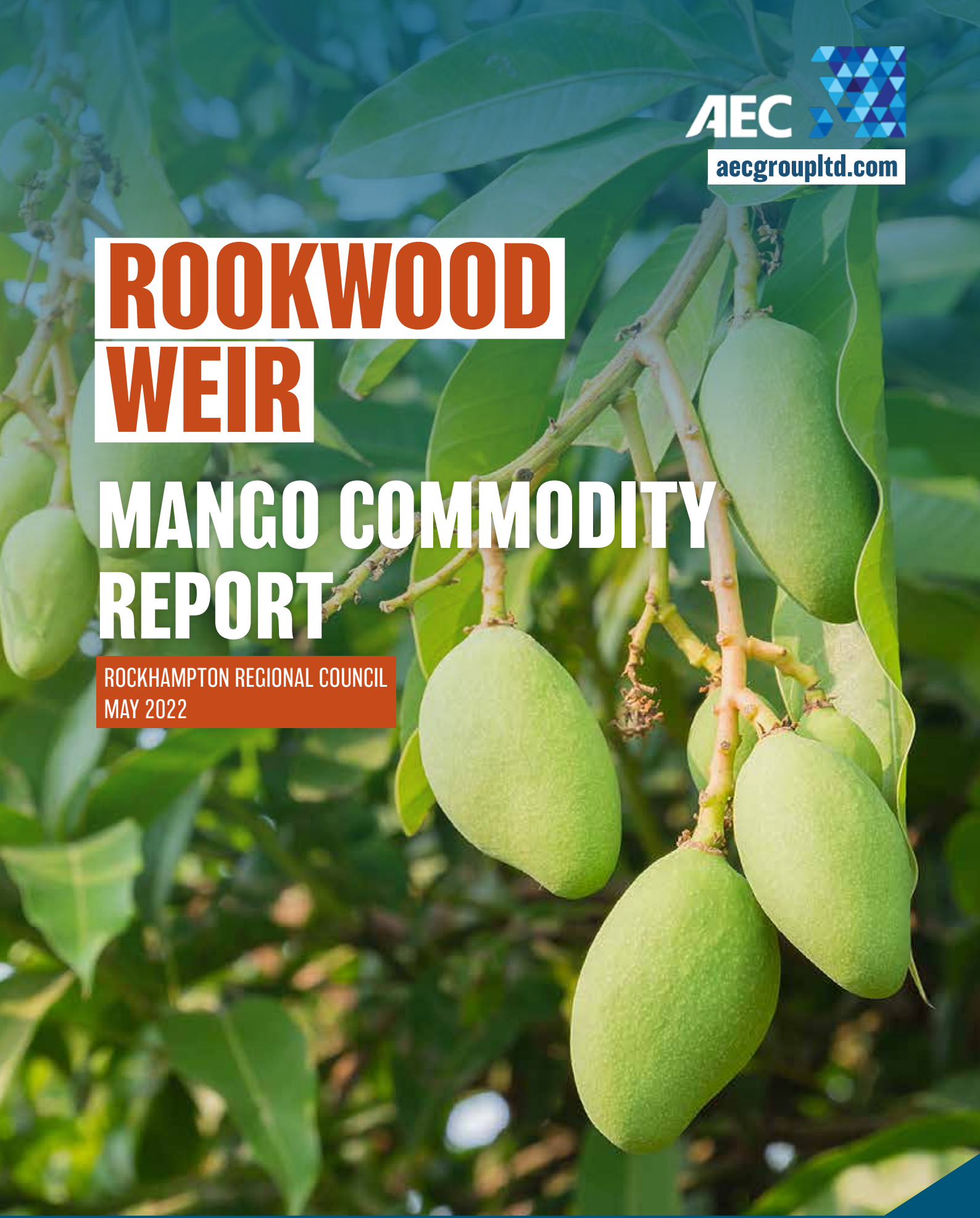

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ROOKWOOD WEIR

MANGO COMMODITY REPORT

ROCKHAMPTON REGIONAL COUNCIL
MAY 2022

THE ROOKWOOD WEIR LANDHOLDER SUPPORT AND GRANTS PROGRAM IS PROUDLY FUNDED BY SUNWATER WITH COORDINATION PROVIDED BY ADVANCE ROCKHAMPTON

ADVANCE ROCKHAMPTON

Rockhampton Regional Council

sunwater

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DISCLAIMER

The document contents form part of the explanatory materials for use in the Rockwood Weir Commodity and Farm Enterprise business case preparation and analysis. It does not purport to be a comprehensive nor complete record of every decision variable used by any party in the running any agricultural operation. The driver tree variables contained herein may be aggregated and/or excluded from any financial modelling used in the broader project. This document only provides a discussion tool to elicit information from potential stakeholders who may participate in the Project.

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EXECUTIVE SUMMARY

BACKGROUND

The Rookwood Weir is a landmark project that will capture water in the lower Fitzroy River for use across the region. Once complete, Rookwood Weir will be the largest weir operated by Sunwater in regional Queensland. This valuable new water source will improve regional water security and deliver economic growth and jobs for Central Queenslanders.

The Rookwood Weir Landholder Support Program (LSP) focuses on providing support to eligible landholders in the Lower Fitzroy region to prepare for the second tranche of water sales from Rookwood Weir. Landholders will be eligible to bid for parcels up to 500 megalitres (ML), of the 7,500 ML of medium priority (MP) water available. The primary objective of the LSP is to provide support to selected landholders to assist their understanding of potential productive use, irrigation, investment requirements and commercial feasibility of obtaining water from Rookwood Weir.

This report provides an in-depth analysis of the global market for mangoes and assesses the potential agribusiness opportunities for the production of mangoes within the Rookwood Weir catchment area.

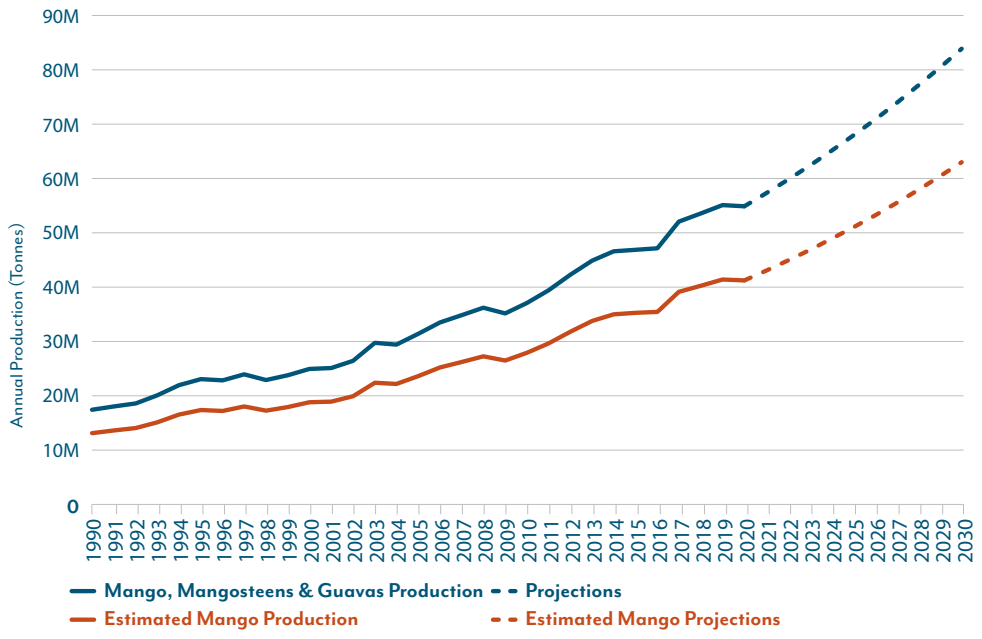
The market outlook presented in this report is based on research of historical and forecast information, and engagement with key stakeholders and industry associations. The analysis also includes commentary on the growing conditions and requirements for commercial mango orchards in the Australian environment, including soil suitability, water availability, orchard management, pest and weed control, infrastructure, and equipment.

COMMODITY OUTLOOK

GLOBAL PRODUCTION

Mangoes are a popular global fruit which are grown in over 100 countries around the globe, 65 of which produce more than 1,000 tonnes of mangoes a year (ISHS, 2014). The global production highlighted in the figure below is based on volumes provided by FAOSTAT which include the production of mangoes, guavas and mangosteens. Mangoes are the dominant fruit on the global scale, with the Organisation for Economic Co-operation OECD and Food and Agriculture Organisation's (FAO) future projections highlighting that, on average, mango accounts for 75% of total production, guava for 15% and mangosteen for the remaining 10% (2022). Unfortunately, standalone mango data is not published separately.

Figure ES. 1. Global Mango, Mangosteens & Guavas Production, 1990 to 2030



Source: FAOSTAT (2022), OECD-FAO (2021).

INDIA

India is by far the largest producer of mangoes, mangosteens and guavas on the global scale, with production totalling 24.7 million tonnes in 2020. It is estimated that approximately 83% of this represented mango production and the remainder represented guava production (based on production statistics for India). The second most prominent producer in 2020 was Indonesia, followed by Mexico.

Mango production in India experienced a declining trend from 2018 to 2020, while the area under cultivation increased. Mango production has been on the decline over these years as a result from various cyclones and extreme weather conditions, bad soil condition, and climate change (The Federal, 2021). Further, in 2021, the west coast of India (where a significant portion of the mango trees are located) was hit by cyclone Tauktae which significantly disrupted mango harvests throughout India. It was reported that around 70% to 80% of the mango crop was yet to be harvested before the cyclone hit (Times of India, 2021).

INDONESIA

Mango production in Indonesia has been increasing by an average annual rate of 4.4% per annum from 1997 to 2020. In 2020, it was estimated that production totalled 2.9 million tonnes.

From 2009 to 2010, Indonesia experienced production decline across all major growing regions (in particular East Java), with production declining by nearly one million tonnes over the year. The decline in production can be attributed to several factors including the volcanic eruption of Mount Merapi which occurred in 2010. The month-long eruptions destroyed more than 1,000 Ha of production farming land (Utami, S., et al., 2018).

CHINA

Although China was listed as the largest producer of mangoes, mangosteens and guavas in 2020, China has historically been the second-largest producer on the global scale. Production volumes in China have largely been on the decline since 2005 where production peaked at 4.1 million tonnes. From 2005 onwards, China has experienced a decline in production, decreasing by an average 3.6% per annum to reach a total of 2.4 million tonnes in 2020. China has issues with access to quality water for agriculture which has led to issues for agricultural production and the general population's access to drinking water (Latham & Watkins, 2018).

A report from Gao A, et. al (2020) suggests that China is the only country around the globe that has the potential to produce mangoes annually. The late maturing mangoes are largely concentrated in Sichuan, Yunnan and the south of Fujian.

MAJOR EXPORTERS AND IMPORTERS

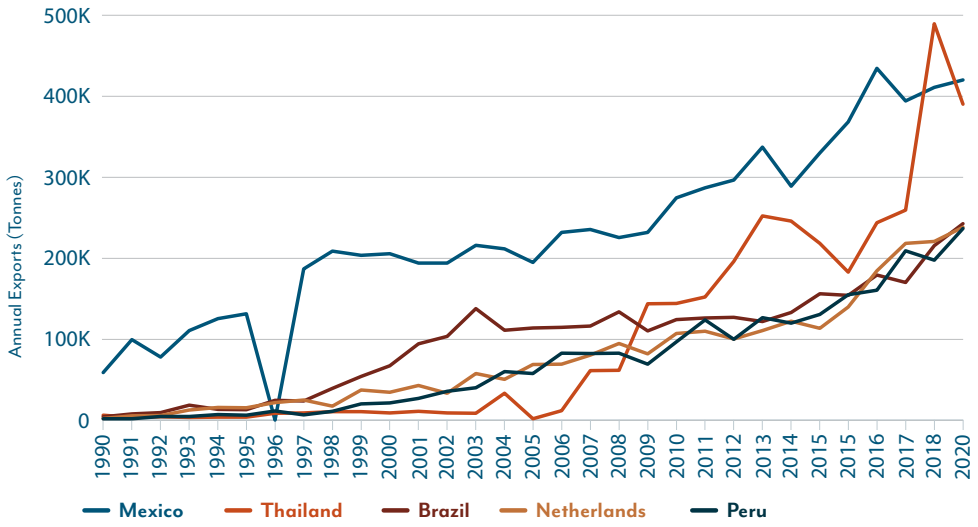
EXPORTERS

Global exports have experienced an average annual increase of 10.1% since 1990, totalling 2.2 million tonnes in 2020. Only 4.1% of the total global mango, mangosteen and guava production was exported in 2020, indicating that a large portion of the fruits are consumed domestically.

In 2020, Mexico was the largest exporter of mangoes, mangosteens and guavas with exports totalling over 421,000 tonnes. Mexico is a large supplier of mangoes to the US, with approximately 88.3% of total exports from Mexico destined for the US in 2020 (FAOSTAT, 2022). Demand from the US for Mexican mangoes are projected to increase in the future, and the import demand will see Mexican mango exports total approximately 22% of global exports in 2030 (653,350 tonnes).

The second largest exporter of mangoes, mangosteens and guavas in the global market was Thailand. In 2020, it was estimated that Thailand exported a total of 391,279 tonnes, accounting for approximately 23.6% of the country's total production for the year. Thailand is a relatively large supplier of mangoes to China, with mango exports to China totalling an estimated 58.6% of total exports in 2020 (FAOSTAT, 2022).

Figure ES. 2. Top Five Largest Exporters of Mangoes, Mangosteens & Guavas, 1990 to 2020



Notes:
- No export data is available for Mexico in 1996.
- Top five largest exporters in 2020.

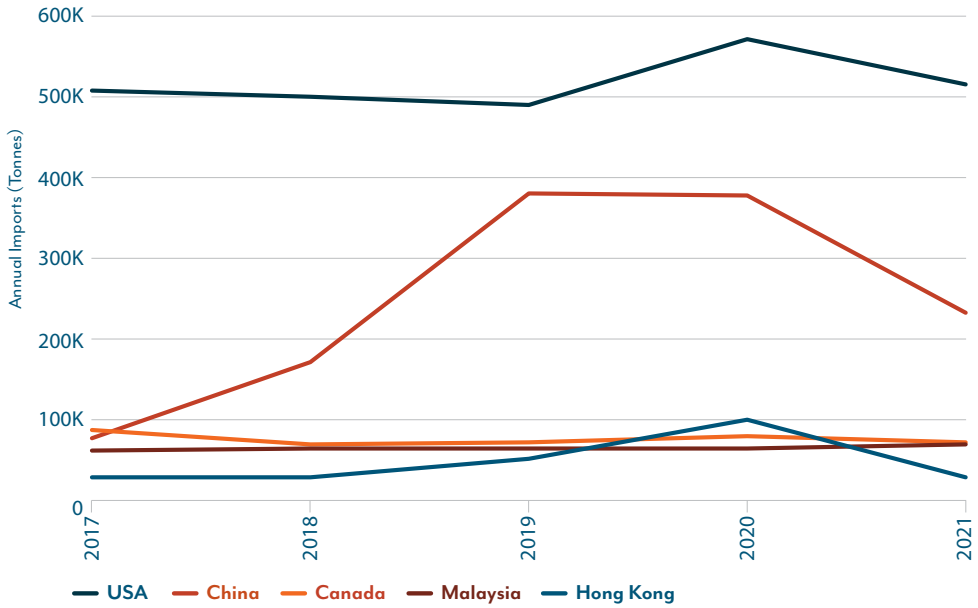
Source: FAOSTAT (2022).

IMPORTERS

The US was the largest-global importer of mangoes, mangosteens and guavas in 2021, importing approximately 516,840 tonnes. From 2017 to 2021, the average annual growth rate of imports in the US has totalled 0.4% per annum.

China was the second largest importer of mangoes, mangosteens and guavas, importing approximately 231,608 tonnes in 2021. The largest supplier of mangoes to China in 2020 was Thailand, accounting for 70.4% of total mango imports in China (Fresh Logic, 2022). Mango, mangosteen and guava imports to China are projected to increase by an average annual rate of 4.9% per annum to 2030. Based on 2020 import information provided by Fresh Logic (2022), it is estimated that in 2030, mango imports to China could total 611,158 tonnes.

Figure ES. 3. Top Five Largest Importers of Mangoes, 2017 to 2021



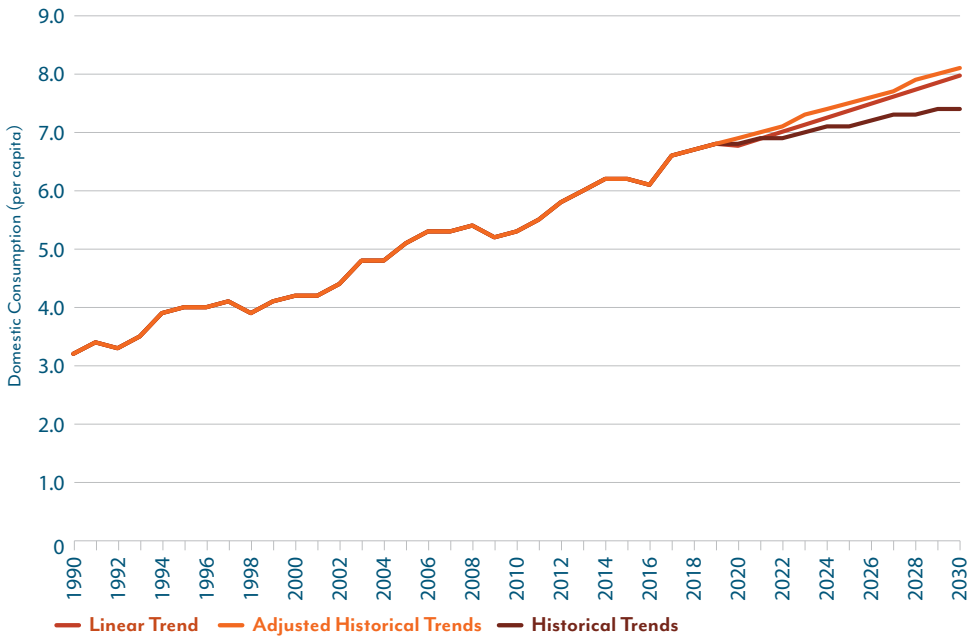
Notes:
- Top five largest importers in 2021.
- No import data for Malaysia in 2019.

Source: Fresh Logic (2022).

GLOBAL CONSUMPTION AND DEMAND

The Agricultural Outlook 2021-2030 highlights that India is projected to experience strong growth in per capita consumption, reaching a total of 28.4 kilograms per capita in 2030 (OECD-FAO, 2021). Similarly, consumption in Asia is projected to grow from 10.4 kilograms in 2020 to 14.6 kilograms per capita in 2030 (OECD-FAO, 2021). The National Mango Board have highlighted that their goal is to increase consumption of fresh mango in the US to approximately 3.2 kilograms per capita in 2030 (Fresh Plaza, 2021b).

Figure ES. 4. Consumption Per Capita, 1990 to 2030 (Kilograms Per Capita)



Source: USDA (2022), IMF (2022), OECD (2022), FAOSTAT (2022), AEC.

AUSTRALIAN INDUSTRY

Australia's production of mangoes, mangosteens and guavas has grown from 9,262 tonnes in 1990 to 51,528 tonnes in 2021. This increase equates to an average annual growth rate of 5.7% and is reflective of increased domestic consumption demand. Forecast information from the Australian Mango Society indicated that mango production could total 55,944 tonnes in the 2022 financial year.

Australia does not export significant volumes of mangoes compared to other countries, with the growth in production reflecting an increase in supply to the domestic market. The industry is relatively opportunistic and if the domestic market is performing well, mangoes will be sold in the domestic market.

In 2021, Kensington Pride was the most widely produced variety in the domestic market (accounting for 36.0% of total production for the year) (Australian Mango Industry Association, unpublished). The second largest variety by production volumes in Australia was Calypso, estimated at 14,428 tonnes in 2021.

CENTRAL QUEENSLAND MANGO PRODUCTION

Mango production is prominent throughout the broader Central Queensland region with approximately 264,405 trees of bearing age and an additional 53,221 trees which are not yet of bearing age in FY2020. From FY2015 to FY2017 the Central Queensland region experienced a year-on-year decline in both non-bearing and bearing trees. This impact is a result of several factors including cyclones, namely Cyclone Marcia in 2015 and Cyclone Debbie at the beginning of 2017.

AUSTRALIA'S KEY MARKETS

In 2021, New Zealand was Australia's largest export market for mangoes, accounting for 18.2% of Australia's exports. This was followed by Singapore (17.1%) and Hong Kong (16.5%).

