year. It shows that the dry season duration is less than or equal to one month in suitable and highly suitable areas for oil palm cultivation in Malaysia.

7.3 Water Quality Depletion

Water quality depletion is another concern in oil palm plantations which occurs due to nutrient leaching with the overuse of nitrogen fertiliser. However, this is a potential pollution source in any agricultural land use in this area, such as tea, rubber, paddy, and cinnamon. Oil palm may contribute comparatively higher owing to its high input need resulting in increased water quality depletion. Therefore, it should be investigated on these sites. Further research is vital to derive comparative results for leaching and minimise the hazards to the water quality caused by any agricultural land use, including oil palm.

Table 7.3: Proposed Climatic Suitability Classification for Malaysia

Climatic Elements	Highly Suitable	Suitable	Moderately Suitable	Currently Unsuitable	"Permanently Unsuitable"
Annual rainfall	2,000-2,500	2,500-3,000	3,000-4,000	4,000-5,000	>5,000
(mm/yr)		1,700-2,000	1,400-1,700	1,100-1,400	<1,100
Duration of the dry season (months)	0	1	2-4	5-6	>6
Mean annual	26-29	29-32	32-34	34-36	>36
Temperature (°C)		23-26	20-23	17-20	<20
Daily solar radiation (MJ m-2)	16-17	17-19	19-21	21-23	>23
		14-16	11-14	8-11	<8
Wind (m s-1)	<10	10-15	15-25	25-40	>40

Source: Lim, K. H. (2011). Climatic Requirements of Oil Palm. In K. J. Goh, S. B. Chiu, & S. Paramananthan, *Agronomic Principles and Practices of Oil Palm Cultivation* (pp. 1-46). Malaysia: Agricultural Crop Trust (ACT).

"Water quality depletion is a potential pollution source in any agricultural land use in this area, such as tea, rubber, paddy, and cinnamon. Oil palm may contribute comparatively higher owing to its high input."

7.4 Rainfall and Productivity

Literature in other countries has confirmed the productivity decline with low rainfall, high rainfall and dry seasons (Table 7.4 and Table 7.5). Some countries, like Thailand and dry regions in Africa, were successful in irrigation to improve the productivity of oil palm cultivation. Average fresh fruit bunches (FFB) productivity in Sri Lanka is around 9 Mt, while the maximum is comparatively very low, around 13 Mt. Therefore, land suitability and management practices of the selected lands should be revisited, considering the low productivity and environmental cost. The reasons behind the prevailing high productivity in the global context need to be identified.

7.5 Landslides and Floods

Some soils in the slopy lands of the WL1a region are prone to landslides during prolonged rainy seasons. Soils with clay layers, when combined with water, become slippery. Therefore, soil conservation measures and correct land selection are critical for plantations in slopy lands. However, tea, rubber, cinnamon, and paddy too, are cultivated in this area.

Lowlands in this area are susceptible to frequent flooding. Therefore, siltation from any agricultural land use may cause flooding if heavy soil erosion is an issue, especially, if it is not managed well. Therefore, strict soil conservation measures are necessary in the absence of undergrowth in oil palm plantations.

7.6 Environmentally Sensitive Areas

Rainforests and water catchment areas can be considered environmentally sensitive areas in the wet zone low country. The spatial analysis revealed that certain plantations are closer to environmentally sensitive areas, such as the

Table 7.4: The Estimated Peak Annual Fresh Fruit Bunch (FFB) Yield Per Hectare of Oil Palm Grown on Highly Suitable Soils in Different Rainfall Regions in Peninsular Malaysia

Rainfall Regions	Peak FFB Yield (Mt/ha/yr)
No dry season	>40
Short fairly regular dry season	35-40
Clear regular dry season	28-33
High rainfall throughout the year	30-35

Source: : Lim, K. H. (2011). Climatic Requirements of Oil Palm. In K. J. Goh, S. B. Chiu, & S. Paramananthan, *Agronomic Principles and Practices of Oil Palm Cultivation* (pp. 1-46). Malaysia: Agricultural Crop Trust (ACT).