Table ES. 1. Australia's Top Four Key Exports in 2020

Country	2020	Proportion Of Exports 2020 (%)
New Zealand	1,123	18%
Singapore	1,059	17%
Hong Kong	1,020	16%
UAE	844	14%
Other	2,137	35%
Total	**6,183**	**100%**

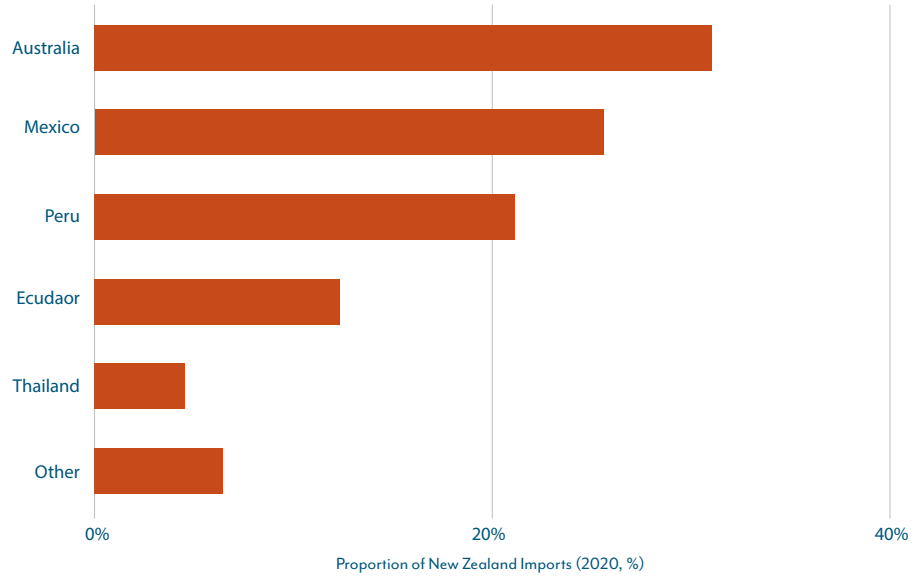
Notes:
- Largest export markets in 2020.
- Data is presented in calendar years, therefore, export volumes will differ to those presented by Hort Innovation which is presented in financial years.

Source: Fresh Logic (2022).

NEW ZEALAND

In 2020, Australia exported little over 1,120 tonnes to New Zealand. The figure below identifies mango imports to New Zealand in 2020 by country. In 2020, it was estimated that Australian mango exports to New Zealand accounted for approximately 30.8% of the country's total mango imports.

Figure ES. 5. Mango Imports to New Zealand, 2020

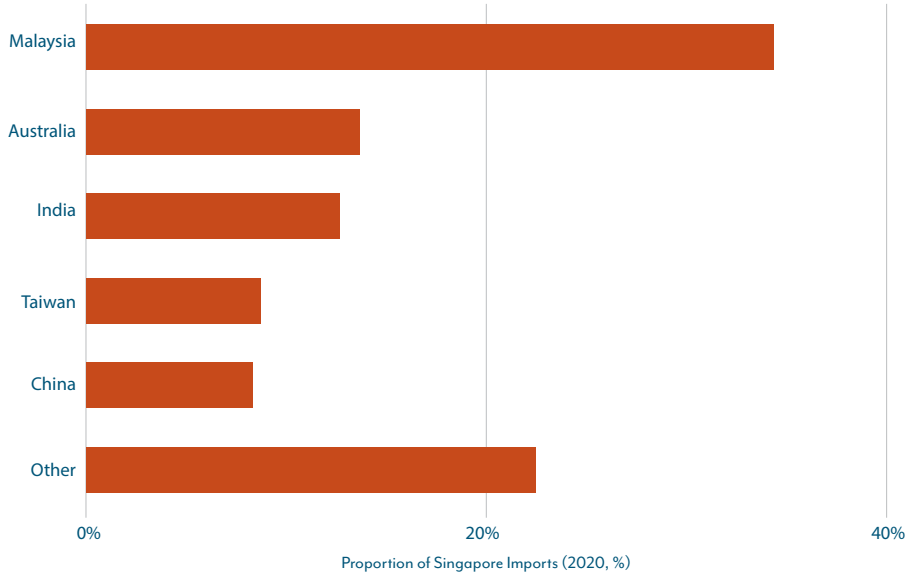


Source: Fresh Logic (2022).

SINGAPORE

In 2020, Singapore was Australia's second-largest export market. The figure below highlights that Singapore sourced a large portion of mango imports from Malaysia, accounting for 34.3% of total imports in 2020. Australia was the second-largest supplier for mangoes into Singapore in 2020, accounting for 13.6% of total imports for the year.

Figure ES. 6. Mango Imports to Singapore, 2020

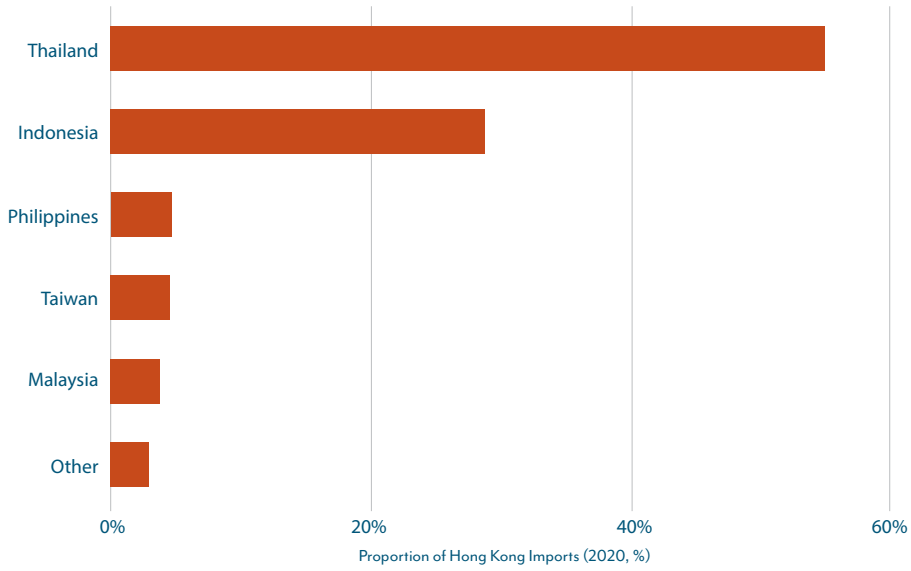


Source: Fresh Logic (2022).

HONG KONG

The figure below highlights that Hong Kong sourced a large portion of mango imports from Thailand, accounting for 54.8% of total imports in 2020. Indonesia was the second largest supplier for mangoes into Hong Kong in 2020, accounting for 28.8% of total imports for the year.

Figure ES. 7. Mango Imports to Hong Kong, 2020



Source: Fresh Logic (2022).

SUPPLY CHAIN REQUIREMENTS

Growers can sell their mangoes directly, or through wholesale agents based at the major metropolitan produce markets and distribution centers. Most Queensland mangoes are consigned to wholesalers in Brisbane, Sydney, Melbourne and Adelaide. Transport to the distribution centers is required to be in refrigerated vehicles, otherwise the quality of the fruit will be impacted.

Figure 4.3 illustrates the major mango production areas and distribution centers in Australia, as well as the major domestic and export markets.

Figure ES. 8. Geographical Distribution of Major Mango Production Zones vs. Domestic and Export Markets (Excluding New Zealand)

Black = Major Production Zones, Blue = Major Domestic Markets, Red = Major Export Markets

Key export markets include both protocol and non-protocol markets. Protocol markets include countries that have an agreement with Australia prescribing the export requirements. For mangoes, these are China, Japan, Korea, New Zealand, and USA. Non-protocol markets include countries whereby there is no agreement with Australia prescribing the export requirements, generally making these countries easier to export to than protocol markets. These markets include, for example, Singapore, Hong Kong and Canada, and might still have phytosanitary requirements.

The below table outlines the detailed requirements of the key protocol markets.

Table ES. 2. Market Protocol Requirements

Country	Orchard Approval by DAWE (annually)	Packhouse approval by DAWE (annually)	Approved crop monitoring program (annually)	Vapour Heat Treatment (Fruit Fly)	Irradiation (Fruit Fly and other arthropods pests)	Mango Seed Weevil (Freedom)
China	✔	✔	✔	✔		✔
Japan		✔		✔		
South Korea	✔	✔	✔	✔		✔
New Zealand					✔	
United States	✔	✔	✔		✔	

Source: AMIA (2020).

There are currently four known vapour heat treatment (VHT) facilities in Queensland, including two facilities in Brisbane (Perfection Fresh and Hannay Douglas), one facility in Giru (Manbulloo), and one facility in Mareeba (Diamond Star). There are currently no VHT facilities in the Rookwood Weir catchment area or the Rockhampton region. If mangoes were selected as commodity for the Rookwood Weir catchment area, harvested mangoes will need to be transported to a treatment plant at either Brisbane or Giru.

Any delay between harvesting and the application of VHT treatment increases the risk of heat damage symptoms appearing when fruit near the end of their supply chain life.

Mango exports are currently transported via air freight from Brisbane and Cairns Airport, or via sea freight from the Port of Brisbane. A port is also located at Burnett River, the Port of Bundaberg, owned by Gladstone Ports Corporation Limited, which is closer to the Rookwood Weir catchment area. However, mangoes are not identified as a primary export at this port.

The COVID-19 associated disruption of the supply chains is an ongoing concern for Australian exporters, with freight costs reported to have increased up to three times and capacity decreasing to about 10% - 25% of normal availability. This has prompted some exporters explore options to ship more commodities by sea. However, there are still significant product quality risks associated with sea freight, particularly if the cold chain is not efficiently managed during the duration of the delivery.

FINANCIAL AND COMMERCIAL ANALYSIS

The average land available on a typical Rookwood Weir land lot which is suitable for mango production is 160ha. With water entitlement restrictions and a conservative water use assumption, the total sustainable land available for orchard development (i.e. planted area) is restricted to 66ha.

The anticipated initial capital investment for a mango orchard is $4.9 million, including, land, land clearing, infrastructure and equipment, water entitlements, and planting. Planting costs for a mango orchard are typically $45 per tree, on a property of 66ha, a Kensington Pride orchard would have a tree population of 12,210.

The first harvest is not expected to occur until the fourth year of growing, when the trees will yield, on average, 15.7kg per tree. The farm will be operating at a loss until the commercial return is achieved when the trees reach their ninth year (FY2033), with a yield of 45.3kg per tree.

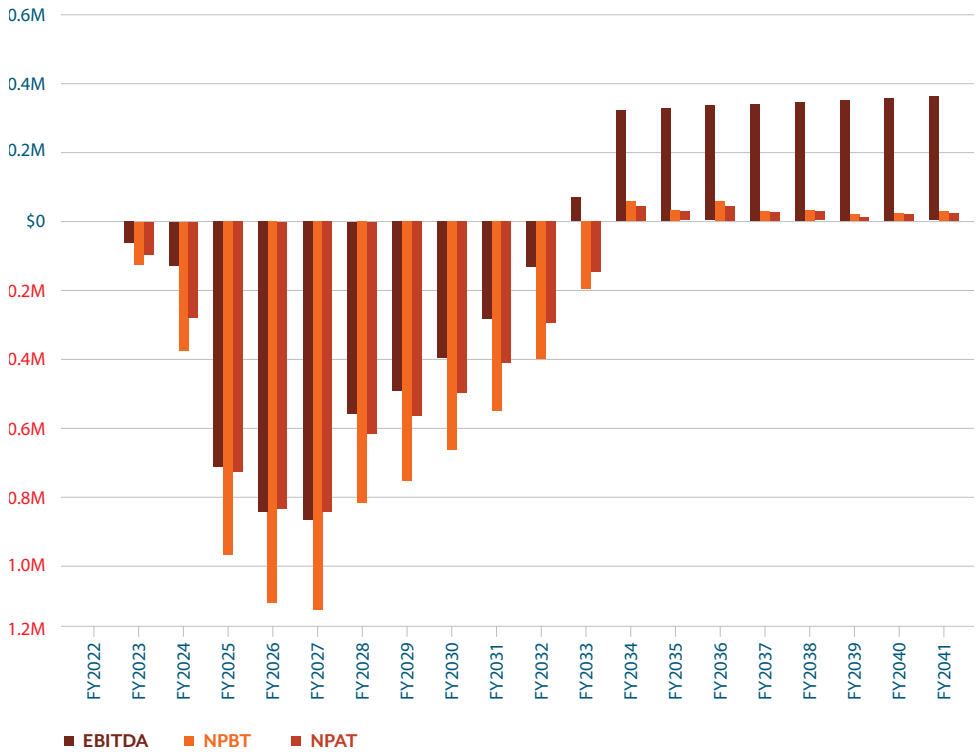
The break-even point for Kensington Pride is February 2028, however, the first year of operating at a profit is predicted to be FY2033, with the plants being planted in FY2025.

With consideration to the capital investment and the operating position, the discounted cash flow will be positive by FY2032. The long-term growth rate for agricultural farm values is 8.8%, with a net present value (NPV) of the farm at $0 the implied internal rate of return is 11.6%. The terminal value of the Mango farm at the conclusion of the analysis (FY2041) is $42.2 million (undiscounted).

The orchard revenue consists of the operating income associated with both fresh fruit and fruit for processing. The price point is determined by the quality of fruit. The estimated weighted average price per tray used in modelling the example farm is $13.67.

The assumed mango orchard in the Rookwood Weir catchment area would be anticipated to reach a positive annual operating position, that is, a positive net profit after tax (NPAT) 12th years after farm purchase, that being FY2034. By FY2041 the NPAT of the orchard is estimated to exceed $22 thousand.

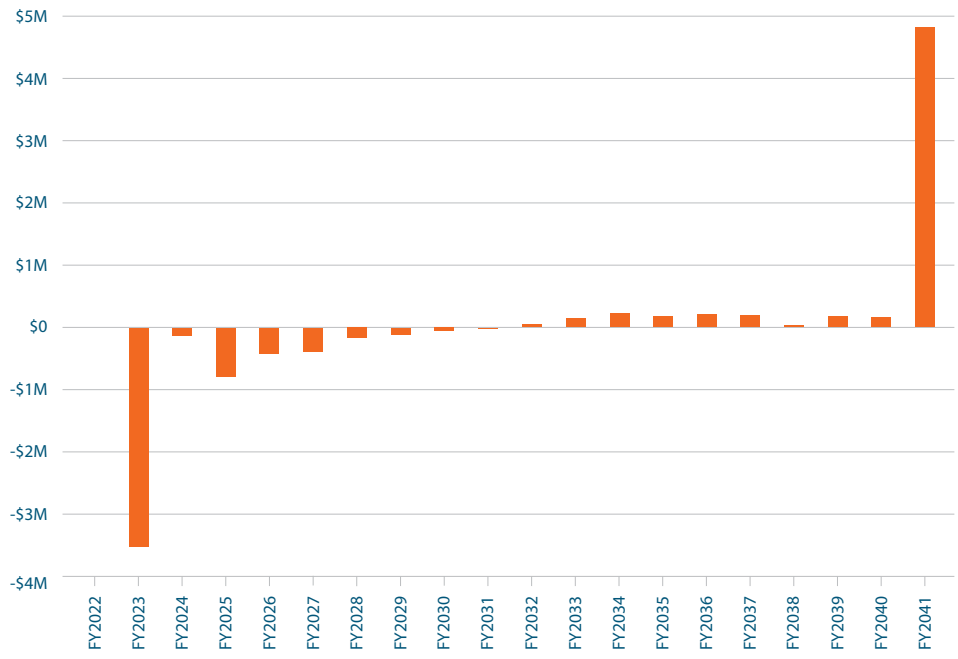
Figure ES. 9. Orchard Operating Profit (FY2022 – FY2041)



Source: AEC.

To understand the value of the orchard investment, a discounted cash flow (DCF) has been calculated. This is shown below in the figure below. By FY2032 the orchard will begin to see positive discounted cashflows. However, given the large capital investment, and the periods of no returns (which ultimately increases the required capital investment), the cumulative discounted cash flows do not return a net positive income within the 20-year period modelling period without the addition of the terminal value to reflect the future value of the orchard and land improvements at maturity.

Figure ES. 10. Discounted Cashflows, Including Terminal Value (FY2022 – FY2041)



Note: Discounted cashflows have been estimated on a 11.6% post-tax discount rate, which is the implied internal rate of return.
Source: AEC.

ECONOMIC IMPACT

Capital investment and operation of the orchard is anticipated to directly contribute to $2.7 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA. A further $1.8 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $1.1 million in production induced (i.e. supply chain) activity and $0.7 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

This level of industry activity is estimated to support the following within the Rockhampton LGA:

- A $1.9 million contribution to GRP including $1.1 million directly
- 16 FTE jobs (including 10 FTE jobs directly), paying a total of $1.3 million in wages and salaries ($0.8 million directly).

Table ES. 3. Economic Activity Supported by a Mango Orchard Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$2.7	$1.1	$0.8	10
Production Induced	$1.1	$0.4	$0.3	4
Consumption Induced	$0.7	$0.4	$0.2	3
Total	**$4.5**	**$1.9**	**$1.3**	**16**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017), ABS (2020a, b, c and d), AEC.

GLOSSARY

TERM	DEFINITION
AEC	AEC Group Pty Ltd
AANZFTA	ASEAN-New Zealand Free Trade Area
ANZCERTA	Australia-New Zealand Closer Economic Relations Trade Agreement
CIF	Cost, Insurance, and Freight
COGS	Cost of Goods Sold
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific
DAWE	Department of Agriculture, Water and Environment
EBIT	Earnings before interest and tax
FAO	Food and Agriculture Organisation
FTA	Free Trade Agreement
Ha (ha)	Hectare[s]
HTW	Herron Todd White
KAFTA	Korea-Australia Free Trade Agreement
Km	Kilometres
MAFTA	Malaysia-Australia Free Trade Agreement
ML	Megalitres
NIS	Nut in-shell
NPAT	Net Profit After Tax
NPBT	Net Profit Before Tax
NSW	New South Wales
OECD	Organisation for Economic Co-operation
QLD	Queensland
PACER	Pacific Agreement on Closer Economic Relations
RCEP	Regional Comprehensive Economic Partnership
ROCE	Return on Capital Employed
VHT	Vapour Heat Treatment

TABLE OF CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

Rookwood Weir is a landmark project that will capture water in the lower Fitzroy River for use across the region. The project comprises of the construction of the weir, and enabling works that will upgrade existing infrastructure to support both the construction of the weir and its operation, which includes:

- Upgrading and widening 16.2 kilometres (km) of Thirsty Creek Road
- Installing a new intersection on the Capricorn Highway and upgrading Second Street and Third Street through to the railway crossing at Gogango
- Building a 21-metre high, 260-metre long bridge at Riverslea to replace the existing crossing and up to 300m of new road on the approaches to the bridge, connecting to the existing road.

The $367 million project is jointly funded by the Australian and Queensland governments and is expected to be completed and operational in 2023. Early works commenced in late 2020, and as of January 2022, the progress on the construction of the weir is approximately at 50% (Sunwater, 2022).

Once complete, Rookwood Weir will be the largest weir operated by Sunwater in regional Queensland. Subject to final design, the weir's planned volume will be 74,325 megalitres (ML), which is estimated to potentially yield up to 86,000ML of medium priority water. This valuable new water source will bring much-needed water security as well as economic growth and jobs for Central Queenslanders.

Rockhampton Regional Council and Advance Rockhampton are co-ordinating the Rookwood Weir Landholder Support Program (LSP), which focuses on providing support to eligible landholders in the Lower Fitzroy region to prepare for the second tranche of water sales from the Rookwood Weir Water Supply Scheme (7,500ML in 2022). Rookwood Weir will provide existing landholders with the opportunity to significantly increase the net return derived from their land by transitioning to intensive irrigated crop production. A range of crops have been identified as suitable for production within the Rookwood Weir Catchment Area, including orchard crops such as macadamias, mandarins and mangoes.

AEC Group Pty Ltd (AEC) and Herron Todd White (HTW) have been commissioned to undertake Business Case Studies (the Study) to provide an in-depth analysis of potential agribusiness opportunities aligned with irrigation in the Rookwood Weir catchment area. This Study will assist local growers to prioritise crop options given available water allocations.

1.2 PURPOSE OF THIS REPORT

The purpose of this report is to provide an in-depth analysis of the global market for each potential crop and assess the potential agribusiness opportunities for production of mangoes within the region. This Study will inform landholders in the Lower Fitzroy region that are considering options for potential crops that could be grown utilising water that will be available for tender through the Rookwood Weir Water Supply Scheme.

The market outlook presented is based on research of historical and forecast information, and engagement with key stakeholders and industry associations. The analysis also includes commentary on the growing conditions and requirements for commercial mango crops in the Australian environment, including soil suitability, water availability, orchard management, pest and weed control, infrastructure and equipment. The report and analysis presents an informed base for a financial model to assess the potential production feasibility and profitability at an individual farm level.

The broader research program will see this report is as one of three reports to inform growers of the potential opportunity and viability of accessing addition water to expand production and productivity. A financial assessment is undertaken for each potential crop, modelled based on a standard farm, to provide potential growers with an overview of the costs, timing and potential returns from operating a farm in the region.

1.3 STRUCTURE OF THIS REPORT

The analysis in this report is structured as follows:

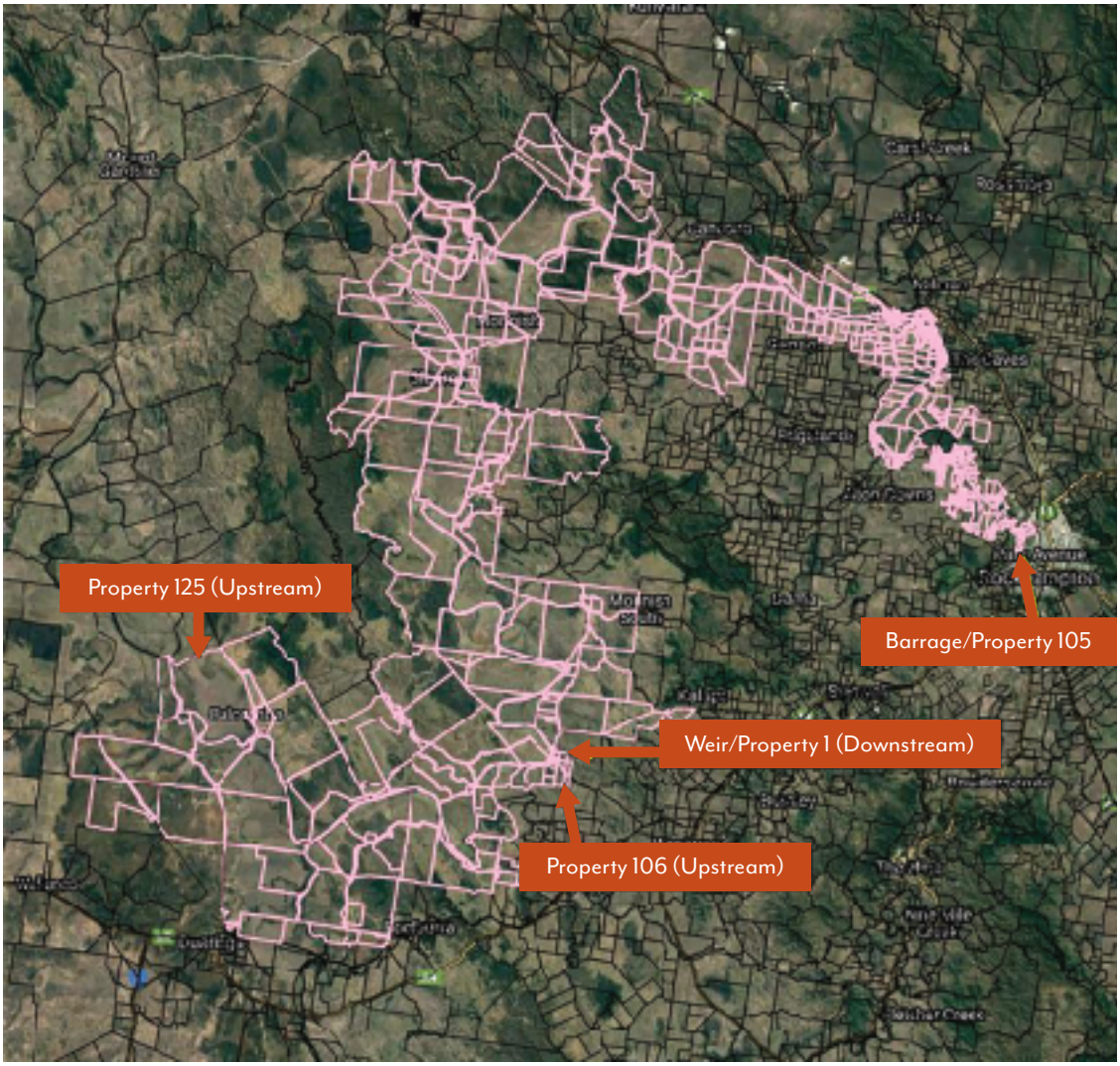
Source: AEC.

1.4 ROOKWOOD WEIR CATCHMENT AREA

The Rookwood Weir is located north-east of Duaringa, on the Fitzroy River within the Fitzroy Basin in Central Queensland and is approximately 66km south-west of Rockhampton.

The Rookwood Weir catchment area, for the purpose of our assessment, has been defined as the property holdings within approximately five kilometres either side of the Fitzroy River, and can be potentially suitable for irrigated crops.

Figure 1.1. Rookwood Weir catchment area



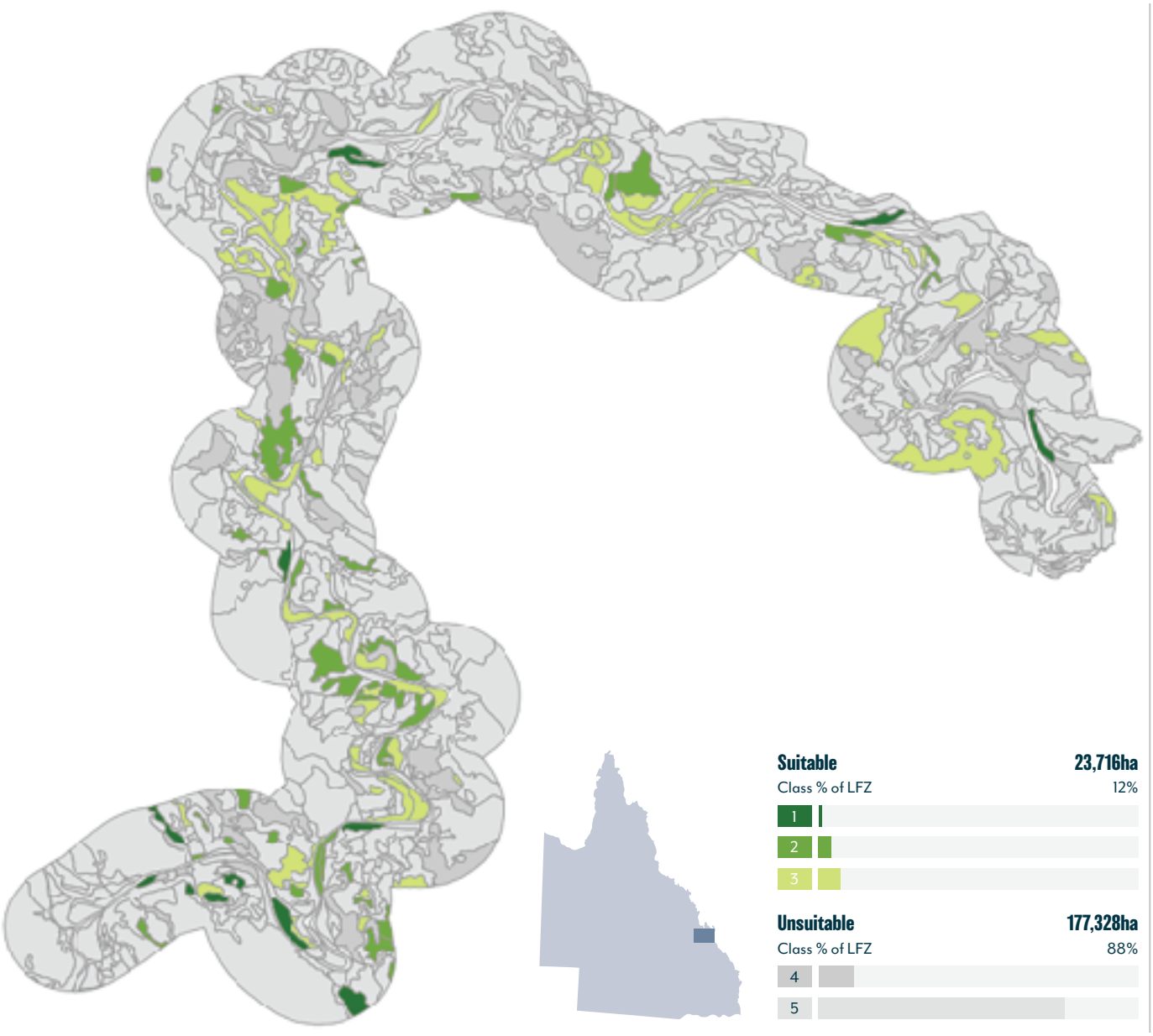
Source: HTW.

1.4.1 LAND SUITABILITY FOR MANGO PRODUCTION

The Rookwood Weir project has worked with Queensland Department of Agriculture and Fisheries (DAF) and Sunwater to develop a crop suitability tool to assess individual landholder area suitability for different crops.

The following map highlights the land areas in the study area that could be used to grow mangoes in the Fitzroy River region based on the DAF soil suitability tool.

Figure 1.2. Land Suitability Fitzroy River



Source: Queensland Government (2021a).

Based on the identified area, the maximum suitable land area that could be used to produce mangoes is 23,700 Ha using trickle irrigation is 23,716 Ha, of which around 10,000 Ha was identified as Class 1 or Class 2 agricultural land.

However, when taking into account the land's slope, another critical element in assessing crop suitability, the total land available for mangoes reduces to approximately 18,700 Ha (HTW, unpublished).

2. OVERVIEW OF THE GLOBAL MARKET

2.1 INTRODUCTION

Mangoes initially originated in India over 4,000 years ago, with commonly grown global varieties including Keitt, Kent, Palmer, Tommy Atkins and Irwin (DAF, 1999). Mangoes gradually spread to south-east Asia then globally into a number of tropical and subtropical regions (DAF, 1999).

By the 1800s, mangoes were introduced to Australia, with a current crop of 1.6 million trees (including bearing and non-bearing). Australia has four key mango varieties which include Kensington Pride (representing 36.0% of production), Calypso (28.0% of production), R2E2 (19.0% of production), and Honey Gold (10.0% of production). Although Kensington Pride represents majority of the mango production in Australia, this variety is not well suited to export due to the fruit's thin skin and the likelihood of bruising through long-distance transport.

Australia's production of mangoes, mangosteens and guavas has grown from 9,262 tonnes in 1990 to 51,528 tonnes in 2021 (representing less than one per cent of global production). For the 2022 season production is expected to exceed 55,000 tonnes, of which 72.8% are expected to be class one and the remaining to be class two.

Australia does not export significant volumes of mangoes compared to other countries on the global scale, however, the industry is relatively opportunistic. If the domestic market is performing well, mangoes (particularly R2E2) will be sold in Australia, if not they will be exported to international markets. Currently around 12% of production is exported, however, consultation with the Australian Mango Industry Association identified a focus to shift exports to 20% of production into the future.

Australia's key export markets have historically been New Zealand, Singapore and Hong Kong. In these markets the R2E2 variety is doing reasonably well, particularly in Hong Kong where appearance is a key driver for consumption.

Production of mangoes, mangosteens and guavas are projected to grow from 54.8 million tonnes in 2020 to 84.0 million tonnes in 2030. The main driver of this production growth is the rising incomes and shifts in dietary preferences in India, with consumption per capita estimated to reach 28.4 kilograms in 2030 (OECD-FAO, 2021). Similarly, consumption in Asia is expected to experience strong growth, growing from 10.4 kilograms per capita in 2020 to 14.6 kilograms per capita in 2030 (OECD-FAO,2022).

International commodity classifications do not require information on mangoes, mangosteens, and guavas to be reported separately. Therefore, data for only mangoes remain sparce across international and Australian datasets. The main dataset for production, import and export statistics highlighted in this report was from the Food and Agricultural Organisation (FAO) which report the information for all fruits as a grouping (mangoes, mangosteens, and guavas).

Where separated information for mangoes was available, this has been reported.

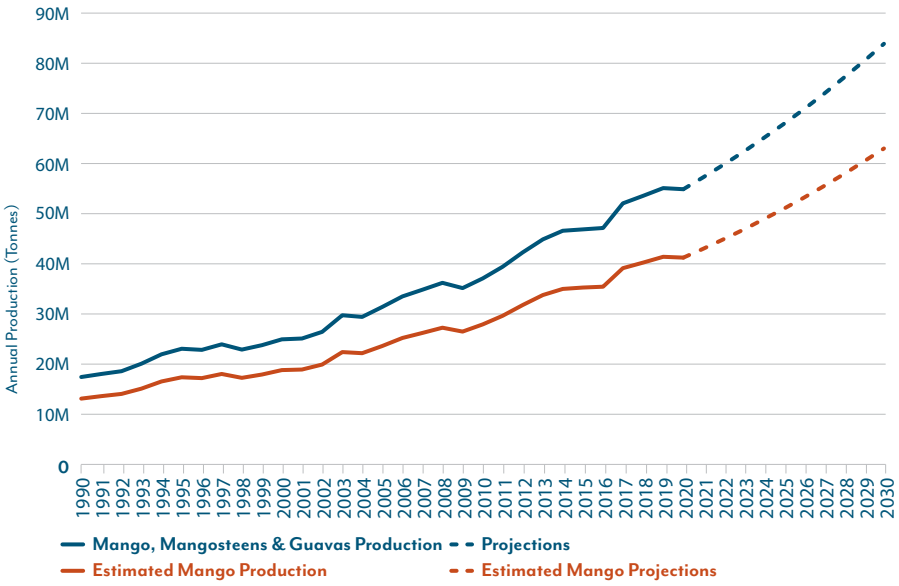
2.2 GLOBAL PRODUCTION

Mangoes are a popular global fruit which are grown in over 100 countries around the globe, 65 of which produce more than 1,000 tonnes a year (ISHS, 2014). The global production highlighted in the figure below is based on volumes provided by FAOSTAT which include the production of mangoes, mangosteens and guavas. Mangoes are the dominant fruit on the global scale, with the Organisation for Economic Co-operation OECD and Food and Agriculture Organisation (FAO) future projections highlights that on average, mango accounts for 75% of total production, guava for 15% and mangosteen for the remaining 10% (2022).

In 2020, it was estimated that the total mango, mangosteen and guava production totalled 54.8 million tonnes (estimated 41.1 million tonnes of mangoes, based on the assumed 75% proportion of total production). Global production has been experiencing an average annual growth rate of 3.9% from 1990 to 2020. This growth in production was largely driven by India, whom is the most dominant producer on the global scale.

The OECD and the FAO have developed an agricultural outlook report from 2021 to 2030. This report projects mango, mangosteen and guava production to reach an estimated 84 million tonnes by 2030 (estimated 63.0 million tonnes of mangoes, based on the assumed 75% proportion of total production). In 2030, Asia is estimated to total 75% of global production while India is estimated to account for around 51% (OECD-FAO, 2021). The strong demand in global mango, mangosteen and guavas over the next 10 years are estimated to stem from the strong demand in India, which will largely be driven by rising incomes and shifts in dietary preferences (OECD-FAO, 2021).

Figure 2.1. Global Mango, Mangosteens & Guavas Production, 1990 to 2030



Source: FAOSTAT (2022), OECD-FAO (2021).

2.3 MAJOR PRODUCERS

Mangoes are tropical fruits and require a tropical climate to grow, that's why a significant portion of mangoes, mangosteens and guavas are grown near the equator.

India is by far the largest producer of mangoes, mangosteens and guavas on the global scale, with production totalling 24.7 million tonnes in 2020. It is estimated that approximately 83% of this represented mango production and the remainder represented guava production (based on production statistics for India).

The second most prominent producer in 2020 was Indonesia, followed by Mexico. Although China is listed as the largest producer of mangoes, mangosteens and guavas in 2020, China has historically been the second largest producer on the global scale. Production volumes in China have largely been on the decline since 2005 where production peaked at 4.1 million tonnes.

The section below analyses the historical production volumes in India, Indonesia and China.

Table 2.1. Top 10 Producers of Mangoes, Mangosteens and Guavas, 2019 and 2020

	2019		2020	
Country	Tonnes	Proportion	Tonnes	Proportion
India	25,631,000	47%	24,748,000	45%
Indonesia	3,294,817	6%	3,617,271	7%
Mexico	2,396,675	4%	2,373,111	4%
China	2,415,000	4%	2,368,180	4%
Pakistan	2,270,229	4%	2,344,647	4%
Brazil	2,002,849	4%	2,135,304	4%
Malawi	1,492,687	3%	1,938,066	4%
Thailand	1,643,058	3%	1,657,589	3%
Bangladesh	1,456,331	3%	1,448,396	3%
Egypt	1,396,540	3%	1,395,244	3%
Other	11,026,945	20%	10,805,296	20%
Total	**55,026,131**	**100%**	**54,831,104**	**100%**

Note: Largest producers in 2020.
Source: FAOSTAT (2022).

INDIA

There are around 1,000 varieties of mangoes in India, however, only around 30 of these varieties are commercially grown. Some of the key mango varieties in India include (APEDA, undated):

- Alphonso
- Banganpalli
- Chausa
- Dashehri
- Langra
- Totapuri
- Kesar

Almost half of the world's mangoes are produced in India alone, with the main mango producing states including Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar, and Gujarat (APEDA, undated). From financial year 2013-14 (FY2014) to FY2015, the Indian mango crop saw a decline in production hectares (Ha), decreasing by over 350,000ha for the year. This decrease was largely attributed to the state of Maharashtra, contributing to over 90% of the decline in production Ha. Although production has been on the decline, mango productivity in India experienced an increase over FY2014 to FY2015 (refer to Table 2.2 below). This highlights improvements in crop management.

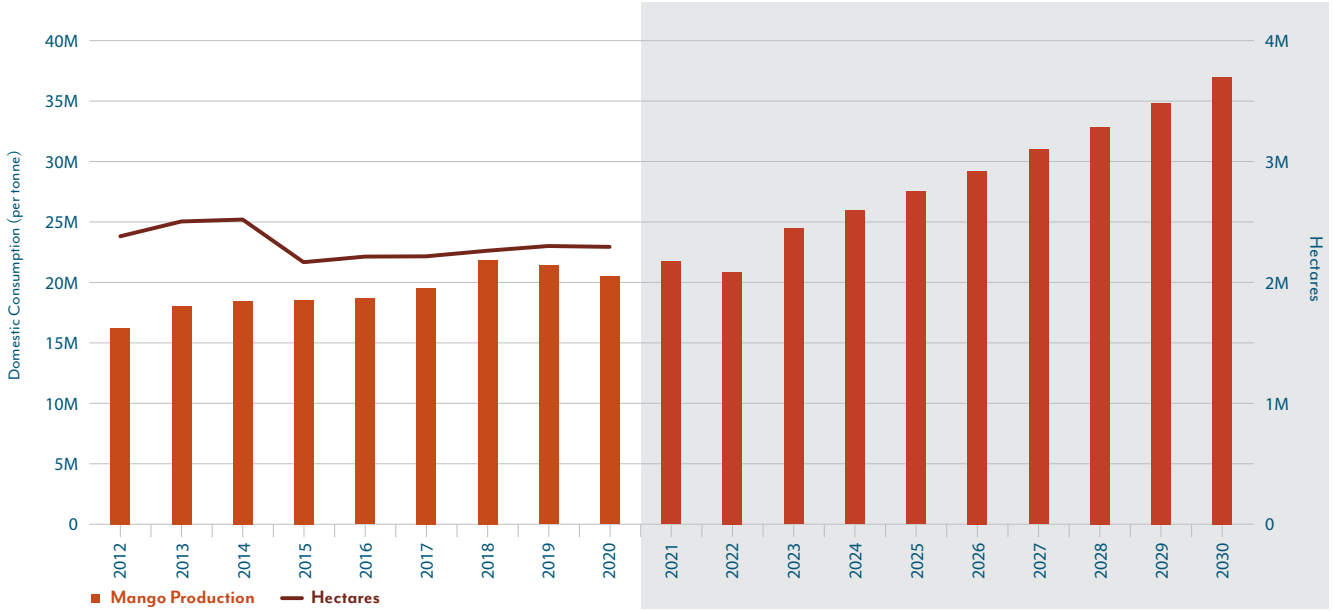
Mango production in India experienced a declining trend from 2018 to 2020, while the area under cultivation increased. Mango production has been on the decline over these years as a result from various cyclones and extreme weather conditions, bad soil condition, and climate change (The Federal, 2021). These impacts have reduced the quality of the mango which created some challenges for mango export (The Federal, 2021).

Mango production covered approximately 2.3 million Ha in FY2020, with an estimated productivity rate of 8.9 tonnes per ha in FY2020. In FY2020, it was estimated that mango production in India totaled 20.4 million tonnes, growing by an average annual rate of 3.0% per annum from FY2012 to FY2020. Reports suggest that mango production in India is projected to increase to 36.9 million tonnes in 2030 (ISHS, 2020).

In 2021, the west coast of India (where a significant portion of the mango trees are located) was hit by cyclone Tauktae which significantly disrupted mango harvests throughout India. It was reported that around 70% to 80% of the mango crop was yet to be harvested before the cyclone hit (Times of India, 2021). The cyclone largely impacted export varieties such as Kesar and Alphonso which are located along the coastal areas of Maharashtra and Gujarat which were the worst impacted areas (Finshots, 2021). It was reported that mangoes from the area normally account for around 25% of India's mango exports, subsequently, the impact from the cyclone will significantly impact mango exports (Finshots, 2021).

The 2022 mango crop in India will be impacted by the delayed flowering caused at the end of last year due to unseasonal rain in October and November (News Meter, 2022). This has resulted in flowering delays of a month, inevitably impacting yield, which has a potential to decline by 10% (News Meter, 2022).

Figure 2.2. Mango Production in India, Historical and Projected (2012 to 2030)



Notes:
- This information does not include guava production and only reflects the production of mangoes.
- FY2020 figures are estimated only.
- Historical estimates are in financial years.
- 2022 to 2029 production figures are estimated based on the average annual growth rate from historical production (2021) to future production (2030).
- 2022 figures reflect a potential 10% decline in production due to weather condition impacts.

Source: NHB (2019), Indian Horticulture Database (2013), National Mango Database (2022), ISHS (2020).

Table 2.2. Mango Productivity (India), Tonnes per Ha

Commodity	2012	2013	2014	2015	2016	2017	2018	2019	2020
Mango Yield	6.8	7.2	7.3	8.6	8.4	8.8	9.7	9.3	8.9

Note: Yield has been calculated by dividing production

Source: NHB (2019), Indian Horticulture Database (2013), National Mango Database (2022), ISHS (2020).

The table below provides an overview of the key growing areas and some specific problems which have impacted on mango production.