Table 7.5: FFB Yields of Oil Palm in Different Countries

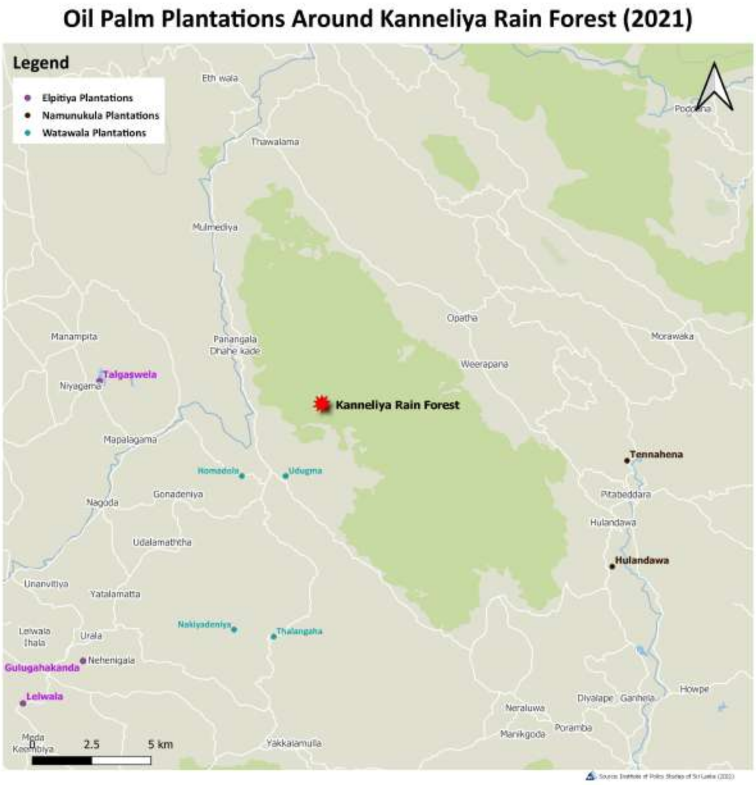
Country	Site	Rainfall (mm/year)	FFB Yield (Mt/ha/yr)
Malaysia	Perak (Kampar area)	2,875	38.8
Indonesia	North Sumatra	2,890	35.1
Thailand	Surat Thani, Krabi	-	12-24
Papua New Guinea	Kimbe	3,877	30.8
	Popondetta	2,643	31.5
	Bialla	5,408	21.4
Costa Rica	Quepos (SE)	3,927	29.5
	Quepos (NE)	2,883	23.0
	Coto	4,044	26.0
Honduras	San Alejo	2,741	29.6
Benin	Pobe	1,101	13.2
	Akpadanou	1,016	9.7
Columbia	Unipalma	2,500	26.7
Zaire	Lokutu	1,700	19.8
	Yaligimba	1,760	13.9
Ivory Coast	La Me	1,486	21.8
Nigeria	-	-	16

Source: Lim, K. H. (2011). Climatic Requirements of Oil Palm. In K. J. Goh, S. B. Chiu, & S. Paramananthan, *Agronomic Principles and Practices of Oil Palm Cultivation* (pp. 1-46). Malaysia: Agricultural Crop Trust (ACT).

Kanneliya and Yagirala rainforests. Figure 7.2 illustrates oil palm plantations situated closer to the Kanneliya rainforest. The forest lies 35 kilometres (km) Northwest of Galle and serves as a key catchment region for two of Sri Lanka's most important rivers, the Gin Ganga and the Nilwala Ganga. Oil palm plantations managed by two RPCs are situated between 0-5 km from the Kanneliya rainforest's borders. Homadola, Thalangaha and Udugama estates of Watawala Plantations PLC and Hulandawa and Thennahena estates of Namunukula Plantations PLC are identified as suitable locations within this boundary for oil palm cultivation. However, any government legislation does not specify these boundaries elsewhere for oil palm cultivation.

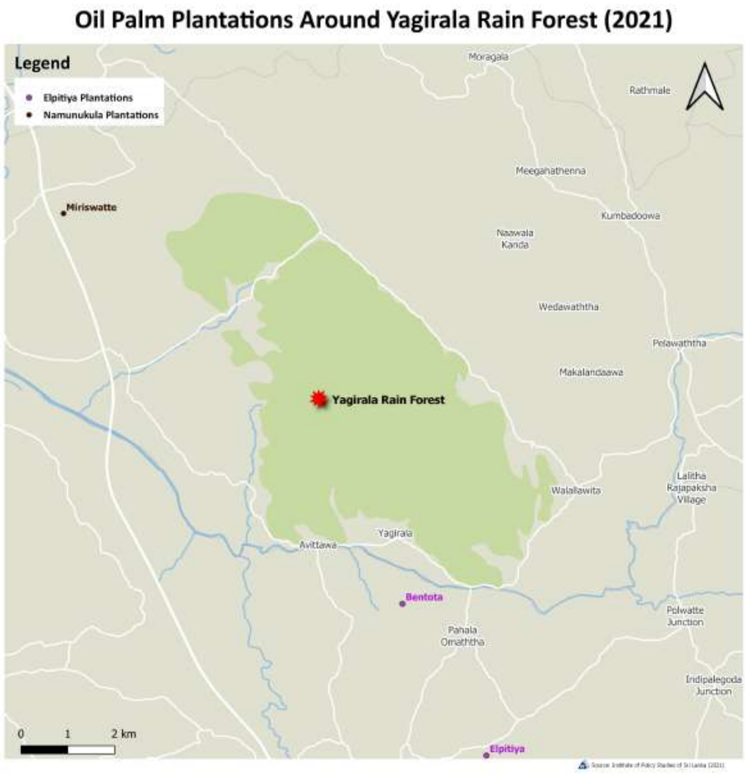
Some plantations are even closer to the Yagirala rainforest (Figure 7.3). Yagirala Forest Reserve is located in Walallawita, Kalutara District. The current environmental regulations decide the boundary to be maintained. Two plantations managed by two RPCs are between 0-2km from the ecosystem's borders; Bentota estate of Elpitiya Plantations and Miriswatte estate of Namunukula Plantations are identified as potential locations for oil palm cultivation closer to the Yagirala rainforest. Observing the legal backdrop of such establishments is, therefore, critical. The recent policy choices made in 2020 to repeal Circulars 5/2001 and 2/2006 (Withanage, 2020) applicable to other state forests would not apply to these two forest

Figure 7.2: Oil Palm Plantations Surrounding Kanneliya Rainforest



Source: Authors illustration

Figure 7.3: Oil Palm Plantations Surrounding Yagirala Rainforest



Source: Authors illustration

reserves. More in-depth spatial analysis is necessary to reveal such impacts, which is beyond the scope of this report. But this is critical for accurate decision making.