Figure 2.3. Key Growing Areas and Production Challenges

State	Productivity (tonnes/Ha)	Issues
Uttar Pradesh	16.4	Senile orchards, alternate bearing, mild to moderate sodium soil concentration (sodicity), nutritional deficiencies, heat waves
Andhra Pradesh	9	Delayed/unseasonal rainfall, temperature fluctuations, low soil fertility
Karnataka	9.7	Rainfed cultivation, low soil fertility and moisture retention
Bihar	9.2	Alternate bearing, unseasonal/deficient rainfall, hailstorms
Gujarat	7.9	Water stress, salinity and nutritional deficiencies
Maharashtra	2.5	Hard lateritic, nutrient deficient acidic soils, high humidity and heat stress in Alphonso growing areas
Odisha	3.8	Acidic soils, rainfed production, poor canopy management, cyclones/ hailstorms

Source: The Federal (2021).

INDONESIA

Mango production in Indonesia has been increasing by an average annual rate of 4.4% per annum from 1997 to 2020. In 2020, it was estimated that production totalled 2.9 million tonnes.

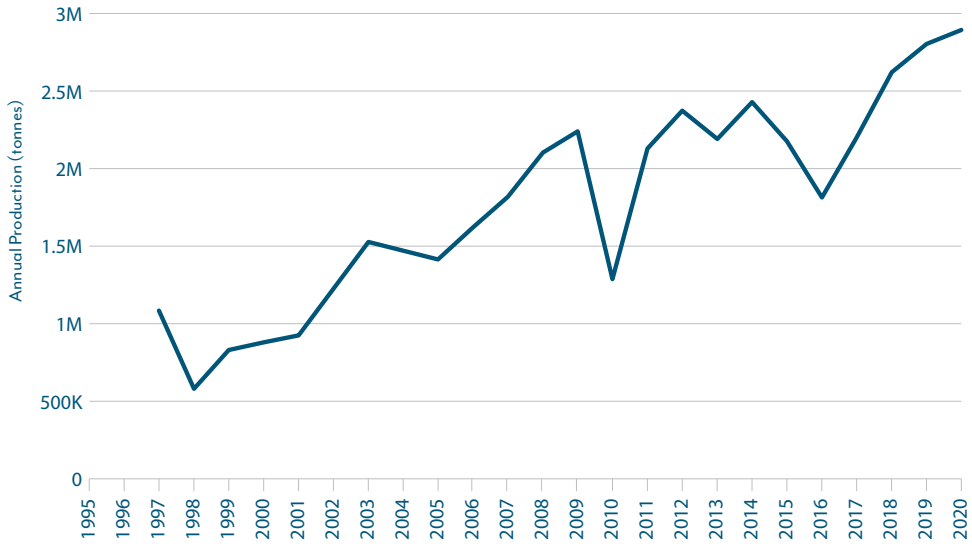
Commercial varieties on mangoes in Indonesia are Manalagi, Golek, Lalijiwo, Arumanis, Gedong and Indramayu (ISHS, undated). The main mango varieties which are sold for export include (ISHS, undated):

- Arumanis: This variety is native to Indonesia and have a vibrant green skin, with light large yellow dots all over. This variety is mainly for export to Japan (specialty Produce, 2021)
- Gedong Gincu: This variety is rounded with a reddish skin colour (Facts of India, undated).

The largest mango producing region in 2020 was East Java (accounting for 44.6% of total production), followed by Central Java (16.6%) and West Java (15.3%). From 2009 to 2010, Indonesia experienced production decline across all major growing regions (in particular East Java), with production declining by nearly one million tonnes over the year. The decline in production can be attributed to several factors including the volcanic eruption of Mount Merapi which occurred in 2010. The month-long eruptions destroyed more than 1,000 Ha of production farming land (Utami, S., et al., 2018).

Production experienced a decline again in 2015 as Indonesia was impacted by a drought which affected 16 provinces including West Java (DMC Dompet Dhuafa, 2015).

Figure 2.4. Production of Mangoes in Indonesia, 1997 to 2020



Note: Production information in 2002 and 2004 was not available.
Source: Statistics Indonesia (2022).

CHINA

In China, commercial mango cultivation is largely located in Guangxi, Yunnan, Hainan, Sichuan, and Guangdong. Guangxi was the largest producing region in 2018, with one of the highest yields per harvested Ha at 18.6 tonnes per Ha.

The table below also highlights the main mango varieties grown in China by Province; however, reports suggest that Keitt is the most population variety with Chinese consumers (Fresh Plaza, 2018). This popularity in the domestic market is attributed to the fruit's large size and production volumes (Fresh Plaza, 2018).

Table 2.3. Mango, Mangosteen & Guava Production in 2018

Area	Total Area (Ha)	Harvested Area (Ha)	Production (Tonnes)	Yield (Tonnes/ ha)	Main Varieties
Guangxi	100,700	39,400	734,700	18.6	Tainoung No1. Guire No. 82, Red Ivory, Guifei, Jinhwang, Guire No 10, Renong No 1
Yunnan	74,100	36,700	473,900	12.9	Keitt, Guifei, Sannian, Nang Klangwan, Jin Hwang
Hainan	56,700	52,100	682,900	13.1	Guifei, JinHwang, Tainoung No1, Nang Klangwan, Taiya, Sensation
Sichuan	27,400	12,600	140,300	11.1	Keitt, Sensation, Renong No1
Guangdong	13,300	12,000	216,000	18.0	Tainoung No.1, Dashehari, Jinhwang
Guizhou	5,600	1,700	10,400	6.1	Guire No.82, Keitt, Red Ivory, Guifei, Jinhwang, Hongyu, Sensation
Fujian	500	400	9,900	24.8	Jinhwang, Honghua, Irwin
Other	16,100	15,900	146,700	9.2	Irwin, Local Mango, Jinhwang, Tainoung No.1
Total	**294,400**	**170,800**	**2,414,800**	**14.1**	-

Source: Gao A, Chen Y, Luo R, Huang J, Zhao Z, Wang W, Wang Y, Dang Z (2020).

A report from Gao A, et. al (2020) suggests that China is the only country around the globe that has the potential to produce mangoes annually. The late maturing mangoes are largely concentrated in Sichuan, Yunnan and the south of Fujian.

Table 2.4. Mango Seasonality in China

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
South-southwest of Hainan, Leizhou Peninsula of Guangdong, Honghe River Basin of Yunnan & South of Taiwan	■	■	■	■	■	■						■
Youjiang River valley of Guangxi, Nujiang-Lancangiiang River Basin of Yunnan, Southwest of Guizhou					■	■	■	■	■			
Cichuan, Yunnan Jinshajiang River dry hot Valley Basin, and South of Fujian								■	■	■	■	

Source: Gao A, et. al (2020).

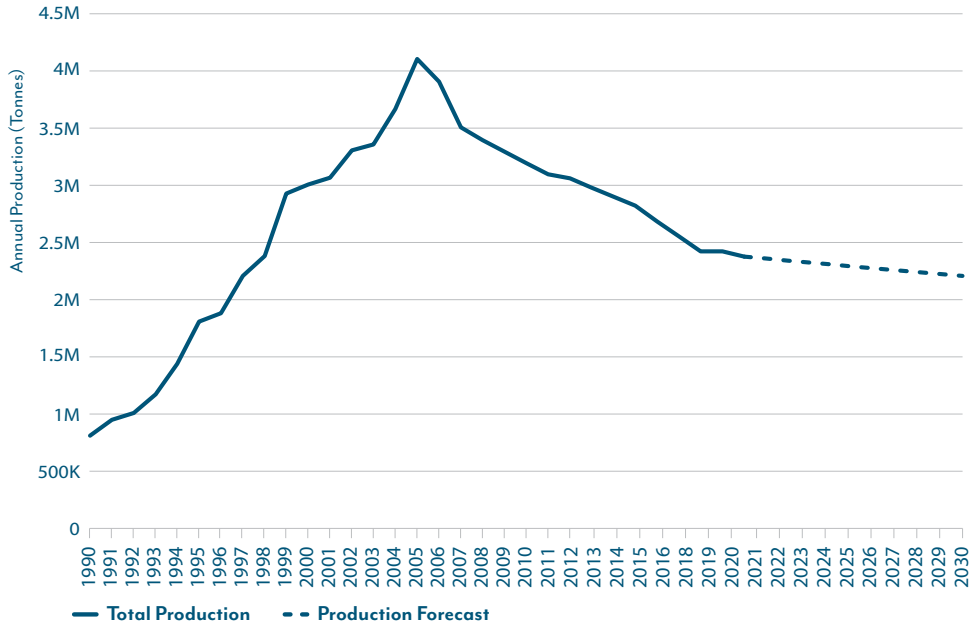
Mango, mangosteen and guava production trends in China are unlike any other country, with steep growth from 1990 to peak at a total of 4.1 million tonnes in 2005. Over these 15 years, production increased by a total of 3.3 million tonnes (equating to an average annual growth rate of 11.5%).

From 2005 onwards, China has experienced a decline in production, decreasing by an average 3.6% per annum to reach a total of 2.4 million tonnes in 2020. China has issues with access to quality water for agriculture which has led to issues for agricultural production and the general population's access to drinking water (Latham & Watkins, 2018).

The Agricultural Outlook 2021-2030 released by the Organisation for Economic Co-operation and Development and the Food and Agriculture Organisation highlights that mango, mangosteen and guava production in China is projected to total 2.2

million tonnes in 2030. This projection is lower than the current production estimated by FAO, highlighting production could continue to decline into the future. This decline in production will increase China's reliance on imports, which are projected to experience strong growth of 4.9% per annum to 2030 (OECD-FAO, 2021).

Figure 2.5. Production of Mangoes, Mangosteens & Guavas in China, 1990 to 2030



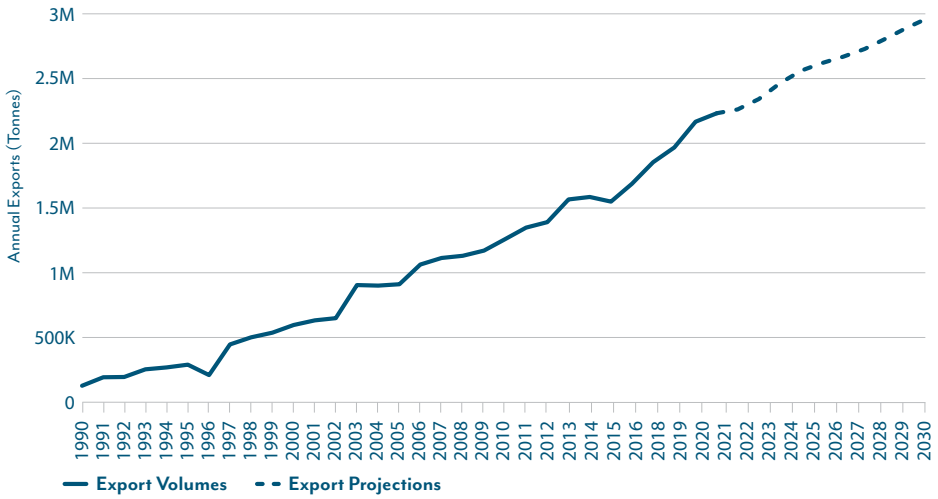
Note: The average annual growth rate from 2020 to 2030 production has been applied to 2020 production volumes to estimate production volumes in the years in between. Source: FAOSTAT (2022), OECD-FAO (2021).

2.3.1 MAJOR EXPORTERS

Global exports have experienced an average annual increase of 10.1% since 1990, totalling 2.2 million tonnes in 2020. Only 4.1% of the total global mango, mangosteen and guava production was exported in 2020, indicating that a large portion of the fruits are consumed domestically.

The Agricultural Outlook 2021-2030 highlights that mango, mangosteen and guava exports could reach a total of 3.0 million tonnes in 2030. The growth in export demand is from rising import demand in both established and emerging import markets (OECD-FAO, 2021).

Figure 2.6. Global Mango, Mangosteen & Guava Export, 1990 to 2030



Note: Historical export volumes highlighted in the graph above are from FAOSTAT. It must be noted that these volumes differ from the historical export volumes reported by the Agricultural Outlook 2021-2030. The average annual growth rate from 2020 to 2030 exports has been applied to 2020 volumes to estimate exports in the years in between. Source: FAOSTAT (2022), Hort Innovation (2021), OECD-FAO (2021).

In 2020, Mexico was the largest exporter of mangoes, mangosteens and guavas with exports totalling over 421,000 tonnes. Mexico experienced relatively sharp growth in exports over the years, growing by an average annual rate of 6.8% from 1990 to 2020. The most exported verities of mangoes in Mexico are Keitt, Kent, Tommy Atkins and Haden (ISHS, 1997).

Mexico is a large supplier of mangoes to the US, with approximately 88.3% of total exports from Mexico destined for the US in 2020 (FAOSTAT, 2022). Mexico is in a competitive position to supply the US with mangoes due to large production volumes and proximity to market advantages. Demand from the US for Mexican mangoes are projected to increase in the future, and the import demand will see Mexican mango exports total approximately 22% of global exports in 2030 (653,350 tonnes).

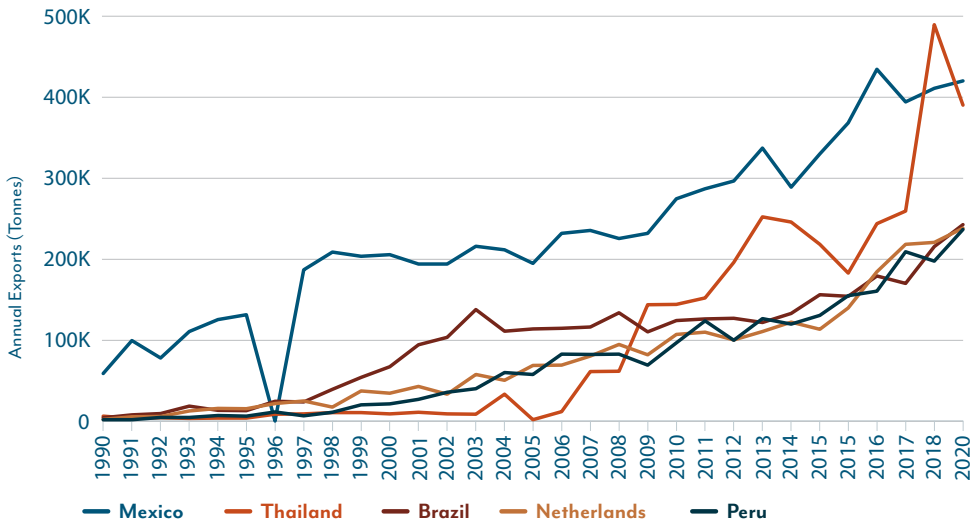
The second largest exporter of mangoes, mangosteens and guavas in the global market was Thailand. In 2020, it was estimated that Thailand exported a total of 391,279 tonnes, accounting for approximately 23.6% of the country's total production for the year. Thailand is a relatively large supplier of mangoes to China, with mango exports to China totalling an estimated 58.6% of total exports in 2020 (FAOSTAT, 2022).

Exports from Thailand experienced decline from 2019 to 2020, largely due to COVID-19 supply chain disruptions impacting on shipments to China (OECD-FAO, 2021). Shipments from Thailand to China increased by approximately 30% from 2019 to 2020, totalling $1,700 USD/tonne in 2020 (OECD-FAO, 2021). Although China's imports from Thailand declined over the year, imports from Vietnam experienced an increase.

Of important note, India was the largest exporter of mangoes, mangosteens and guavas in 2009, with exports reaching a peak of 286,616 tonnes. Since 2016, exports of mangoes from India have been on the decline largely due to increasing local demand. In 2020, India was the sixth largest export of mangoes, mangosteens and guavas in the global market.

From 2020, the export of Indian mangoes to the US has been restricted as USDA officials were unable to visit India for the inspection of irradiation facility due to COVID-19 restricted travel (Deccan Herald, 2022). At the end of 2021 the US started accepting testing certificates of specified agencies in India, which allows India to export mangoes to the US once again (Fresh Plaza, 2021a).

Figure 2.7. Top Five Largest Exporters of Mangoes, Mangosteens & Guavas, 1990 to 2020



Notes:
- No export data is available for Mexico in 1996.
- Top five largest exporters in 2020.

Source: FAOSTAT (2022).

2.3.2 MAJOR IMPORTERS

The US was the largest global importer of mangoes, mangosteens and guavas in 2021, importing approximately 516,840 tonnes. From 2017 to 2021, the average annual growth rate of imports in the US has totalled 0.4% per annum.

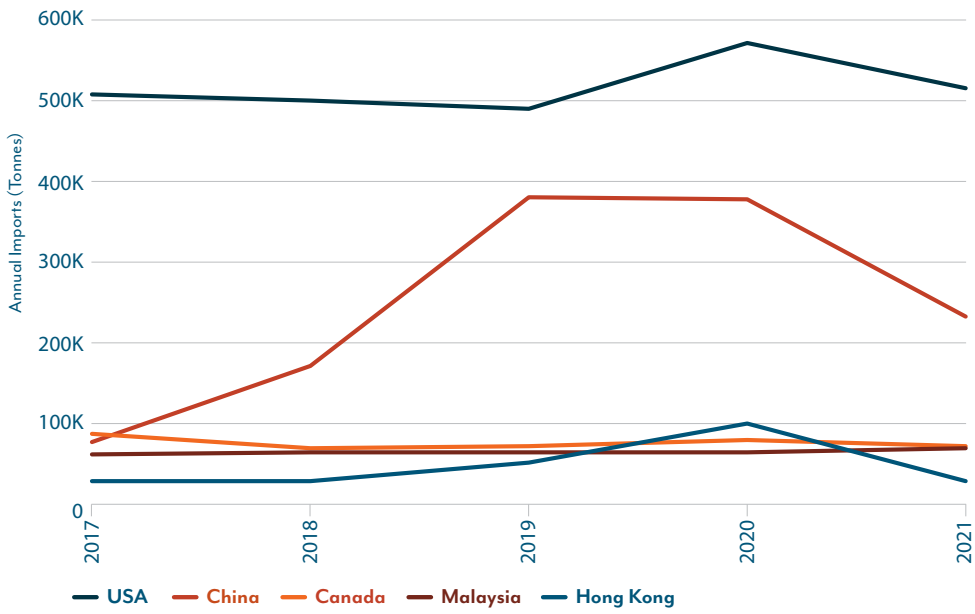
Over the years the US has become more reliant on imports of mangoes, particularly from Mexico which accounted for approximately 62.5% of imports in 2020 (FOASTAT, 2022). The second largest supplier of mangoes to the US in 2021 was Peru, accounting for approximately 13.5% of total mango imports to the US (FAOSTAT, 2022).

China was the second largest importer of mangoes, mangosteens and guavas, importing approximately 231,608 tonnes in 2021. The largest supplier of mangoes to China in 2020 was Thailand, accounting for 70.4% of total mango imports in China (Fresh Logic, 2022).

Mango, mangosteen and guava imports to China are projected to increase by an average annual rate of 4.9% per annum to 2030. Based on 2020 import information provided by Fresh Logic (2022), it is estimated that in 2030, mango imports to China could total 611,158 tonnes. The projected increase in imports is largely income driven demand for mangosteens, which is projected to be met by increasing imports from Thailand (OECD-FAO, 2021).

In 2021, mangoes from Cambodia were approved for direct export to China (China Dialogue, 2021). In 2021, Cambodia exported approximately 600 tonnes of mangoes to China (Khmer Times, 2021). The agreement will allow Cambodia to export 500,000 tonnes of fresh Keo Romiet mangoes to China each year (Producer Report, 2021).

Figure 2.8. Top Five Largest Importers of Mangoes, 2017 to 2021



Notes: Top five largest importers in 2021. No import data for Malaysia in 2019. Source: Fresh Logic (2022).

2.3.3 GLOBAL CONSUMPTION

Historical Food Balances information (FAOSTAT, 2022) was collected for the broad Commodity group (Fruits). Food Balances data was disaggregated to mangoes, mangosteens and guavas using published estimates of production (FAOSTAT, 2022), imports, exports. Relationships between remaining components of the Food Balances account (stock variation, losses, processing, residuals) were estimated assuming consistent relationships to production levels. The resulting food supply estimate was compared to total population estimates to determine a historical estimate of consumption per capita.