7.7 Waste Generation

Harvested bunches are removed as solid waste after extracting the seeds. Milling and refining generate tonnes of POME, a mix of crushed shells, water, and fat residues. The solid part is used as an energy source for boilers, while the empty bunches are used for compost production. These are pollutants of water streams (water quality and aquatic environment) unless well treated and deodorised before releasing it into the environment. Two mills located in the cultivated area are expected to adhere to proper waste management guidelines. The CEA has provided general guidelines to manage mill effluents. For example, Watawala Plantations has taken measures to treat the wastewater from the mill and the treated water is used for irrigation. Empty bunches are shredded/ pressed and the fibre is mulched in the field.

Noise and air pollution issues are common in industrial developments such as rubber processing, tea processing and coconut processing factories. Therefore, such pollution has to be managed according to the CEA guidelines.

"Few studies have highlighted the need for having specific guidelines for waste handling in the palm oil industry in Sri Lanka."

Other than these, refineries of locally produced and imported crude palm oil generate much environmental waste. Hence, the country bears a considerable part of the environmental cost through refining, which can be considered a value addition. Those refineries are not located in the cultivated area and are confined to the Wattala-Kerawalapitiya area. However, managing waste is crucial to minimise the environmental cost. Refinery waste (oily sludge) is a potential input for fertiliser production that applies circular economy principles and can be used for oil palm cultivation (Ngan, 2021). Currently, mill effluent is used as a fertiliser source.

Few studies have highlighted the need for having specific guidelines for waste handling in the palm oil industry in Sri Lanka (Arachchige, et al., 2019; Weerasekara, 2006; Thilakarathna, et al., 2020).

7.8 Deforestation and Biodiversity

Any agricultural land use, particularly monoculture plantations, reduces biodiversity considerably due to the loss of food chains and habitats. Therefore, converting forest land to agricultural land use has a high environmental cost. For example, oil palms contain less than 20% of the above-ground biomass of rainforest trees and thus have a lower potential to absorb carbon dioxide from the atmosphere (European Union, 2018). Oil palm plantations sustain fewer species than rubber, cocoa, or coffee plantations (Fitzherbert, Struebig, & Morel, 2008). For example, converting rubber fields to oil palm caused a 14% decrease in bird diversity in Indonesia (Peh, Sodhi, Jong, & Sekercioglu, 2006).

This economic-environment tradeoff is balanced in sustainable economic development decisions. Sri Lanka has authorised marginal rubber lands for oil palm cultivation. Hence, deforestation is not a criticism relevant for oil palm plantations unless rubber is considered a forest tree crop. However, the depletion of biodiversity and above-ground biomass is much more than the previous land use.

8. Socioeconomic Aspects of Oil Palm

8.1 Social Acceptance

Social acceptance of the new land use is critical in oil palm plantations for many reasons. Firstly, assuring environmental sustainability is essential, given that the surrounding community directly feels the environmental cost. Reported environmental costs in literature were namely; aggravating the groundwater depletion during droughts, regeneration of seeds in water streams, soil erosion and floods, damaging and blocking the water streams, possible hazards from falling bunches and fronds, waste disposal and water quality, noise and odour (CEA, 2018).

However, most issues can be effectively addressed through proper management guidelines, correct land selection and an appropriate monitoring system. For example, Watawala Plantations PLC has taken measures for volunteer cleaning of the water streams, buffer zone establishment, riparian zone establishment, forest and catchment area conservation and soil conservation. Therefore, efforts should be taken to provide guidelines for other estates to manage plantations sustainably.

"Efforts should be taken to provide guidelines for other estates to manage plantations sustainably. Lack of community inclusion is a limitation in this land use compared to rubber lands. Promoting the smallholder sector is controversial."

The previous land use was rubber in most areas. Hence, some indirect benefits they enjoyed, such as firewood, green leaf harvesting, access to water streams and labour opportunities, are excluded (CEA, 2018). Therefore, lack of community inclusion is a limitation in this land use compared to rubber lands.

The Watawala Plantations PLC has taken steps to distribute oil palm seedlings to smallholders to include them in the business. However, this may incur additional environmental costs due to difficulties in management and monitoring. Therefore, promoting the smallholder sector is controversial. It is vital to address community concerns by diverting some funds for the community's well-being and the environment. For example, it would be effective if the RPCs would divert the funds to effectively address the issues generated by oil palm cultivation. These include addressing water scarcity issues during the drought (establishing drinking water sources for the community and protecting the water streams), promoting home gardening among the community, and introducing new income earning opportunities (small businesses, cottage level businesses and linking with markets) for the community.

8.2 Economic Impact of a Cultivation Ban

The purpose of establishing oil palm cultivation at the policy level was to partially curb the import bill on palm oil imports. It was expected to meet roughly 50% of the import demand during 2015. This was around 82,404 Mt, expecting nearly 4 Mt/ha productivity and was equivalent to USD 8.3 Mn worth of imports during 2015.

At present, 10,310 ha are cultivated out of the target of 20,000 ha. Current crude palm oil production is nearly 25,000 Mt with an average productivity level of 2.5 Mt/ha. Malaysia's average productivity level in 2020 was 3.6 Mt/ha (Malaysian Palm Oil Council, 2022) and Indonesia's 3.2 Mt/ha.

The FFB production values show that the average value is 9.77 Mt/ha, which ranges from 3.28 to 13.68 Mt/ha. The FFB productivity values for Malaysia and Indonesia are 38.8 and 35.1 Mt/ha, respectively. Therefore, the achievable target of palm oil production at the current productivity level is 50,000 Mt from 20,000 ha. In 2020, the saved foreign exchange from crude palm oil imports was estimated to be USD 17 Mn, considering the average landed price of USD 679.4/Mt. It is equivalent to LKR 126,655.16/Mt.

"In 2020, the saved foreign exchange from crude palm oil imports was estimated to be USD 17 Mn."

The average cost of production of 1 Mt of FFB is LKR 33,290 and the average sales price is LKR 52,980/Mt (around 59% profit margin). Therefore, nearly 3.9 Mt of FFB are needed to produce 1 Mt of crude palm oil. The cost of FFB to produce 1 Mt of oil, excluding the processing cost, is LKR 206,622.

The price of imported oil after tax varies with the CIF price and the tax rates. In 2020, the average CIF price of crude palm oil was LKR 126,655/Mt; in 2021, it was LKR 175,121/Mt. According to the tax structure of the import tariff guide 2022, after tax price per 1 Mt was around LKR 202,243 in 2020 and LKR 279,633 in 2021. Table 8.1 shows the tax structure and tax calculations considering the 2020 price.

This is considering a 15% general duty and 15% Cess rate, 12% Value Added Tax (VAT) and 10% Ports and Airports Development Levy (PAL). Tax is around 59.6% of the CIF value. Currently, palm oil is imported under an import license scheme.

The local palm oil remains profitable, considering the variable costs and current policy context.

Table 8.1: Current Tax Structure of Imported Palm Oil

	Duty Rate	Value - LKR
CIF		126,655
Customs duty	15.0%	18,998
Surcharge	0%	-
PAL	10%	12,666
Cess Levy	15%	20,898
VAT	12%	23,026
Excise Duty	0%	-
RIDL	0.0%	-
SRL	0.0%	-
NBT	0%	-
Total Tax value		**75,588**

Source: Department of Customs. (2022). *Import Tariff Guide: Tariff Calculator.* Colombo: Department of Customs.

Usually, the profitability of local palm oil depends on import tax rates on crude palm oil (and its derivatives) and the world market price of crude palm oil (and its derivatives). For example, the local selling price of 1Mt of crude palm oil in 2021 was LKR 282,000, according to the Watawala Plantations PLC, closer to the CIF price in 2021. If the taxes are reduced, the profitability will be comparatively low. Low profits would incentivise the RPCs to increase productivity and shift away from moderately suitable lands (or less productive lands). Current local productivity levels are low compared to world productivity levels. However, owing to the current profitability, a reasonable payback period can be expected for the investments.

Palm oil is a low-price substitute for both local and imported coconut oil. For example, the wholesale market price of coconut oil was around LKR 310,092/Mt in 2019 (Coconut Development Authority (b), 2021) and LKR 480,000/Mt in 2022 (Coconut Development Authority, 2022). The import price of 1 Mt of coconut oil in 2020 was LKR 212,980 and LKR 332, 997 in 2021 (Coconut Development Authority (b), 2021). Tariff on palm oil is imposed to protect the local coconut oil industry and ensure a reasonable price for the coconut grower. It reduces the price gap and adulteration of coconut oil with palm oil. The growing demand for fresh coconuts from processing industries assures a reasonable farmgate price for the coconut growers. However, the tariff protection hinders the efficiency gains in both local palm oil and coconut oil industries while increasing the burden on consumers. It can disincentivise productivity improvements in oil palm cultivation and the coconut oil industry to adopt modern and safe technology and value addition, for instance, virgin coconut oil production and lauric acid extraction.

The RPCs have made necessary investments for oil palm cultivation and processing based on government policy decisions. The total investment cost so far is around LKR 23 Bn. Investment on processing plants (mills) and the two refineries of RPCs alone cost LKR 14 Bn. In 1980, three processing plants were initiated in Nakiyadeniya

and capacity expanded in 1992. The AEN processing plant was established in 2007.

Additionally, 33,390 employees in the palm oil sector represent around 0.4% of the country's labour force, and some smallholders are attached to Watawala Plantations PLC. However, policy provisions are not observed for smallholder participation in oil palm cultivation. In case of a phase out, the current employees can be shifted to alternative income opportunities or alternatives the RPCs would adopt.