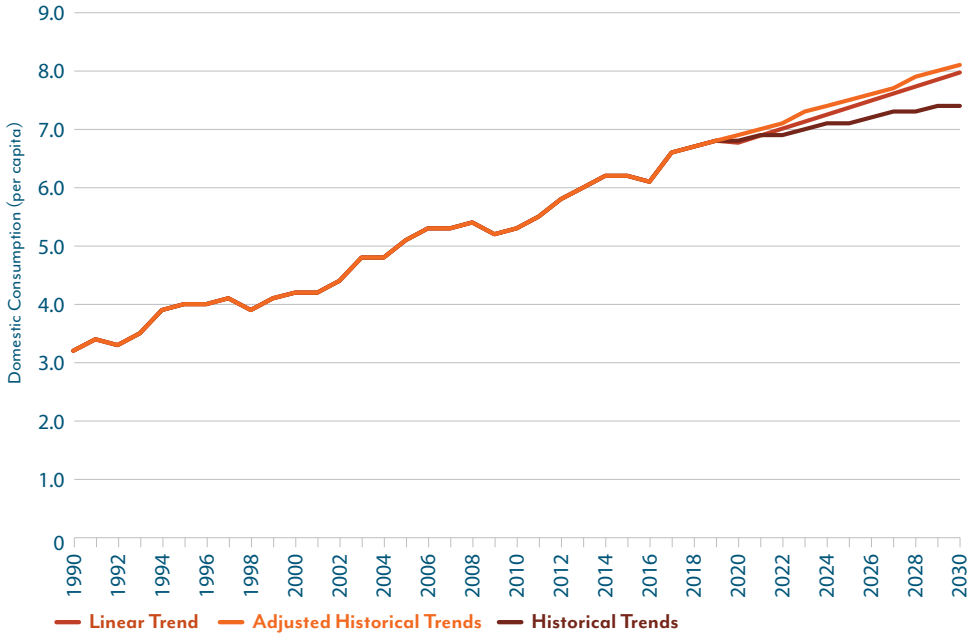
Initial estimates of consumption per capita have been developed based on:

- Linear trend line applied to the historical period and projected forward (Linear Trend)
- Application of the historical average annual change in consumption per capita to the latest rate of consumption per capita (Historical Trends)
- Application of half the rate of annual change in consumption per capita to the latest rate of consumption per capita (Adjusted Historical Trends).

Three projection scenarios have been developed to highlight the potential projected consumption per capita, per annum. Based on the historical domestic consumption trends for mangoes, there is more potential for future domestic consumption to reach historical trend volumes.

Based on the historical trend volumes, consumption could total approximately 8.1 kilograms per capita in 2030.

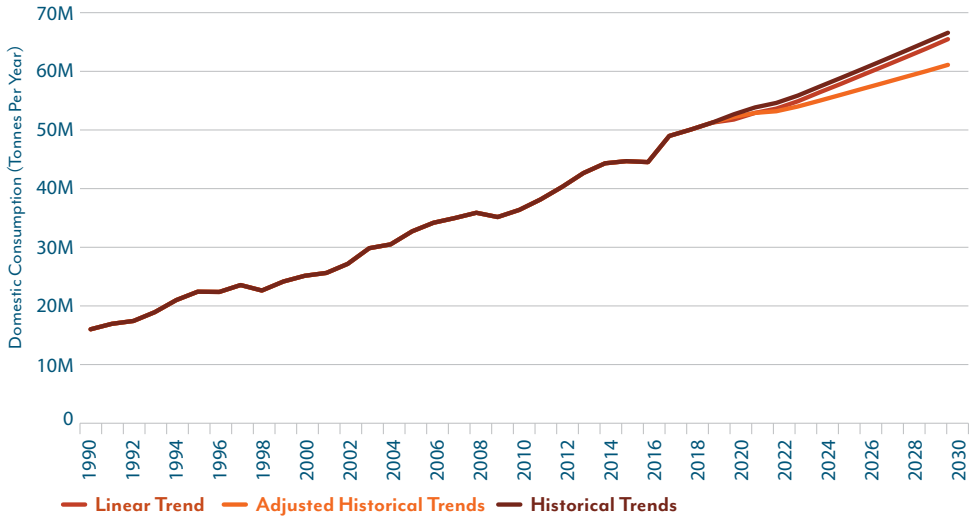
Figure 2.9. Consumption Per Capita, 1990 to 2030 (Kilograms Per Capita)



Source: USDA (2022), IMF (2022), OECD (2022), FAOSTAT (2022), AEC.

Based on historical trends, it is estimated that domestic consumption of mangoes could grow from an estimated 53.8 million tonnes in 2021 to 66.6 million tonnes in 2030.

Figure 2.10. Consumption, 1990 to 2030 (Tonnes)



Source: USDA (2022), IMF (2022), OECD (2022), FAOSTAT (2022) AEC.

The Agricultural Outlook 2021-2030 highlights that India is projected to experience strong growth in per capita consumption, reaching a total of 28.4 kilograms per capita in 2030 (OECD-FAO, 2021). Similarly, consumption in Asia is projected to grow from 10.4 kilograms in 2020 to 14.6 kilograms per capita in 2030 (OECD-FAO, 2021).

The National Mango Board have highlighted that their goal is to increase consumption of fresh mango in the US to approximately 3.2 kilograms per capita in 2030 (Fresh Plaza, 2021b). In 2019, mango was ranked as the 17th top fresh fruit by retail sales and by 2025 is it positioned to be among the top 15 (Fresh Plaza, 2021b).

2.3.4 GROWTH MARKET FOR MANGOES

China's decreasing production in mangoes, mangosteens and guavas over the years has increased the countries reliance on imports to satisfy domestic demand. Production is expected to future decline to 2.2 million tonnes in 2030, driving growth in imports. It is projected that mango, mangosteen and guava imports to China will increase by an average of 4.9% per annum through to 2030.

Historically, the main supplier to China has been Thailand and the increasing demand for imports is expected to be driven by mangosteen (OECD-FAO, 2021). It is projected that the increase in mangosteen demand from China will largely be met by imports from Thailand (the largest exporter of mangosteens) (OECD-FAO, 2021).

The US is also projected to experience growth in demand over the next 10-year period. The largest supplier of mangoes to the US is Mexico, accounting for 65.1% of total mangoes, mangosteen and guava imports on average from 2010 to 2020. The growing demand in the US will largely be met by an increase in exports from Mexico (OECD-FAO, 2021).

Australia is a relatively small producer, importer and exporter of mangoes in the global scale. The industry in Australia is relatively opportunistic, and if the domestic market is performing well than supply will be directed towards the domestic market. A priority for the Australian market is to increase mango exports into the future, growing exports from around 12% of production currently to approximately 20% of production. A key market for identification is the US and Japan.

The Australian Mango Industry Association are developing an export strategy which may lead to the identification of new markets that are currently not identified by the industry.

3. THE AUSTRALIAN MANGO INDUSTRY

3.1 CULTIVARS

There are nine common mango varieties grown in Australia. The most popular variety in Australia is the Kensington Pride, which is grown throughout the subtropical and tropical regions.

Each type of mango has unique attributes including texture, peak availability and colour. The table below highlights the most popular mango varieties in Australia and provides an overview of each variety. The Queensland Department of Agriculture and Fisheries Mango Information Kit (1999) details the varieties in more detail.

Figure 3.1. Popular Mango Varieties in Australia

Mango Variety	Flavour	Peak Availability
Kensington Pride (Bowen Mango)	Sweet & tangy	September to February
Calypso	Sweet juicy	September to March
R2E2	Sweet fresh	October to February
Honey Gold	Rich sweet	November to March
Palmer	Sweet	January to March
Keitt	Sweet, mild	January to March
Kent	Sweet	January to March
Parvin	Sweet juicy and tangy	February
Brooks	Sweet	February to April

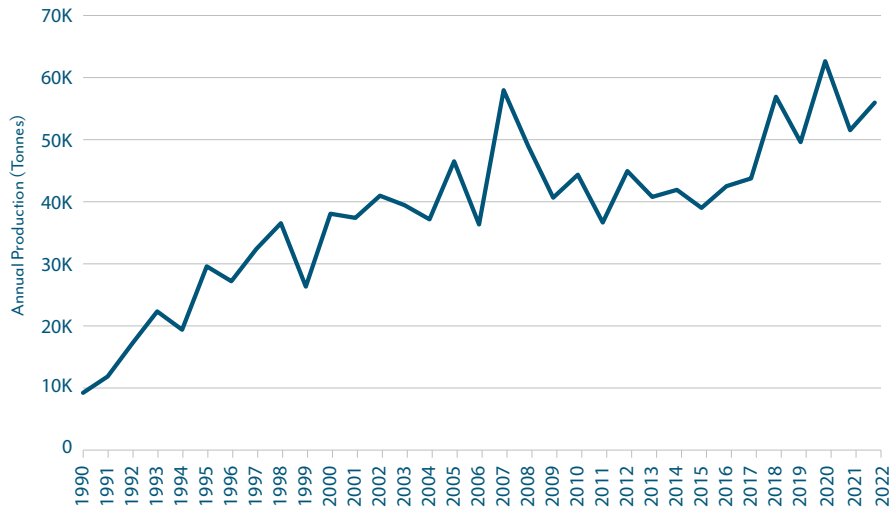
Source: Australian Mangoes (undated)

3.2 AUSTRALIAN MANGO PRODUCTION

Australia's production of mangoes, mangosteens and guavas has grown from 9,262 tonnes in 1990 to 51,528 tonnes in 2021. This increase equates to an average annual growth rate of 5.7% and is reflective of increased domestic consumption demand. Forecast information from the Australian Mango Society indicated that mango production could total 55,944 tonnes in the 2022 financial year. Of this estimated production, it can be expected that 72.8% are class one mangoes (40,740 tonnes) and the remaining 27.2% are class two mangoes (15,204 tonnes).

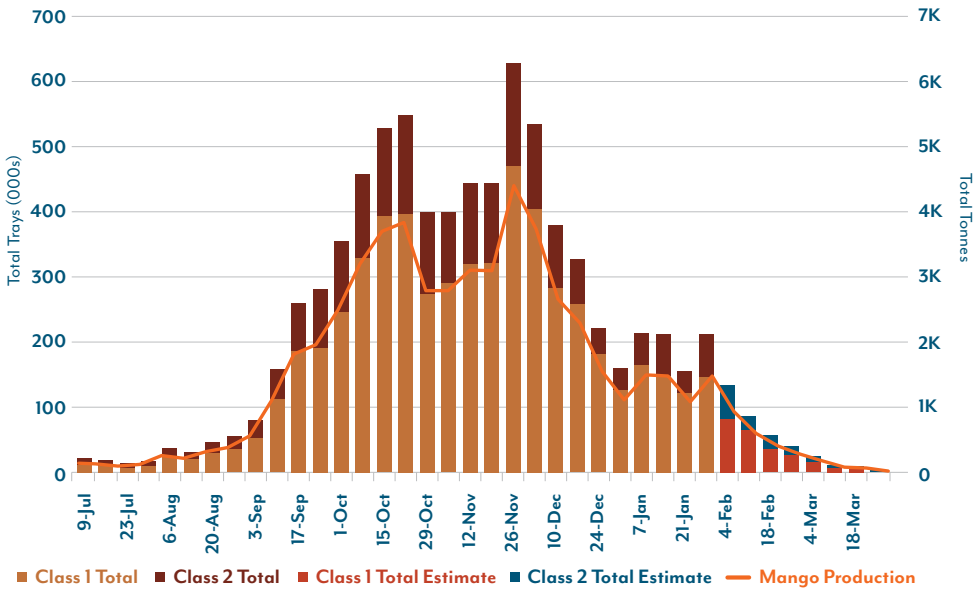
Australia does not export significant volumes of mangoes compared to other countries, with the growth in production reflecting an increase in supply to the domestic market. The industry is relatively opportunistic and if the domestic market is performing well, mangoes will be sold in the domestic market. If the domestic market is not performing well, the mangoes will be exported to international markets. Currently around 12% of production is exported, however consultation with the Australian Mango Industry Association identified a focus to shift exports to 20% of production into the future.

Figure 3.2. Australian Mango, Mangosteen & Guava Production, 1990 to 2021



Notes:
• 2021 production data reflects data provided by Hort Innovation in FY2021. The historical data from Hort Innovation does not reflect historical FAO data.
• 2022 production data is estimated from information provided by the Australian Mango Society for FY2022 crop forecast.
Source: FOASTAT (2022), Hort Innovation (2021), Australian Mango Industry Association (2022).
The figure below highlights the estimated mango production for 2022 by class.

Figure 3.3. Australian Production Forecast (FY2022)



Source: Australian Mango Industry Association (2022).

In 2021, Kensington Pride was the most widely produced variety in the domestic market (accounting for 36.0% of total production for the year) (Australian Mango Industry Association, unpublished). The second largest variety by production volumes in Australia was Calypso, estimated at 14,428 tonnes in 2021.

Table 3.1. Proportion of Mango Production 2021 & 2022

Variety	Proportion in 2021	Estimated Production 2021	Estimated Production 2022
Kensington Pride	36.0%	18,550	20,140
R2E2	19.0%	9,790	10,629
Calypso	28.0%	14,428	15,664
Honey Gold	10.0%	5,153	5,594
Keitt	2.0%	1,031	1,119
Other	5.0%	2,576	2,797
Total	**100.0%**	**51,528**	**55,944**

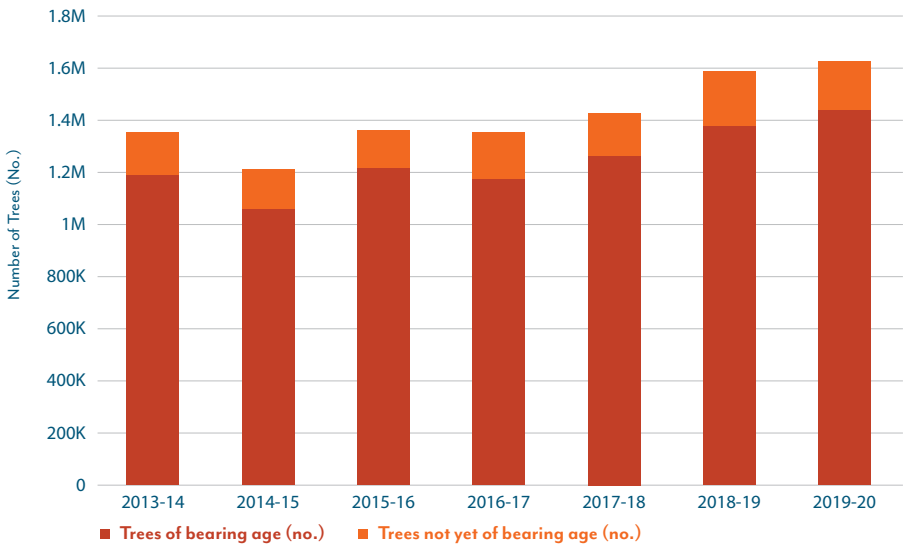
Note: Production estimates have been developed based on the proportion estimated provided by the Australian Mango Industry Association and production data from Hort Innovation.
Source: Hort Innovation (2021), Australian Mango Industry Association (2022, unpublished).

The Australian mango tree crop has experienced year on year increase from FY2017 to FY2020, reaching a total of 1.4 million bearing trees. Decline was experienced in FY2015 and FY2017, with impacting factors including:

- Cyclone Olwyn making landfall in Western Australia in 2015. The cyclonic winds impacted mango production and the ability for the trees to bear fruit (ABC, 2015). Production was down by 50% compared to levels achieved the previous year in 2014 (ABC, 2015).
- Cyclone Marcia impacted in the Central Queensland region in the beginning of 2015. The strong winds damaged many agricultural crops, including mango production.
- Impact of Dieback in Western Australia (Derby) in 2016, which is a progressive death of the tree. One farmer reported that nearly 200 mango trees in his orchard were impacted by the disease (ABC, 2016).
- Cyclone Debbie impacted the Mackay – Isaac – Whitsunday region (a key mango producing area), hitting the region towards the end of March 2017. Nearly 25% of the trees located in Bowen sustained some form of damage, negatively impacting the national tree crop numbers (ABC, 2017).

From FY2018 to FY2019, the number of non-bearing trees experienced an increase of nearly 50,000 trees. This increase highlights additional plantings in Australia, which will result in an increase in production as these trees begin to mature.

Figure 3.4. Number of Mango Trees, Australia (FY2014 to FY2020)



Notes: The ABS define bearing age as 'when trees or plants would normally be expected to produce a saleable harvest'.
For yield information by age see Table A. 3.
Source: ABS (2021, 2020, 2019, 2018a & b, 2016, 2015).

3.2.1 Key Growing Areas

MANGO TREES & SEASONALITY

There are approximately 1.6 million mango trees planted over 16,555ha spanning from the east coast of Australia to Western Australia. The majority of the trees are concentrated in Queensland (59% of trees) and the Northern Territory (35% of trees). Of the total mango trees in Australia, it is estimated that approximately 183,891 trees are not yet of bearing age (approximately 11% of Australia's total mango trees).

In Queensland, the main mango producing areas are located in the Burdekin, Bowen, Bundaberg, Mareeba and Dimbulah areas (DAF, 2014a).

Table 3.2. Australian Mango Production, FY2020

	NSW	VIC	QLD	SA	WA	NT	Total
Total trees (no.)	8,366	488	964,301	6,451	79,710	565,448	1,624,764
Trees not yet of bearing age (no.)	115	200	102,017	951	2,779	77,829	183,891
Trees of bearing age (no.)	8,251	288	862,284	5,500	76,931	487,619	1,440,873
Production (t)	158	01	42,221	3	1,318	18,903	62,603
Yield (kg/tree)	**19.2**	**0.0**	**49.0**	**0.6**	**17.1**	**38.8**	**43.5**

Notes:
- Production in Victoria is recorded as 0.
- The ABS define bearing age as 'when trees or plants would normally be expected to produce a saleable harvest'. For yield information by age see Table A. 3.

Source: ABS (2021).

Australian mangoes are not produced in the month of April to June, however, they are prominent in the month of October to January.

Table 3.3. Mango Seasonality by State

Area	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
NSW							Low	High				
QLD				Low	Medium	High	High	Medium	Low			
WA				High	High	Low	Medium	Low				
NT	Low	Low	Medium	High	High	Low						

LEGEND: High Medium Low

Source: Hort Innovation (2021).

The mango market in Australia is largely dominated by four main varieties, including Kensington Pride, Calypso, R2E2, and Honey Gold. A breakdown of production by variety throughout the year is highlighted below (Hort Innovation, 2021).

Table 3.4. Mango Variety by Seasonality

Variety	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Kensington Pride	Low	Low	Medium	Medium	High	High	High	Low				
Calypso			Low	Low	Medium	High	High	Low				
R2R2			Low	High	High	High	Medium	Low				
Honey Gold					Low	Medium	Medium	Low				
Other							Low	Medium	Low			

LEGEND: High Medium Low

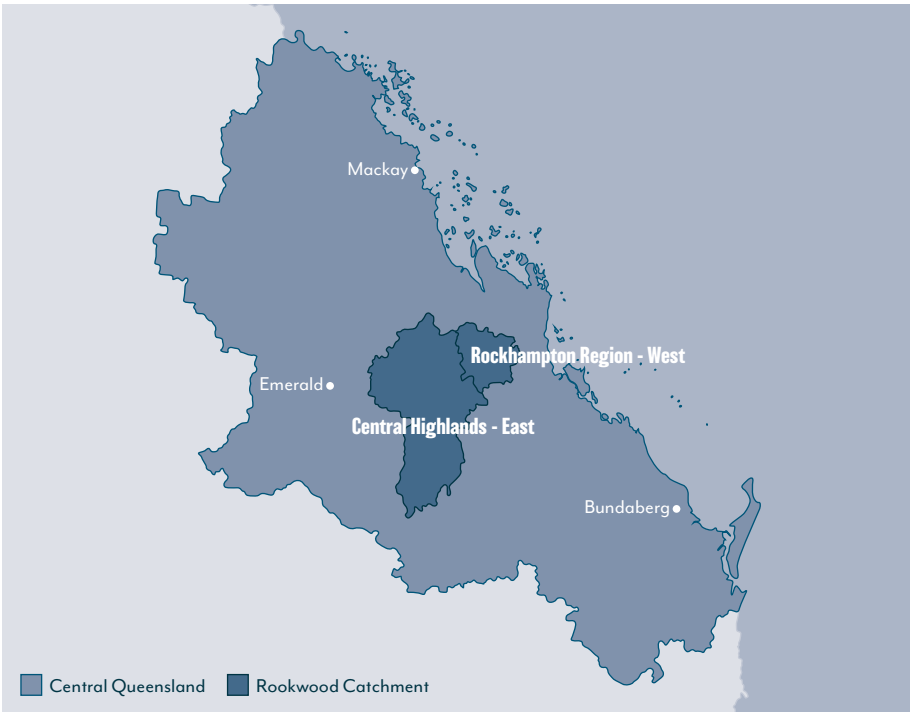
Source: Hort Innovation (2021).

CENTRAL QUEENSLAND MANGO PRODUCTION

Mango production is prominent throughout the broader Central Queensland region with approximately 264,405 trees of bearing age and an additional 53,221 trees which are not yet of bearing age in FY2020. From FY2015 to FY2017 the Central Queensland region experienced a year-on-year decline in both non-bearing and bearing trees. This impact is a result of several factors including cyclones, namely Cyclone Marcia in 2015 and Cyclone Debbie at the beginning of 2017.