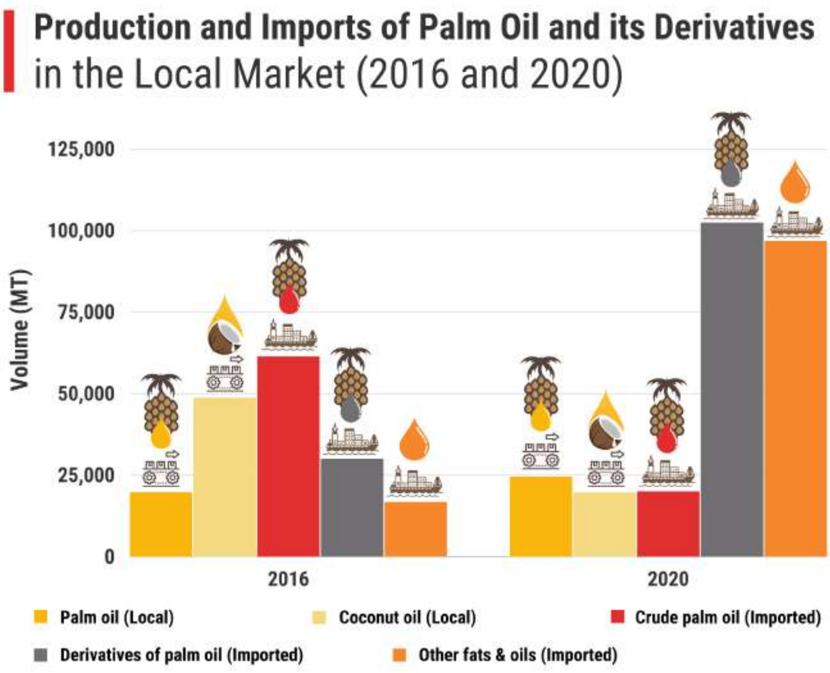
Therefore, the loss for RPCs would be nearly LKR 23 Bn, assuming no depreciation and no foregone income. However, the country has to cope with USD 17 Mn worth of forex outflow annually at the current production level (25,000 Mt) and the current world market price levels (USD 679.4/ Mt).

Capital cost = LKR 23 Bn

Annual forex outflow = USD 17 Mn = LKR 3.16 Bn

The environmental cost of oil palm cultivation can vary from other cultivation practices due to its high rate of input consumption. Criticism of deforestation can be ignored because the previous land use was rubber. Biodiversity loss is observed in agricultural lands, especially in monoculture cultivation systems. However, previous land use and alternative land uses can be more favourable for the environment and biodiversity.

Therefore, the main environmental risks which are non-conclusive through literature include groundwater depletion, water quality depletion, high soil erosion, soil compaction, increased risk of floods, landslides and threat to water catchment areas, regeneration (threat of invasiveness) and waste disposal. It is necessary to closely revisit the potential environmental cost associated with oil palm cultivation and processing and the potential practices to avoid such hazards and associated costs. If the cost to the environment is likely to outweigh the benefits to the economy, banning oil palm cultivation is appropriate, with a satisfactory compensation scheme for the investors.



Source: Coconut Development Authority, (2020).

8.3 Cultivation of Oil Palm vs Coconut

Coconut is a long-established crop with a history that dates back to the ancient king's era. It is well adapted to the domestic economy, food security and culture even after its commercial establishments, which began during Portuguese rule. Oil palm is an exotic crop introduced to the country that has many environmental concerns regardless of its economic appeal as an oil crop. Sri Lanka has decided at the policy level to phase out the oil palm cultivations over 10 years and plans to promote coconut cultivation instead. However, the stakeholders claim that the arguments are unwarranted for such a ban and possible expansion for coconut lands is limited while the productivity improvements remain partially possible.

Economic:As an oil crop, coconut can generate oil 1 Mt /ha while oil palm generates 2.5 Mt/ha under current productivity levels. The average price of coconut oil in 2019 was LKR 310,092/Mt, while crude palm oil price was around LKR 126,655.16/Mt. Approximately 9,250 coconuts are required to produce 1 Mt of coconut oil. The cost of coconuts itself surpasses the price of coconut oil. The profit margin is managed by the sales of byproducts, mainly poonac. Therefore, oil palm remains cheaper as an oil crop than coconut.

Sri Lanka has not yet reached the global oil palm productivity level of 3.6 Mt/ha. Additionally, a coconut plantation generates byproducts, some of which are raw materials for other industries. Intercropping space is available in coconut plantations. On the one hand, almost 65% of the coconut production is consumed for culinary purposes, while the rest goes to the food processing industries. Hence, coconut can be identified as a crop related to domestic food security and export industries. On the other hand, oil palm produces a single product to minimise the import demand. Most suitable lands for the oil palm do not overlap with land used for coconut. However, overlap and the tradeoff exist for rubber cultivation. Considering the country's requirement for edible oil, oil palm remains economically attractive given the limited land resources. Increasing the land productivity of coconut plantations remains a possible option to reduce domestic demand for imported oil, particularly for household use. However, it cannot meet the industry demand quantitatively and qualitatively due to its unique properties.

Health: Coconut oil (CNO) has been a major source of dietary fats for centuries in Sri Lankan diets and plays a potential role in nutrition and health. Apart from its food and industrial applications, CNO has attracted its attention for numerous health effects. The consumption of CNO has risen due to scientific-based high advertising campaigns for its numerous health benefits such as hypocholesterolemic, anticancer, antiepatosteatotic, antidiabetic, antioxidant, anti-inflammatory, and antimicrobial and moisturising properties. Though it has been proven for health-beneficial effects, the consumption of CNO is still underrated due to a lack of supportive scientific evidence. Though studies done in Asian countries, including Sri Lanka, show a favourable impact on cardiac health and serum lipid profile, the limitations in several studies conducted among Western countries impede the endorsement of the real value of coconut oil. Hence, extensive long-term studies with proper methodologies are essential to clear controversies and misconceptions about CNO consumption. Similarly, palm oil has mixed outcomes for health-related issues. However, the issues related to processing, storage and quality of oil are the major concerns embedded in the health-related issues of both oils. For example, coconut oil is criticised for the availability of aflatoxin, which can harm human health in a certain concentration. The main reason for aflatoxin is the processing technology, particularly copra processing. A recent study has detected that 38% of the coconut oil samples with aflatoxin, while virgin coconut oil and other vegetable oils, were below the detection level given the methodology used (Karunarathna, 2019). Therefore, a technology shift for healthy processing technologies such as virgin coconut oil and other value additions such as lauric acid with export potential is recommended for the coconut oil industry.

"A recent study has detected that 38% of the coconut oil samples with aflatoxin, while virgin coconut oil and other vegetable oils, were below the detection level. Therefore, a technology shift for healthy processing technologies such as virgin coconut oil recommended for the coconut oil industry. "

Environmental: Coconut cultivation is rarely criticised for environmental costs. It is cultivated mainly in lowlands, intercropped with other crops, and planted in home gardens. Oil palm cultivation is criticised for several environmental issues. Oil palm is grown in wet zone low country landscapes, which are slopy and may not be well suited for coconut cultivation. Soil erosion, groundwater depletion, water quality depletion, mill effluents, regeneration, blocking water streams, salinisation, landslides and floods are the inherent environmental issues attached to oil palm cultivation. The most suitable landscape for oil palm is in environmentally sensitive areas such as rainforests and catchment areas. Also, the crop is aggressive, restricting other plant species' undergrowth. Hence, the soil is uncovered and mulching, therefore, other soil conservation practices are crucial in minimising soil erosion. Most soils in WL1a are prone to landslides during continuous rainy periods. Therefore, stringent measures must be practised in oil palm plantations, whereas managing coconut lands is comparatively easier.

Social Acceptance and Inclusiveness: Coconut plantations are socially accepted at both plantation and smallholder levels. It is grown in home gardens as well. Being a multipurpose tree, coconut is considered "Kalpa Wruksha" and "Kap Ruka" among Sri Lankans. It is highly attached to the food habits and culture of the people. Further, it generates an acceptable economic return, a healthy source of food and zero environmental hazards. Community members benefit from related labour work and various coconut-based industries.

However, oil palm, an exotic crop with a single output, can be considered a cash crop with limited uses for the surrounding community. Processing and extraction technologies are also possible only at the industry level. Due to the limitations of having an undergrowth, biodiversity is comparatively low. Additionally, having an oil palm in proximity to public roads is hazardous. Some people are concerned about soil erosion, floods, groundwater level and water quality depletion and less employment generation. Therefore, social acceptance is considerably low for oil palm. However, addressing these issues may be essential to increase social acceptance.

9. Conclusions and Recommendations

9.1 Conclusions

The local palm oil industry currently holds the potential to provide around 6% of the local edible oil demand. The study shows that oil palm cultivation has the potential to save around USD 17 Mn in forex outflow annually, which varies with international prices, exchange rate volatility and local productivity. Capital investment estimated so far is LKR 23 Bn. Additionally, the industry employs over 33,390 people and has attractive profit margins.

The average productivity of lands in Sri Lanka is 2.5 Mt/ha, which is below the global best average productivity levels of 3.6 Mt/ha in Malaysia and 3.2 Mt/ha in Indonesia. Hence, initial policy planning for 4 Mt/ha is unrealistic. Yet, the palm oil price is substantially lower than coconut oil. Due to palm oil's specific characteristics, coconut oil is barely considered a perfect substitute for industry needs. Moreover, the current coconut production capacity is insufficient to meet the local edible oil demand. Currently, nearly 74% of the fats and oil requirements in the country are supplied through imports.

Tax on palm oil imports protects the local edible oil industries, palm oil and coconut oil. However, it disincentivises productivity improvements in oil palm cultivation and value addition in the coconut oil industry.

The annual rainfall and the dry spell length are the main determinants of FFB productivity, both locally and internationally. Hence, selecting the most suitable lands for oil palm cultivation benefits the economy and the environment.