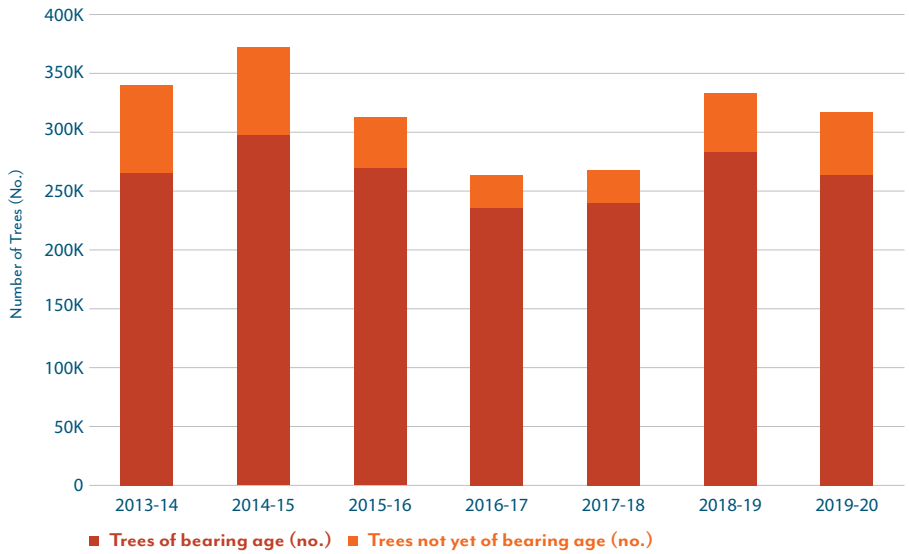
There are mango farms throughout the Central Queensland region and Rockhampton, including Pinata Farms. Pinata Farms has approximately 6,500 trees which are under cultivation, producing up to 40,000 trays of Honey Gold mangoes on average per season (Pinata Farms, 2022).

Figure 3.5. Rookwood Weir Catchment Area and Central Queensland



Note: For the purposes of this report, Central Queensland has been defined as the Mackay – Isaac – Whitsunday Statistical Area 4 (SA4), the Central Queensland SA4 and the Wide Bay SA4.
Source: AEC.

Figure 3.6. Number of Mango Trees in Central Queensland

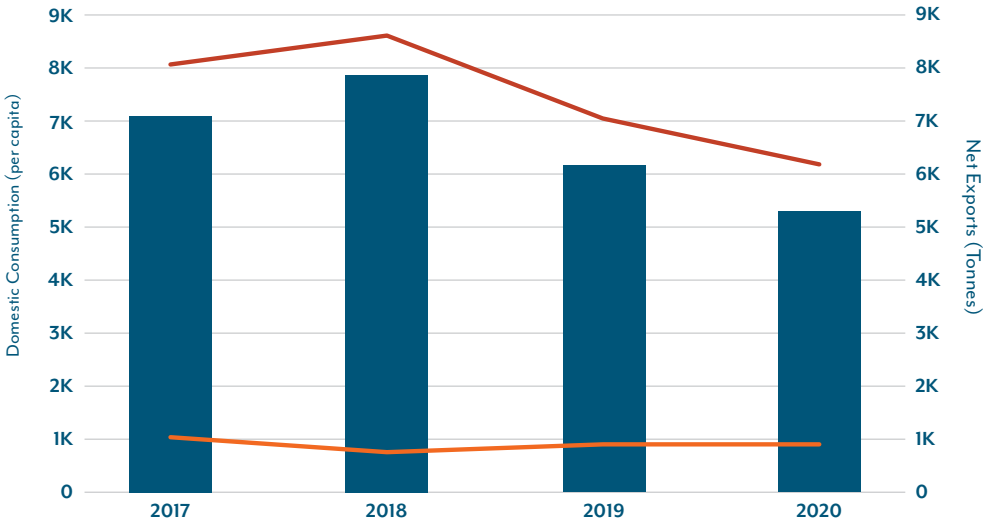


Notes: The ABS define bearing age as 'when trees or plants would normally be expected to produce a saleable harvest'. For yield information by age see Table A. 3.
Source: ABS (2021, 2020, 2019, 2018 a & b, 2016, 2015).

3.3 AUSTRALIA'S TRADE BALANCE

Based on information provided by Fresh Logic (2022) Australia has been a net exporter of mangoes over the analysis period from 2017 to 2020. In 2020, it was estimated that net exports for mangoes totalled 5,281 tonnes.

Figure 3.7. Australia's Trade Balance



Note: Data is presented in calendar years, therefore, export volumes will differ to those presented by Hort Innovation which is presented in financial years.
Source: Fresh Logic (2022).

3.4 MANGO PRICES IN AUSTRALIA

On average, the 'other' category for mangoes in Queensland has experienced a higher price point than key varieties including Calypso, Honey Gold, Kensington Pride and R2E2. This price differential has been exaggerated particularly in the months of April 2017 and January 2021.

In April 2017, it was estimated that the princess variety received an average price of $6.4 per kilogram, driving the high price difference in comparison to other varieties. In January 2021, the price for Pearl Extra was estimated at an average $6.1 per kilogram while the price for Peal No1 received an average of $5.4 per kilogram. The decline in average price received for 'other' mangoes in January 2022 was largely due to no price recorded for higher value varieties such as Pearl, Mahachanok, and Dragon's Tooth.

The figure below highlights that the seasonality for 'other' varieties are later than Calypso, Honey Gold, R2E2 and Kensington Pride.

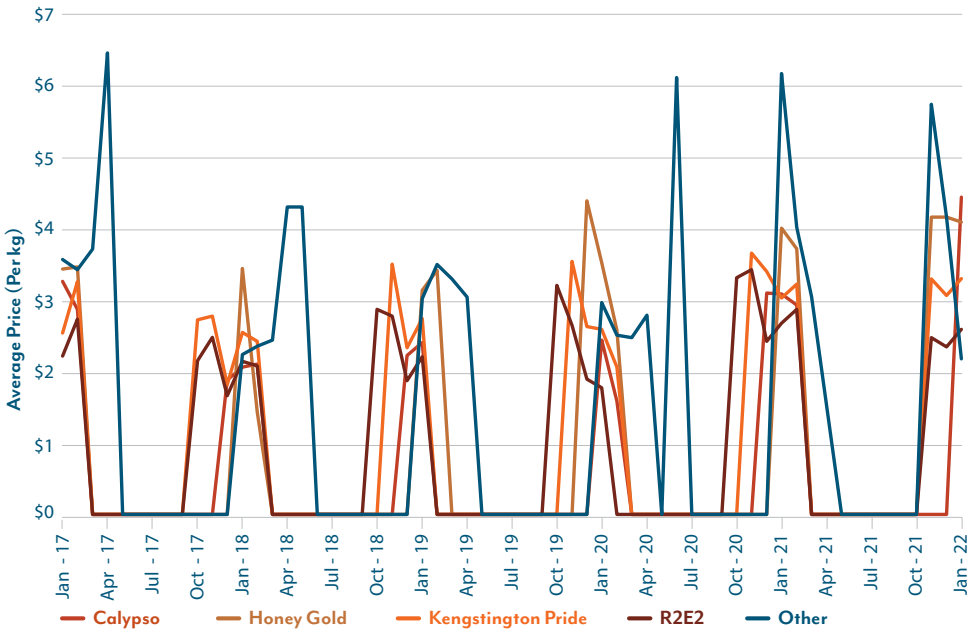
In January 2022, the average price for mangoes in Queensland were estimated to total:

- Calypso: $4.4 per kilogram on average
- Honey Gold: $4.1 per kilogram on average
- Kensington Pride: $3.3 per kilogram on average
- R2E2: $2.6 per kilogram on average
- Other: $2.2 per kilogram on average.

The US Federal Reserve are preparing to raise interest rates over the coming years resulting in a lower exchange rate, with Australia largely 12-18 months behind major advanced economies (Financial Review, 2022). As a result, it is likely there will be increased price pressure in Australia due to the falling exchange rates (due to interest rate differentials) until interest rates equalise.

The financial analysis contained in section 6 provides more detail on price expectations for the Central Queensland region.

Figure 3.8. Queensland Mango Prices (Average $/kg)



Notes:
- Average annual and average by variety.
- Other includes Brook, Bundy, Dragons Tooth, Heidi, Keitt, Kent, Mahachanok, Palmer, Pearl, Princess, Ruby Red and Tommy Atkins.

Source: Ausmarket Consultants (unpublished).

3.5 AUSTRALIA'S KEY MARKETS

In 2021, New Zealand was Australia's largest export market for mangoes, accounting for 18.2% of Australia's exports. This was followed by Singapore (17.1%) and Hong Kong (16.5%).

Table 3.5. Australia's Top Four Key Exports in 2020

Country	2020	Proportion of Exports
New Zealand	1,123	18%
Singapore	1,059	17%
Hong Kong	1,020	16%
UAE	844	14%
Other	2,137	35%
Total	**6,183**	**100%**

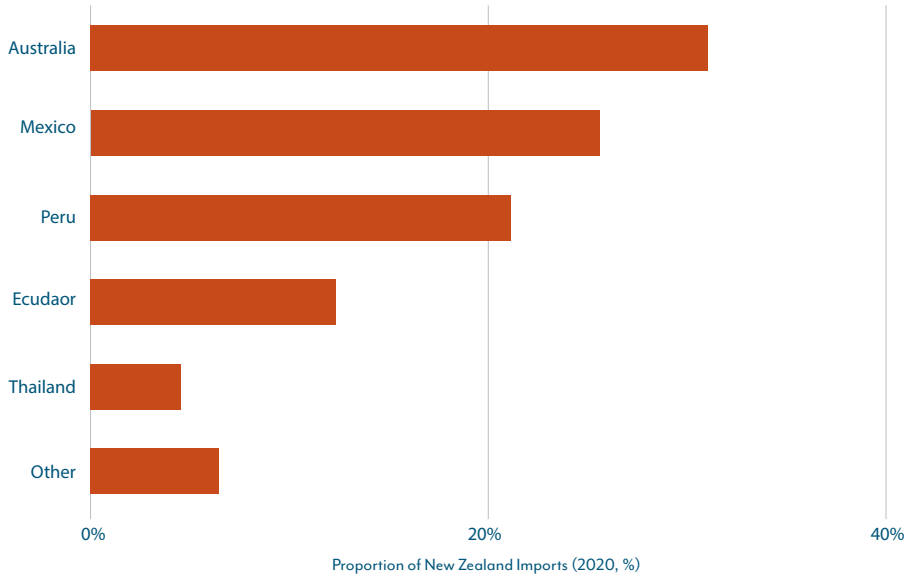
Notes:
- Largest export markets in 2020.
- Data is presented in calendar years, therefore, export volumes will differ to those presented by Hort Innovation which is presented in financial years.

Source: Fresh Logic (2022).

NEW ZEALAND

In 2020, Australia exported little over 1,1200 tonnes to New Zealand. The figure below identifies mango imports to New Zealand in 2020 by country. In 2020, it was estimated that Australian mango exports to New Zealand accounted for approximately 30.8% of the country's total mango imports.

Figure 3.9. Mango Imports to New Zealand, 2020

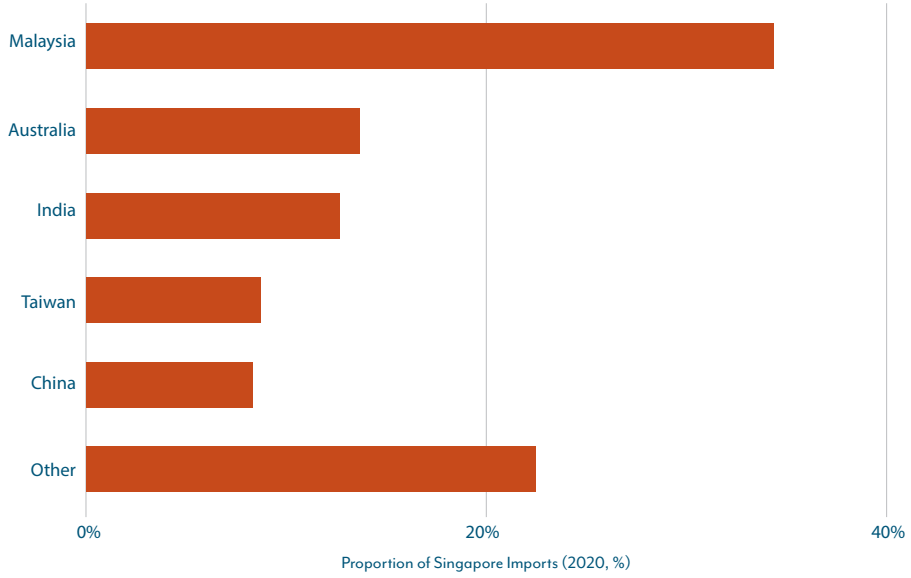


Source: Fresh Logic (2022).

SINGAPORE

In 2020, Singapore was Australia's second largest export market. The figure below highlights that Singapore sourced a large portion of mango imports from Malaysia, accounting for 34.3% of total imports in 2020. Australia was the second largest supplier for mangoes into Singapore in 2020, accounting for 13.6% of total imports for the year.

Figure 3.10. Mango Imports to Singapore, 2020

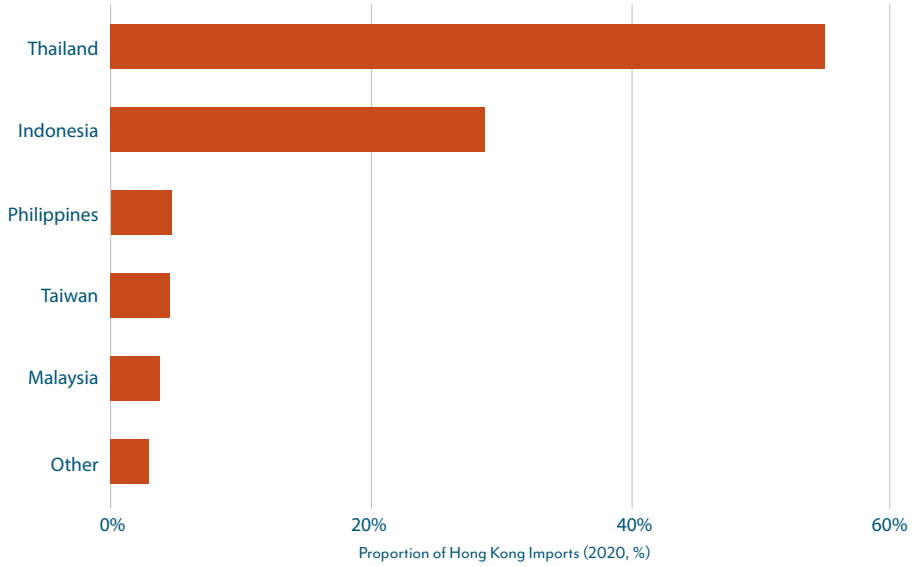


Source: Fresh Logic (2022).

HONG KONG

The figure below highlights that Hong Kong sourced a large portion of mango imports from Thailand, accounting for 54.8% of total imports in 2020. Indonesia was the second largest supplier for mangoes into Hong Kong in 2020, accounting for 28.8% of total imports for the year.

Figure 3.11. Mango Imports to Hong Kong, 2020



Source: Fresh Logic (2022).

3.6 MARKET VIABILITY ANALYSIS

The three key markets for Australia that were identified in section 3.5 above include:

- New Zealand
- Singapore
- Hong Kong

This following section provides a snapshot of each key market that has been identified for mangoes. This snapshot includes

- Market depth and maturity
- Market access considerations (access to Free Trade Agreements)
- Production seasonality and import competition
- Economic strength, market growth and consumer capacity to pay.

3.6.1 NEW ZEALAND

In 2020, New Zealand was Australian's largest market for mango exports, with Australia exporting approximately 1,123 tonnes. This accounted for only 1.8% of Australia's total production for the year.

Due to climate conditions, New Zealand are largely reliant on mango imports to satisfy domestic demand.

POPULATION & 2050 FORECAST

2021: 5.1 million

2050: 6.3 million

In 2020, Australian mango exports to New Zealand accounted for 30.8% of the country's total mango imports

GDP

2020: $41,441 per capita (USD)

2026: $58,293 per capita (USD)

New Zealand imported 3,644 tonnes of mangoes in 2020

Source: OECD (2022), World Bank (2022), Statista (2022), Fresh Logic (2022).

MARKET ACCESS CONSIDERATION

- Australia and New Zealand have a number of FTAs in place, eliminating tariffs for Australian mango exports to the country. The AANZFTA eliminated all tariff regimes on Australian mangoes in 2012, however, tariffs also remain nil under the RCEP, CPTPP, PACER, and ANZCERTA.
- New Zealand's other key suppliers of mangoes (Peru, Mexico and Thailand) also do not have any tariff implications.

PRODUCTION SEASONALITY AND IMPORT COMPETITION

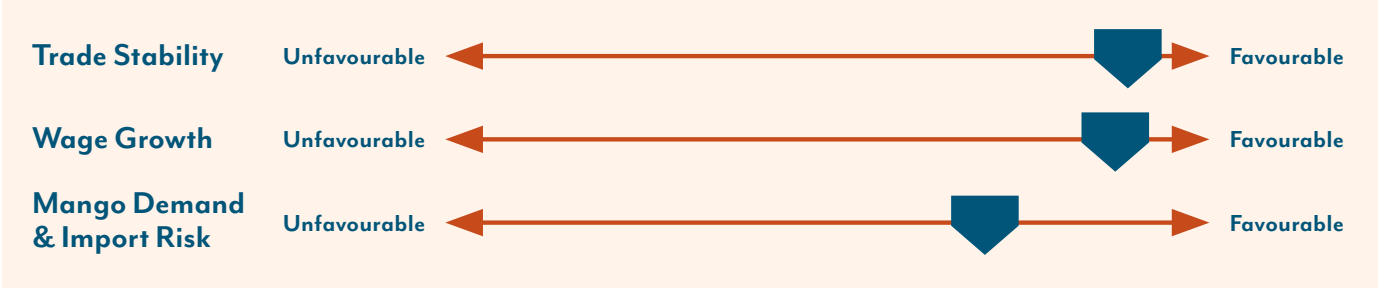
Australia's peak harvest window for mangoes is between the months of October of January, which slightly coincides with Peru's peak harvest season. Of important note, Thailand supplies mangoes all year round.

Table 2.7. New Zealand Mango Import Seasonality, Peak Harvest

Variety	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Australia				■	■	■	■					
Mexico	■	■	■									
Peru						■	■	■	■	■		
Thailand									■	■	■	■

Source: Tridge (2022a, b), Fresh Fruit Portal (2020).

Australia has significant proximity to market advantages, with a travel time of little over three hours from Brisbane via aircraft. For comparison, Peru (New Zealand's second largest supplier), has a travel time of over one day.



3.6.2 SINGAPORE

Australia's most popular varieties in Singapore include R2E2, Calypso, and Kent, with small volumes of both Keitt and Kensington Pride (CRCNA, 2020). The Calypso variety in Singapore is slightly more expensive than other Australian alternatives and is not preferred by general merchandise stores (CRCNA, 2020). Class one is the preferred fruit in Singapore market, with high-end supermarkets preferring premium fruit (CRCNA, 2020).

POPULATION & 2050 FORECAST

2021: 4.1 million

2050: 4.6 million

In 2020, Australian mango imports to Singapore accounted for 34.3% of the total mango imports

GDP

2020: $59,798 per capita (USD)

2026: $82,522 per capita (USD)

79.8% of Australian mango exports to Singapore were re-exported to Malaysia in 2018

Source: OECD (2022), World Bank (2022), Statista (2022), CRCNA (2021), Fresh Logic (2022).

MARKET ACCESS CONSIDERATION

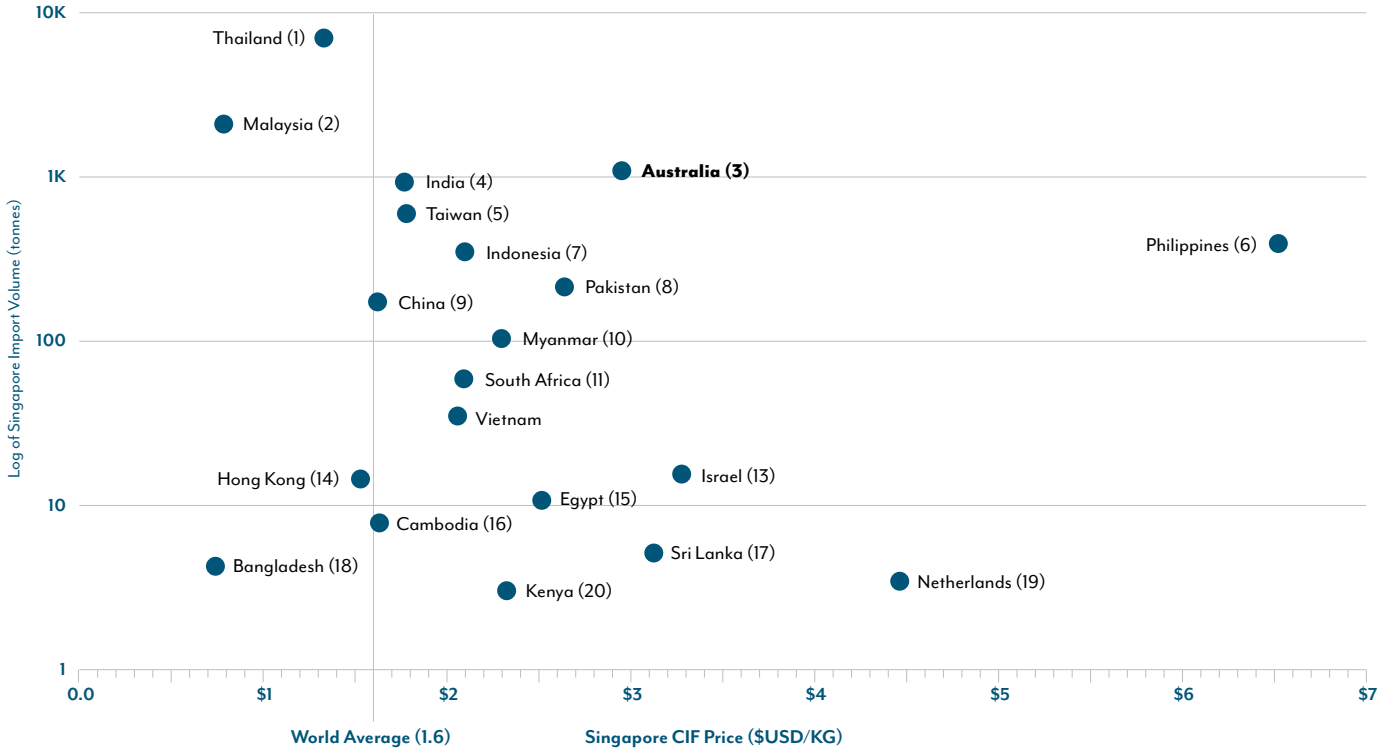
- Singapore is considered an open market without any import restrictions, and if fruit is required to be redirected from other markets than fruit is often directed to Singapore (CRCNA, 2020). This can have implications on competitiveness and prices in the market, given that the market is relatively small, with imports totaling 27,364 tonnes in 2020.
  - Under the CPTPP which entered into force at the end of 2018, the tariff for Australian mango exports to Singapore has been eliminated
  - Singapore's top three suppliers (Thailand, Malaysia and India) also do not have any tariffs on mango exports.