Any agricultural land use would reduce the quality of the environment in terms of biodiversity, GHG emissions, soil erosion, nutrient leaching, water quality depletion etc. This will vary depending on the nature of the crop. According to the literature, oil palm has potential specific issues, mainly related to soil erosion, groundwater depletion, water quality depletion, siltation, regeneration and mill effluent disposal, which require guidelines for stringent management practices. However, the literature on environmental impacts remains non-conclusive. The RPCs have taken measures to adopt sustainable management practices. Yet, close monitoring by the authorities is not evident.

More importantly, suitable lands for oil palm cultivation exist in the low country wet zone areas, which are closer to environmentally important and sensitive areas. However, there is no regulation governing the establishment of plantation crops and replacing existing conventional plantations in ecologically sensitive locations. Nevertheless, the CRI has provided some guidelines for oil palm cultivation.

Social acceptance tends to be very low owing to its perceived environmental impacts on the community and a lack of community inclusiveness. Encouraging oil palm smallholders would not be a solution to address inclusiveness since monitoring the potential environmental risks would not be feasible. Currently, no policy provision has been brought into force for smallholders to adopt oil palm.

The health hazards of palm oil consumption literature remain non-conclusive. However, unhealthy processing, adulteration with repeatedly used oils and unhealthy storage contribute to health-related issues of locally consumed edible oils (palm oil and coconut oil).

Consumption patterns show that per capita consumption of edible oil has gradually increased locally and globally. Owing to the current economic crisis in Sri Lanka, affording the local edible oil needs through imports will be challenging.

9.2 Recommendations

The productivity levels of mature oil palm are low compared to the global productivity levels. Therefore, possible causes for low productivity should be identified and measures to improve productivity must be adopted.

Literature on environmental issues remains mixed and non-conclusive. Hence, scientific land use planning techniques and accurate spatial analysis considering hydrological and hydrogeological conditions are necessary to identify suitable areas for oil palm cultivation due to its criticism of groundwater depletion. Necessary guidelines and regulatory provisions are essential for establishing oil palm plantations (and other crop plantations) in environmentally sensitive areas.

Periodic monitoring is recommended as a precautionary measure to minimise potential environmental issues regardless of mixed literature.

Further, it is necessary to enhance the community's inclusiveness and acceptance through facilitating community programmes, such as supporting other home gardening activities and alternative income sources and linking these to markets. Moreover, RPCs need to gain community acceptance by minimising potential environmental impacts discussed in the literature, such as groundwater depletion, water quality depletion, regeneration, siltation and soil erosion, which would directly affect the surrounding environment and the community.

Oil palm smallholder cultivation has no policy provisions. Due to the scattered nature of cultivation, difficulties would arise in proper monitoring and environmental management for the potential impacts, such as regeneration and local biodiversity. Hence, the relevant authorities need to pay attention to regulating smallholder cultivation.

Necessary assistance should be provided for the RPCs by the relevant authorities to manage the environmental sustainability of the oil palm industry.

The monitoring cost would be a considerable expense for the government and possibly be financed through the import Cess collected from palm oil imports or a production levy from the local producers.

Meanwhile, maintaining a low import tariff level for palm oil and its derivatives is recommended considering the low productivity levels of the oil palm estates. A shift in coconut oil industry technology for better technologies and value-added products, such as virgin coconut oil production and lauric acid extraction, is vital to minimise the impact on the coconut industry.

It is necessary to closely revisit and monitor the potential environmental cost associated with oil palm cultivation (compared to rubber and tea) and processing and the effectiveness of potential practices to avoid such hazards and associated costs. If the environmental cost is likely to outweigh the economic benefits, banning oil palm cultivation is appropriate, with a reasonable compensation scheme for the RPCs. The analysis regarding these concerns should be conducted independently and fairly with the involvement of relevant experts and authorities adequately representing the sector stakeholders.

Health hazards of consuming edible oils (palm oil, coconut oil and other edible oils locally produced and imported) need to be minimised through necessary enforcement, monitoring and awareness creation on processing, storage, quality control and adulteration.

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Annex - 01

Key To Tables of Land Use Requirments

Key to Sri Lanka Soil Classes

1. Reddish brown earths with moderate amount of gravel in subsoil and low humic gley soils,undulating terrain.
2. Reddish brown earths with high amount of gravel in subsoil and low humic gley soils, undulating terrain.
3. Reddish brown earths and solodised solonetz undulating terrain.
4. Reddish brown earths, noncalcic brown soils and low humic gley soils, undulating terrain.
5. Reddish brown earths and immature brown loams, rolling, hilly and steep terrain.
6. Noncalcic brown soils and low humic gley soils, undulating terrain.
7. Noncalcic brown soils, soils on old alluvium and solodised, solonetz, undulating terrain.
8. Red- Yellow latosols, flat to slightly undulating terrain
9. Calcic red-yellow tatosols, flat terrain.
10. Solodised solonetz and solonchacks, flat terrain.
11. Grumusols, flat terrain.
12. Soils on recent marine calcareous sediments, flat terrain.
13. Alluvial soils of variable drainage and texture, flat terrain.
14. Regosols on recent beach and dune sands, flat terrain.
15. Red-yellow podzolic soils and mountain regosols, mountainous terrain.
16. Red-yellow podzolic soils, steeply dissected,hilly and rolling terrain.
17. Red-yellow podzolic soils with strongly mottled subsoil and low humic gley soils, rolling and undulating terrain.
18. Red-yellow podzolic soils with soft and hard laterite, rolling and undulating terrain.
19. Red-yellow podzolic soils with dark B horizon and red-yellow podzoilc soils with prominent A1 horizon, rolling terrain.
20. Red-yellow podzolic soils with semi prominent A1 horizon,hilly to rolling terrain.
21. Redish brown latosolic soils,steeply dissected,hilly and rolling terrain.