PRODUCTION SEASONALITY AND IMPORT COMPETITION

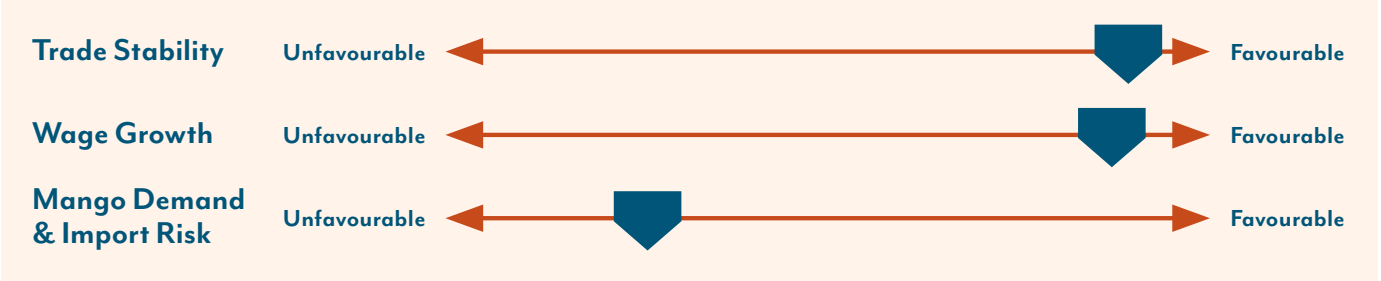
By large, Thailand and Malaysia are the two largest mango suppliers to Singapore, supplying mangoes year-round, with supply peaking in the months of February to May (CRCNA, 2020). Australia only supplies Singapore from September to April, with the peak of supply occurring between November to January (CRCNA, 2020). Throughout Australia's peak supply, the largest competitors are Thailand and Malaysia.

The figure below highlights the price differences of imports into Singapore (quoted as cost, insurance, and freight (CIF) prices) in 2013 to 2017. The prices of mangoes imported from Thailand and Malaysia are lower than the world average, with Thailand prices recorded at $1.3 USD/kg (CIF) from 2013-17 and Malaysia prices at $0.8 USD/kg (CIF). Australia's prices were higher than most supplying countries.

Figure 3.12. Five-year Average Volumes and Average CIF Singapore Price (2013 to 2017)



Source: CRCNA (2020).



3.6.3 HONG KONG

Australia's most popular mango varieties in Hong Kong include R2E2 and Calypso, and Kent and Kiett to a lesser extent (CRCNA, 2020). Due to the large size and blush colour, R2E2 is the most popular in the Hong Kong market (CRCNA, 2020). The volumes of sales of other mango varieties depend on the availability of R2E2 in the market.

Demand for Calypso has been rising over recent years for gift-giving, due to its appealing colour and shape (CRCNA, 2020). However, there is disadvantages of Calypso in the market, including higher price point than R2E2 and smaller sized fruit with less flavour (CRCNA, 2020).

The market in Hong Kong is largely focused on the appearance of the fruit, requiring a high blush ratio (CRCNA, 2020).

POPULATION & 2050 FORECAST

2021: 7.5 million

2050: 9.1 million

In 2020, Australia exported 1,020 tonnes to Hong Kong, comparatively Thailand exported 55,011 tonnes

GDP

2020: $46,324 per capita (USD)

2026: $61,797 per capita (USD)

80.4% of Australian mango exports to Hong Kong were re-exported to China in 2018

Notes:
- Population forecasts have been estimated based on population projections by IMF and OECD.
- 2026 GDP per capita has been based on projected population and total forecast Gross Regional Product (GRP) provided by Statista.

Source: OECD (2022), IMF (2022), World Bank (2022), Statista (2022), Fresh Logic (2022).

MARKET ACCESS CONSIDERATION

- The market in Hong Kong is based around quality product, due to significant competition in the market (CRCNA, 2020)
- With strong competition in the market, there is potential to reduce the wholesale price of mangoes through oversupply (CRCNA, 2020)
- Exports of mangoes from Australia, Thailand, Indonesia and the Philippines to Hong Kong do not have tariff implications.

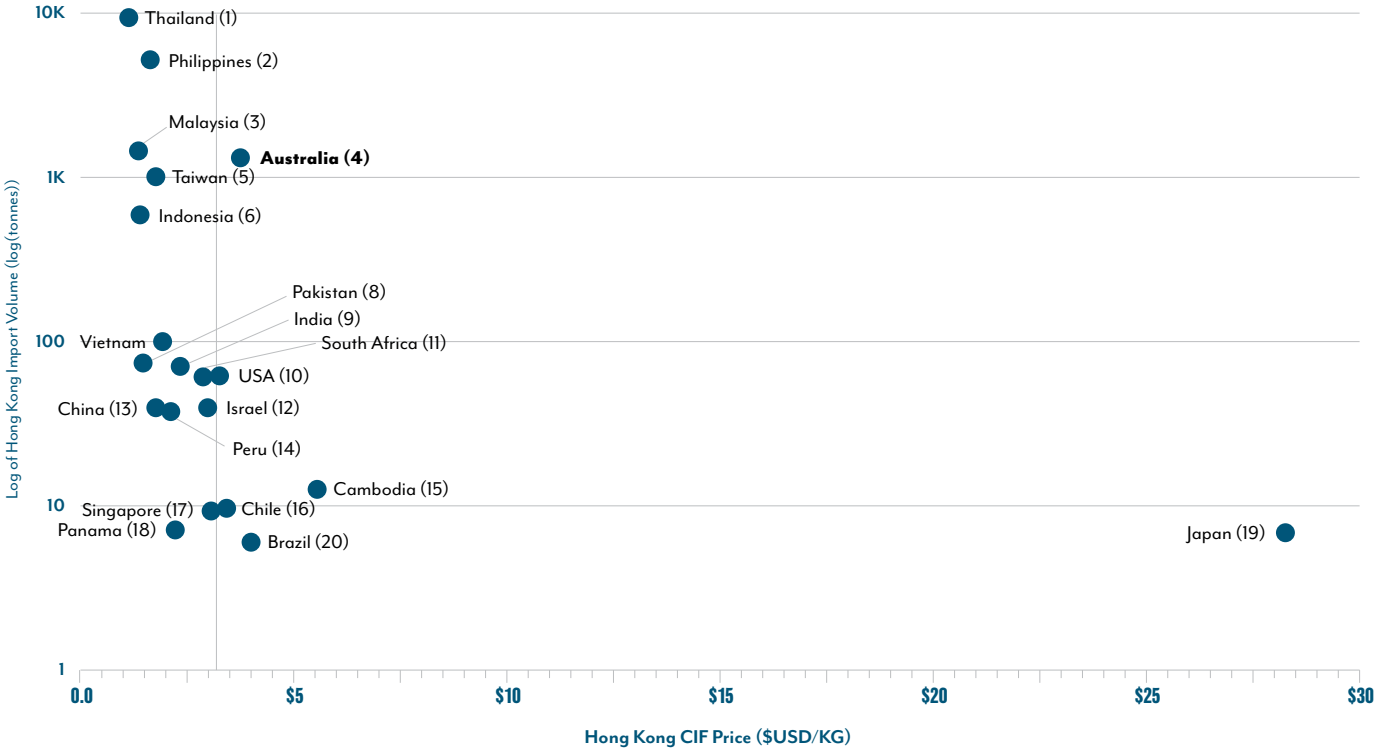
PRODUCTION SEASONALITY AND IMPORT COMPETITION

The Philippines, Thailand and Indonesia supply Hong Kong with mangoes all year round. Supply from Thailand and the Philippines is relatively consistent throughout the year, with Indonesia's peak supply extending from February to April (CRCNA, 2020).

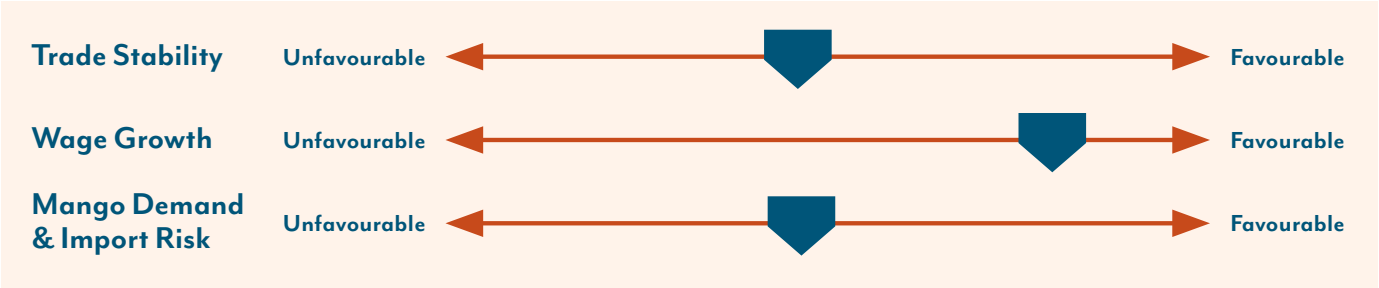
Australia's supply of mangoes into Hong Kong spans from August to the end of April, with the peak supply season from November to January (CRCNA, 2020). Over Australia's peak supply season, Australia's market share is over 30%, with key competitors during this time including the Philippines, South Africa and Indonesia (CRCNA, 2020).

Compared to Hong Kong's largest mango suppliers (Thailand, Indonesia and the Philippines), Australia is more expensive. Australia is the largest supplier with prices over $3.0 USD/kg.

Figure 3.13. Five-year Average Volumes and Average CIF Hong Kong Price (2013 to 2017)



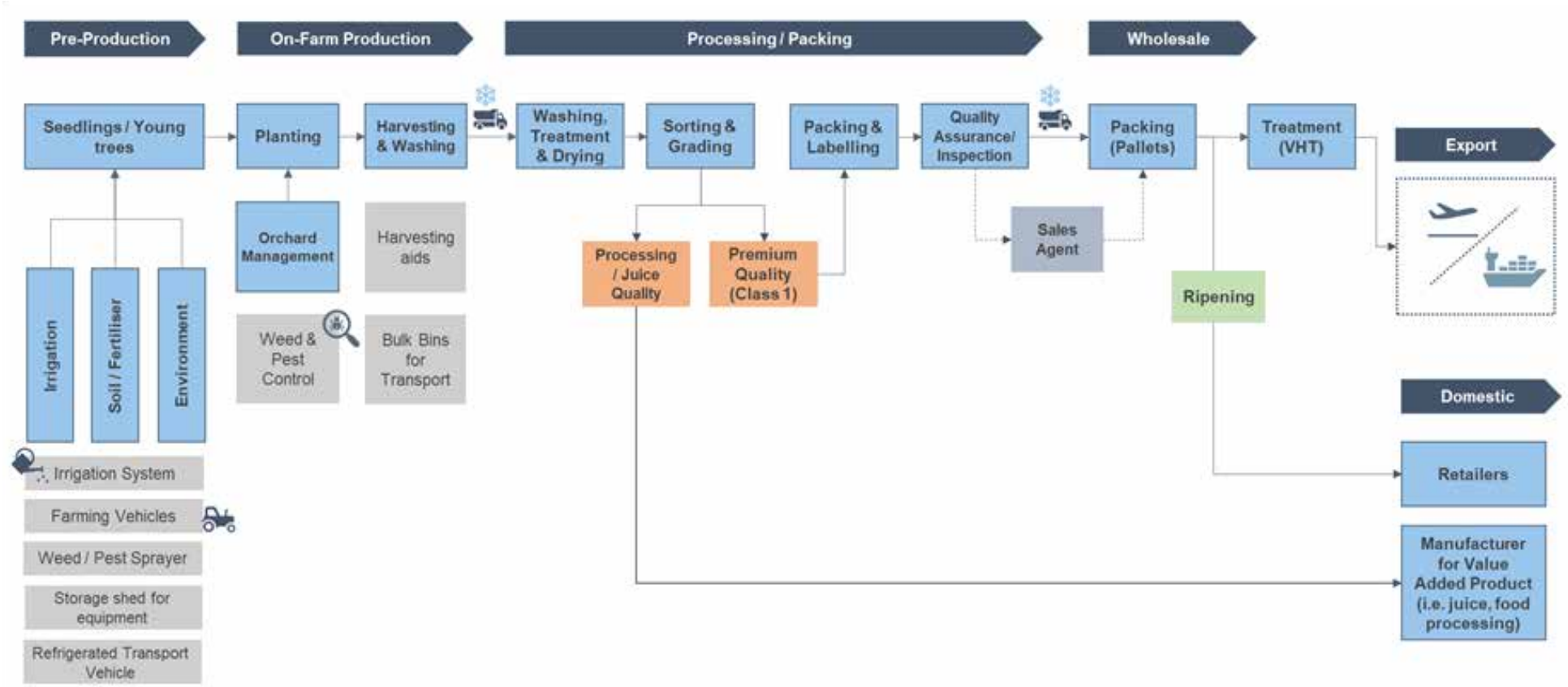
Source: CRCNA (2020).



4. MANGO SUPPLY CHAIN ANALYSIS
4.1 OVERVIEW

The figure below introduces a high-level supply chain analysis to investigate the activities and processes used to supply mangoes within the Central Queensland region (refer to Figure 4.1). It is important to understand this process to identify potential industry constraints or opportunities for the region at each point of the supply chain.

Figure 4.1. Mangoes Supply Chain



Source: AEC.

The below analysis will focus on the infrastructure and equipment requirements required at each point of along the supply chain.

PRE-PRODUCTION

Pre-production refers to the tasks and infrastructure associated with orchard establishment, prior to the planting of Mango trees. According to the Queensland Government's Mangoes Information Kit (DAF, 1999), essential infrastructure and equipment to set up and operate a mango orchard include:

- An irrigation system including a dam, piping and under-tree sprinklers
- Soil and fertiliser (and fertiliser spreader)
- Weed and pest sprayers, and safety equipment
- Tractors and vehicles, which includes a large tractor to operate spray (and harvesting) equipment, and a heavy-duty trailer
- Storage shed for farm chemicals
- Packing shed, including fork-lift, packing and grading equipment and a cold room (some growers use central packing sheds).

While many activities will not generally require Council approval if the land is zoned for rural activities and agriculture, Council approval for the clearing of land and the construction of buildings for on-farm operations (such as a storage and production facilities) may be required.

ON-FARM PRODUCTION

Grafted trees may carry a few fruit in their second year. Full production may not be reached for 8-10 years. Growing conditions and orchard management practices are outlined in Appendix A.

Mangoes are fragile and must be harvested with care. They are generally picked in a hard, green mature state, so they are ripened to an acceptable quality for eating. Sap that comes from destemming the mangoes have the potential to burn the skin of the fruit, impacting the exterior and the final appearance. It is also potentially harmful to human skin, if not wiped off immediately. Harvest aids may be used in the picking process to remove mature fruit off the trees. These handling systems typically also have a mango bath containing a chemical wash to remove the sap. Mangoes can also be harvested with the stems intact and de-sapped at the packing sheds.

Once picked, the mangoes are moved to a bulk bin, lined with a foam pad, for transport to the packing shed. Fruit is transported in a refrigerated truck to prolong storage life and maximise fruit quality. Uncooled fruit tends to ripen irregularly and is more prone to post-harvest diseases.

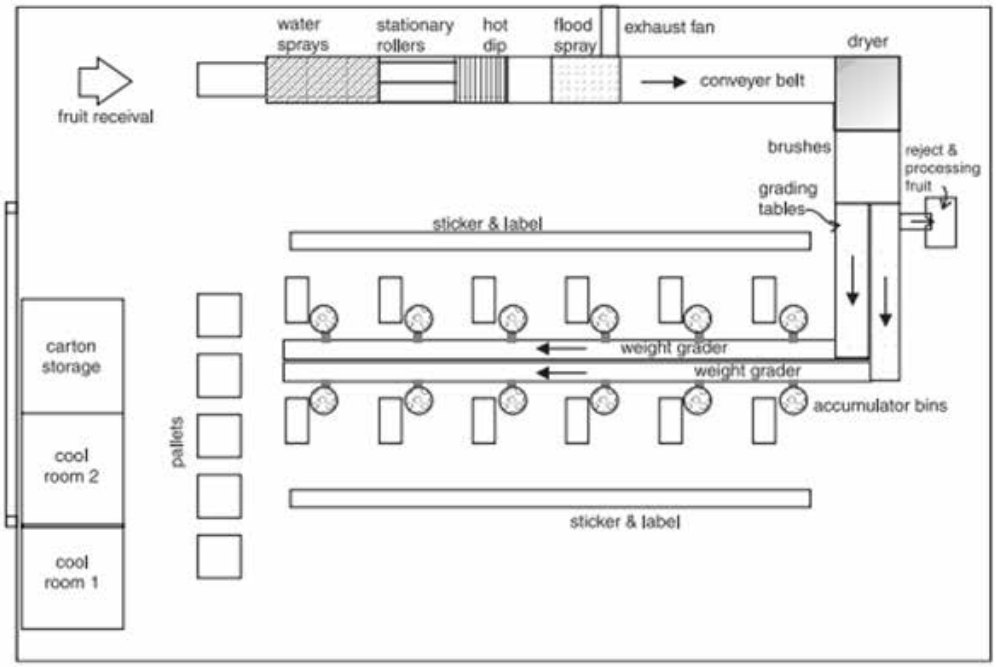
PROCESSING/PACKING

Most growers generally have their own packing shed and cold storage facility on farm. At the packing station, the fruits generally go through the following process:

- Washing, treatment and drying: Mangoes are placed into a water drop, washed and treated for fruit fly and bacteria. After post-harvest treatments, fruit must be dried before packing otherwise it will be impacted by skin browning.
- Sorting and Grading: Mangoes are sorted and graded according to size, and level of blemishes and visible defects. Sorting and grading can be done by hand, or by machine (such as a weight grader). Mango grades include Premium, Class one and Class two. Product that is not of export quality is generally sold to a manufacturer for value-add products such as juice, canned mangoes etc. Fruit sorting and grading is generally undertaken at a specialist and centralised packhouse facility due to the capital cost associated with establishing that facility.
- Packing and Labelling: Mangoes for the domestic market are largely packed in seven-kilogram packages, while fruit for export may be packed in smaller five kilogram cartons (i.e., mangoes exported to the US).
- Quality Assurance and Inspection: A final inspection is undertaken before the tray is placed in a cooling facility until it is transported out.

Infrastructure for washing, treatment, drying, sorting, packing and labelling is required. Figure 4.2 illustrates the layout of a typical packing shed. In addition to the figure below, technological advances have enabled more efficient and automated sorting, which utilises cameras to assess the external quality of fruit, detecting blemishes and visual defects.

Figure 4.2. Typical Layout of a Mango Packing Shed



Source: DAF (1999).

WHOLESALE

Growers can sell their mangoes directly, or through wholesale agents based at the major metropolitan produce markets and distribution centers. Most Queensland mangoes are consigned to wholesalers in Brisbane, Sydney, Melbourne and Adelaide. Transport to the distribution centers is required to be in refrigerated vehicles, otherwise the quality of the fruit will be impacted.

Ethylene gas can be used to trigger the ripening of fruit, bringing on uniform colouring and ripening (DAF, 1999). Ripening facilities may be found at the distribution centers, prior to retail sales to supermarkets, and other bulk buyers. Artificially ripened fruit generally has a shorter storage life and will need to move quickly through the market chain. As such mangoes are generally not ripened prior to export, and will tend to naturally ripen during transport to the destination countries. If required, export destinations may have ripening facilities.

Figure 4.3 illustrates the major mango production areas and distribution centers in Australia, as well as the major domestic and export markets.

A new export hub at the Darwin Airport was constructed in 2020, and the first mangoes to be air freighted to Singapore via the new export hub occurred in September 2021. The new hub also includes a vapour heat treatment plant.

Figure 4.3. Geographical Distribution of Major Mango Production Zones vs. Domestic and Export Markets (Excluding NZ)

Black = Major Production Zones, Blue = Major Domestic Markets, Red = Major Export Markets
Source: Higgins et. al (2007).