22. Immature brown loams, steeply dissected,hilly and rolling terrain.
23. Bog and half-bog soils, flat terrain.
24. Latosols and regosols on old red and yellow sands, flat terrain.
25. Alluvial soils of variable drainage and texture, flat terrain.
26. Regosols on recent beach sands, flat terrain.
27. Rock knob plain.
28. Eroded land.
29. Erosinal remnants(inselbergs)
30. Steep rockland and lithosols.

Table 11.1: Soil Textures

LS	Loamy Sand	**CL**	Clay Loam
SL	Sandy Loam	**ZCL**	Silty Clay Loam
L	Loam	**SC**	Sandy Clay
SCS	Sandy Clay Loam	**ZIC**	Silty Clay
ZL	Silt Loam	**C**	Clay
Z	Silt		

Annex - 02

Table 12.1: Fatty Acid Composition (%) of Palm Oil, its Fractions and PKO Compared to Other Widely Used Vegetable Oils

Fatty Acid	Palm Oil	Palm Olein	Palm Stearin	PKO	Coconut	Soybean	Cotton Seed	Olive
Caproic (6:0)	ND*	ND	ND	ND-0.8	ND-0.7	ND	ND	ND
Caprylic (8:0)	ND	ND	ND	2.4-6.2	4.6-10.0	ND	ND	ND
Capric (10:0)	ND	ND	ND	2.6-5.0	5.0-8.0	ND	ND	ND
Lauric (12:0)	ND-0.5	0.1-0.5	0.1-0.5	45-55	45.1-53.2	ND-0.1	ND-0.2	ND
Myristic (14:0)	0.5-2.0	0.5-1.5	1.0-2.0	14-18	16.8-21	ND-0.2	0.6-1.0	<0.1
Palmitic (16:0)	39.3-47.5	38-43.5	48.0-74.0	6.5-10	7.5-10.2	8.0-13.5	21.4-26.4	7.5-20.0
Stearic (18:0)	3.5-6.0	3.5-5.0	3.9-6.0	1.0-3.0	2.0-4.0	2.0-5.4	2.1-3.3	0.5-5.0
Oleic (18:1)	36--44	39.8-46	15.5-36.0	12-19	5.0-10.0	17-30	14.7-21.7	55-83
Linoleic (18:2)	9-12	10-13.5	3.0-10.0	1.0-3.5	1.0-2.5	48.0-59.0	46.7-58.2	3.5-21.0
Linolenic (18:3)	ND-0.5	ND-0.6	ND-0.5	ND-0.2	ND-0.2	4.5-11.0	ND-0.4	<1.5
Arachidic (20:0)	ND-1.0	ND-0.6	ND-1.0	ND-0.2	ND-0.2	0.1-0.6	0.2-0.5	<0.3
Total SFAs	43.3-5.0	42.5-51.1	53-83.5	71.5-98.2	81-85.2	10-19.2	25.3-31.4	8-25.4
Total MUFAs	36--44	39.8-46	15.5-36.0	12-19	5.0-10.0	17-30	14.7-21.7	55-83
Total PUFAs	9-12.5	10-14.1	ND-1.5	1.0-3.7	ND-0.4	52.5-70	46.7-58.6	3.5-22.8

Source: Extracted and adapted from Codex Standard for Named Vegetable Oils (CODEX-STAN 210 - 1999).
*ND: Not Detected

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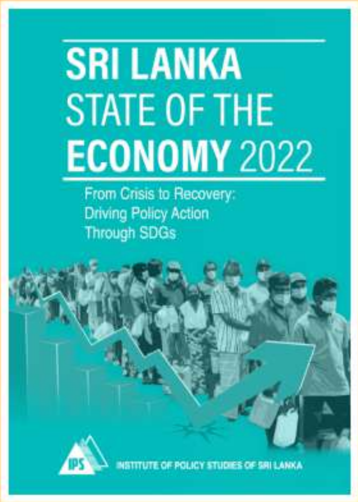

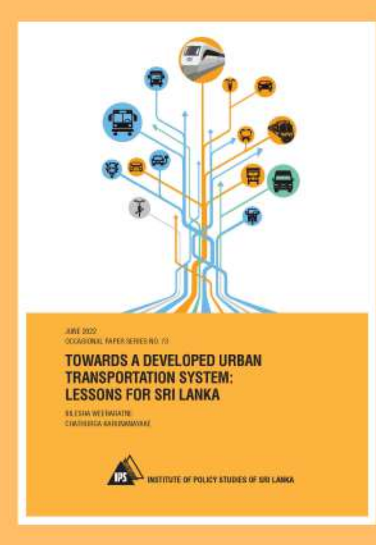

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