EXPORT MARKETS

Key export markets include both protocol and non-protocol markets. Protocol markets include countries that have an agreement with Australia prescribing the export requirements. For mangoes, these are China, Japan, Korea, New Zealand, and USA. Non-protocol markets include countries whereby there is no agreement with Australia prescribing the export requirements, generally making these countries easier to export to than protocol markets. These markets include for example Singapore, Hong Kong and Canada, and might still have phytosanitary requirements.

The below table outlines the detailed requirements of the key protocol markets.

Table 4.1. Market Protocol Requirements

Country	Orchard Approval by DAWE (annually)	Packhouse approval by DAWE (annually)	Approved crop monitoring program (annually)	Vapour Heat Treatment (Fruit Fly)	Irradiation (Fruit Fly and other arthropods pests)	Mango Seed Weevil (Freedom)
China	✓	✓	✓	✓		✓
Japan		✓		✓		
South Korea	✓	✓	✓	✓		✓
New Zealand					✓	
United States	✓	✓	✓		✓	

Source: AMIA (2020).

Vapour Heat Treatment (VHT) is required for exporting mangoes to China, Japan and South Korea. This is required as a disinfestation protocol. VHT treatment also promotes the ripening process and potentially leads to a two-day reduction in the supply chain life.

Mangoes can be exported via both air and sea freight. Air freight is more commonly used to ensure the shelf life and fruit quality is maximised at the export destination. Australia's proximity to Asia and relatively low air freight costs have optimised freshness and shelf life during exports (Horticulture Innovation Networks, 2021).

The COVID-19 associated disruption of the supply chains is an ongoing concern for Australian exporters, with freight costs reported to have increased up to three times and capacity decreasing to about 10% - 25% of normal. This has prompted some exporters explore options to ship more commodities by sea. However, there are still significant risks associated with sea freight, particularly if the cold chain is not efficiently managed during the duration of the delivery.

Typical days from Brisbane port loading to destination port unloading are outlined in the table below.

Table 4.2. Typical Days for Transport

Destination	Days
Singapore	16
Busan (South Korea)	25
Hong Kong / Guangzhou (China)	18 – 26
Jebel Ali (UAE)	24 -35

Source: DAF (2020).

DOMESTIC MARKETS

The domestic market includes both large and small retailers (including supermarkets), local retailers and restaurants, and manufacturers/processors.

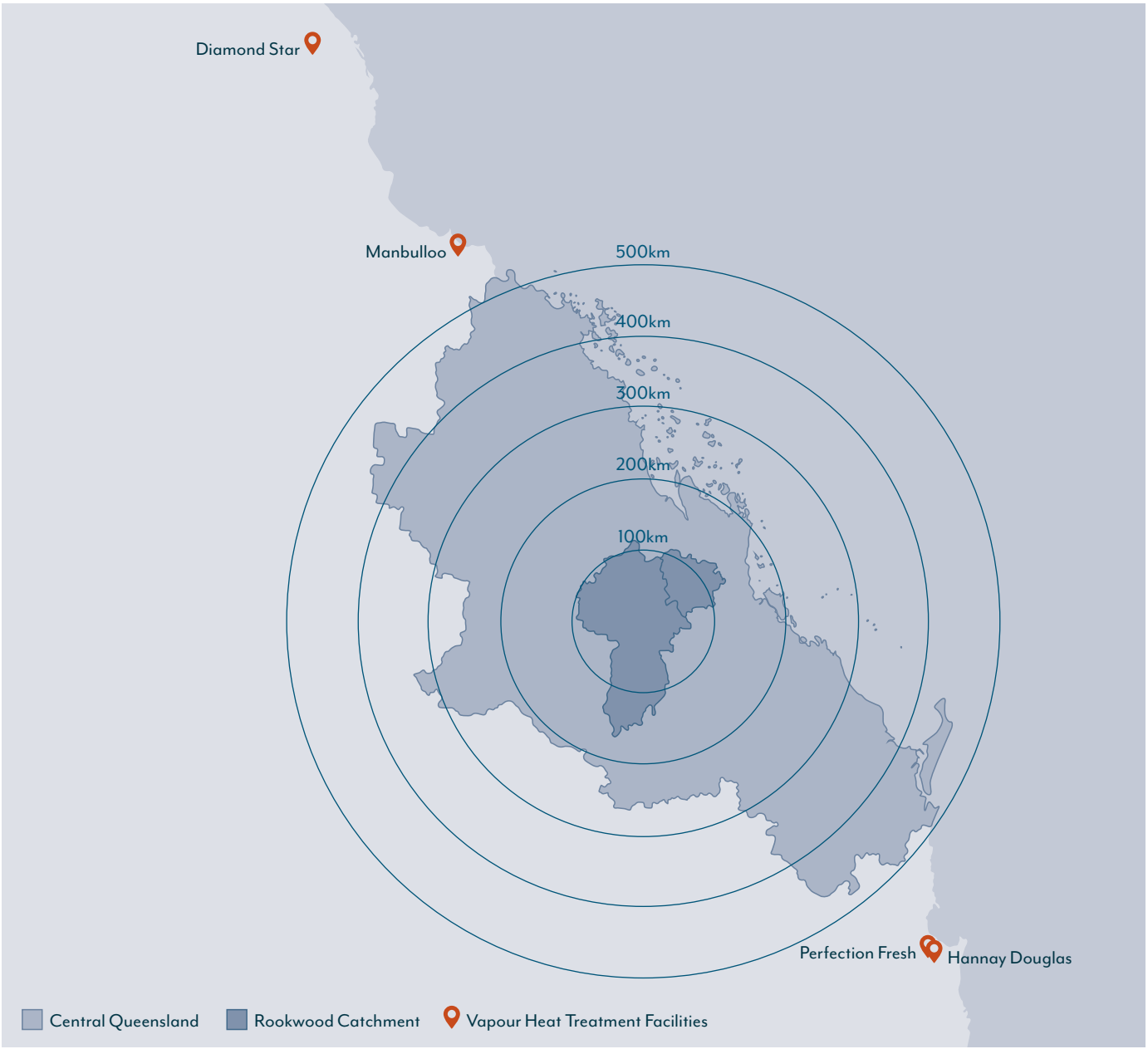
Retailers are the point of sale to end consumers and households, and can be large or small. The fresh food supply chain is largely dominated by the major supermarkets, including Coles and Woolworths. Other supermarket chains include IGA, FoodWorks, and Aldi.

Processors are organisations that manufacture juice, jam and canned fruit from the fresh fruit. Fresh produce can be sold to processors directly from farmers, from packers or from the wholesalers. The processors pack the juice in different packing sizes for the retailers. In Queensland, the Golden Circle Cannery in Brisbane is a major processing outlet. Other processors include Foodpac in Netherdale (North Queensland), Simsha in Townsville (North Queensland), Tropico Pty Ltd at Palmwoods and CB Juice (Central Burnett Fruit Processors) in Munduberra.

4.2 INFRASTRUCTURE REQUIREMENTS AND GAPS IN CENTRAL QUEENSLAND

There are currently four known vapour heat treatment (VHT) facilities in Queensland, including two facilities in Brisbane (Perfection Fresh and Hannay Douglas), one facility in Giru (Manbulloo), and one facility in Mareeba (Diamond Star). There is also another facility located at the new export hub at the Darwin Airport in the Northern Territory (DAF, 2020). These treatment facilities are illustrated in Figure 4.4.

Figure 4.4. Mangoes Vapour Heat Treatment Facilities (VHT), Queensland



Source: AEC.

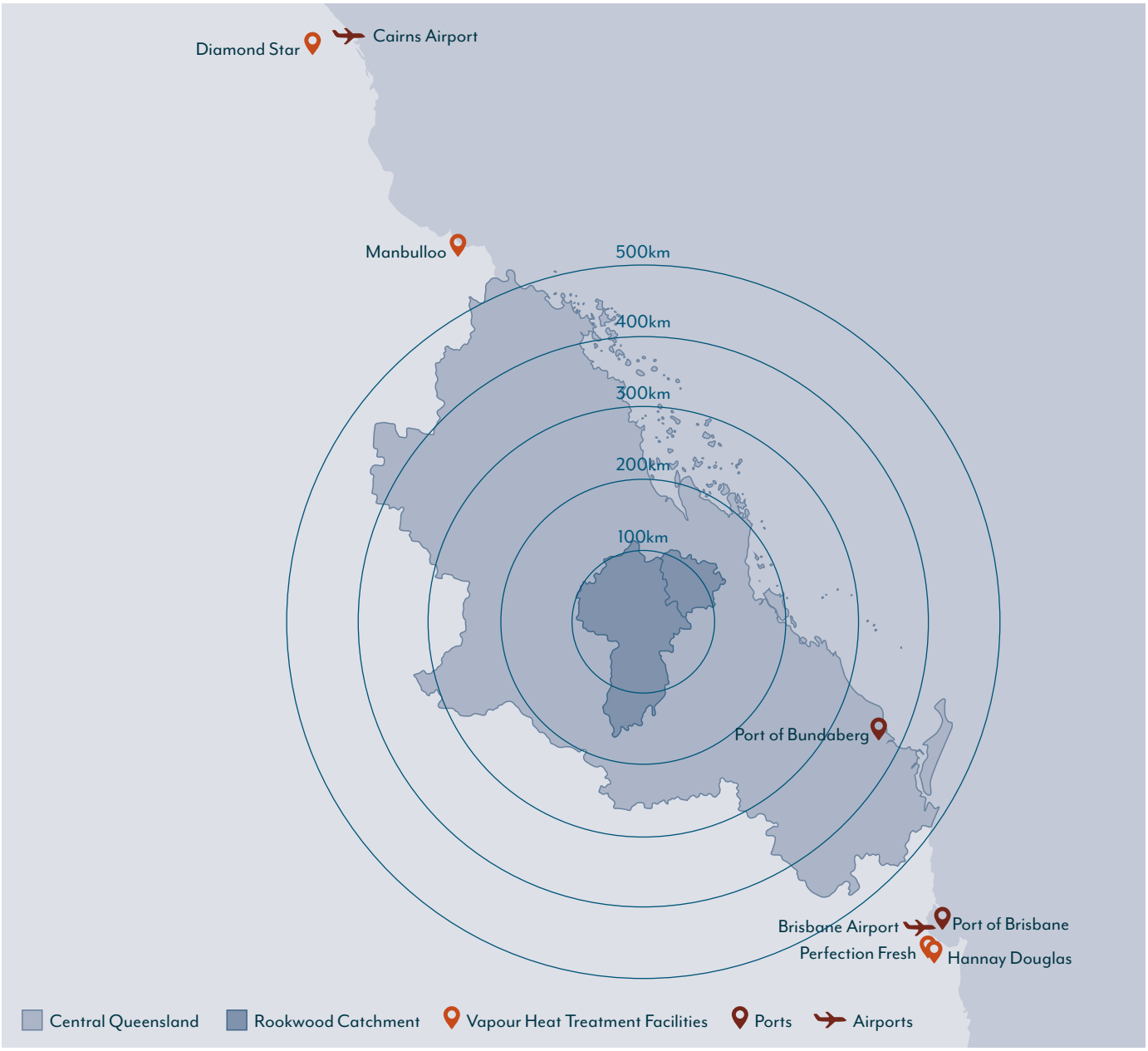
There are currently no VHT facilities in the Rookwood Weir Catchment Area or the Rockhampton region. If mangoes were selected as commodity for the Rookwood Weir Catchment Area, harvested mangoes will need to be transported to a treatment plant at either Brisbane or Giru.

Increasing the time between harvest and VHT treatment increases the risk of heat damage symptoms appearing when fruit near the end of their supply chain life. Symptoms commonly include scald and lenticel damage (Serviced Supply Chains project, 2020).

Mango exports are currently transported via air freight from Brisbane and Cairns Airport, or via sea freight from the Port of Brisbane. A port is also located at Burnett River, the Port of Bundaberg, owned by Gladstone Ports Corporation Limited, which is closer to the Rookwood Weir Catchment Area. However, mangoes are not identified as a primary export at this port. The two main wharves, Sir Thomas Hiley Wharf and John T. Fisher Wharf handles sugar, gypsum, wood pellets, bulk liquids, molasses and silica sand. The current port infrastructure at the Port of Bundaberg is not suitable for mango exports. Although agribusiness is identified as an important industry in the Precinct Outlook for Port of Bundaberg (GPC, 2019), it not listed specifically as a 'future trade of the port', which includes dry bulk commodities (minerals), general cargo and bulk liquids.

The export freight locations are illustrated in Figure 4.5.

Figure 4.5. Export Freight Locations, Rookwood Weir Catchment Area



Source: AEC.

5. COMPETITIVE ANALYSIS AND MARKET OUTLOOK

Australia is a relatively small producer, importer and exporter of mangoes in the global context. The industry in Australia is relatively opportunistic, participants have the benefit of strong domestic demand and volatile export market factors such as transport costs and supply timing. This leads to more sporadic supply of mangoes to international markets.

A priority for the Australian market is to increase mango exports into the future, growing exports from around 12% of production currently to approximately 20% of production. To achieve this, Australia will be required to look at existing markets and identify additional opportunities for expansion. The Australian Mango Industry Association are currently developing an export strategy which may lead to the identification of new markets which are currently not identified by the industry.

A map of key importers and exporters of mangoes, mangosteens and guavas is provided below. The Netherlands re-exports mangoes imported to other European countries and does not produce any mangoes domestically.

Figure 5.1. Major Exporters and Importers, Mangoes, Mangosteens and Guavas

Note: Top five largest importers and exporters in 2020.
Source: AEC.

The Queensland Government have a created a shortlist of markets for the export of Australian mangoes, mangosteens and guavas which include:

- Singapore
- Hong Kong
- New Zealand
- China
- United Arab Emirates
- South Korea
- Malaysia

Most of these markets are existing key export destinations for Australian produce. Australia also exports mangoes to Japan with varieties including Keitt, R2E2, Kensington Pride, Kent and Palmer. Currently Calypso and Honey Gold are not approved for export to Japan, however consultation with the Australian Mango Industry Association indicated that these varieties could be approved in the future.

The table below provides an outline of the key opportunities and challenges in each market.

Table 5.1. Market Opportunities and Challenges for Australia

Country	2020	Proportion of Exports
Singapore	• Rising consumer preference for fresh fruit • High level of disposable incomes • Niche market for Australia's clean and quality fruit for the high-end market, particularly R2E2 and Calypso	• Thailand is identified as the top producer, supplying Nam Doc Mai, Keo Savoy and Ok Rong • Price sensitive retailers and consumers • Open market without import restrictions, increasing competition in the market • Mangoes largely imported through traders, rather than grower exporters • Packaging style and colour of Australian produce • Mangoes transported by road from Thailand, resulting in cheaper transportation costs
Hong Kong	• Consumers looking for new varieties and experiences • Premium mangoes as gifts during festive seasons – packing and campaigns around the local festivals • High demand for R2E2 due to large size and blush colour • Counter seasonal production to large suppliers	• Competitive market with little trade barriers • Importers, food service operators and retailers often are expecting financial and marketing support from suppliers for promotion of product • Largely re-exports Australian mangoes to China
New Zealand	• Proximity to market advantages • Buyers are categorized in the middle to upper income brackets • Opportunities in early supply from the Northern Territory during August and September when fruit from South America is not available	• Growing imports from South America countries

Country	2020	Proportion of Exports
China	❯ Projected increase in imports ❯ High quality mangoes (R2E2) which are well accepted in the market ❯ Consumer shift to healthy and nutrient rich foods ❯ Eliminated tariffs ❯ Counter peak seasonal production to China ❯ $2.24 million research collaboration with CRCNA, Perfection Fresh, DAF and University of Queensland to identify and resolve issues with export of mangoes to China. To be completed by mid of 2023: ❯ Increase value of Calypso mangoes to China from $1 million per annum to around $20 million per annum	❯ Introduction of additional supplying countries (i.e., Cambodia is allowed to export 500,000 tonnes of mangoes to China per annum) ❯ Sourcing a portion of Australian mangoes through Hong Kong ❯ Meeting demand for consistent quality and quantity ❯ Importers and wholesalers in Guangzhou Jiangnan market often re-grade and re-pack the fruit into new boxes. ❯ Higher price than local mangoes ❯ Local mangoes are largely available throughout the year ❯ Direct imports from Australia are more expensive than the grey channel via Hong Kong ($60-$84 for a 7kg tray compared to $49-$79 CIF)
United Arab Emirates	❯ Confidence in dealing with Australian exporters	❯ Strong price competition for cheaper product ❯ Logistics for Australian product is higher than for key competitors
South Korea	❯ Export Calypso to the market ❯ More sensitive to quality over price ❯ Potential for demand growth ❯ Increased perception of Australian premium product ❯ Reduction in tariff from 3% to 0% by 2023 under the KAFTA ❯ Tariff advantages over major suppliers including Thailand, Philippines and Mexico which will remain at 24% and 30% respectively	❯ Strict import regulation, with only 10 countries being approved for market access (including Australia) ❯ Low imports from Australia and small supply window compared to key competitors ❯ R2E2 is the only variety imported from Australia ❯ Preference for domestic fruit, even if fruit is more expensive. South Korea is growing mangoes in greenhouses, leading to higher prices than imported products
Malaysia	❯ No tariff implications under the MAFTA ❯ Proximity to existing markets (Singapore) and minimal incremental transport costs	❯ Imports significant volumes from Thailand. Imports of mangoes, mangosteens and guavas from Thailand accounted for 94.0% of total imports on average from 2010 to 2020. ❯ Thailand supplies mangoes all year round.
Japan	❯ Generally, consumers are not price sensitive for fresh fruit ❯ Introduce additional varieties to market ❯ Market the fruit as a premium and quality product	❯ Strict import regulations, with 11 countries being approved for market access (including Australia) ❯ Declining mango imports ❯ Australia is the smallest supplier of mangoes to Japan ❯ Familiarity with Irwin, sunset and apple mangoes ❯ Preference for local fruit that is known for high quality and standards ❯ Australia overlaps supply windows of Brazil and Peru ❯ Australian mangoes more expensive than key competitors.

Source: CRCNA (2021, undated), Australian Government (2022), Australian Mango Industry Association (2014).

The table below outlines the strengths, weaknesses, opportunities and threats of the Australian mango industry which may be of relevance to potential growers of mango crops in the Rookwood Wier Catchment Area.

Table 5.2. SWOT Analysis – Australian Mango Production

Strengths	Weaknesses
› Several FTAs with key markets, reducing costs to supply mangoes internationally › Generally regarded as a premium product › Australian mangoes differ from competitors in appearance and taste.	› Difficult to respond quickly to market signals due to long lead time to increase production › Cost implications for freight compared to other major competitors › Increased price pressure in Australia due to falling exchange rates (until interest rates equalise) › The mango industry is largely focused on supplying the domestic market › Kensington Pride, which dominates domestic production, are not suited well for export due to thin skin.
Opportunities	**Threats**
› Continued investment in research and development › Opportunistic market, adaptable to demand in the domestic and international market › Australia's supply window corresponds to gift giving festivities in many Asian countries › Industry association developing strategies to support export growth.	› Logistic challenges due to the impact of COVID-19 › Trade disputes between China and Australia may impact future supply to the market › Competitive markets, especially in Singapore and Hong Kong with no import restrictions › Weather impacts, particularly from cyclones › Biosecurity outbreaks or breaches impact exports and brand image.

Source: AEC.

6. FINANCIAL AND COMMERCIAL ANALYSIS

ROOKWOOD WEIR FINANCIAL FEASIBILITY – KEY ASSUMPTIONS & FINDINGS

- The average land available on a typical Rookwood Weir land lot which is suitable for mango production is 160ha. With water entitlement restrictions and a conservative water use assumption, the total sustainable land available for orchard development (i.e. planted area) is restricted to 66ha.
- The anticipated initial capital investment for a mango orchard is $4.9 million – including, land, land clearing, infrastructure and equipment, water entitlements, and planting.
- The first harvest is not expected to occur until the fourth year of growing, when the trees will yield, on average, 15.7kg per tree. The farm will be operating at a loss until the commercial return is achieved when the trees reach their ninth year (FY2033), with a yield of 45.3kg per tree.
- The break-even point (for Kensington Pride) is February 2028, however, the first year of operating at a profit is predicted to be FY2033, with the plants being planted in FY2025.
- With consideration to the capital investment and the operating position, the discounted cash flow will be positive by FY2032.
- The long-term growth rate for agricultural farm values is 8.8%, with a net present value (NPV) of the farm at $0 the implied internal rate of return is 11.6%. The terminal value of the Mango farm at the conclusion of the analysis (FY2041) is $42.2 million (undiscounted).

6.1 APPROACH

The commercial and financial feasibility of an average mango orchard in the Rookwood Weir Catchment Area has been evaluated on a discounted cash flow basis over a 20-year evaluation period. This analysis assumes a greenfield farm establishment in the region, and includes the cost of land, capital investment required, operating costs, and the anticipated revenue over the 20-year time frame. The following sections detail the following:

- Orchard establishment
- Orchard operations
- Sources of funding
- Financial Feasibility (including sensitivity analysis)

6.2 ROOKWOOD WEIR WATER AVAILABILITY

The Rookwood Weir Water Supply Scheme allows for a maximum 500ML water allocation for agricultural landholders. Under the assumption this water is provided with a conservative 80% reliability and 6ML per ha per year is required for mango production (DAF, 1999), the maximum growing area in the Rookwood Weir catchment area is 66ha. However, DAF recognise areas in central and southern Queensland may require less than 6ML/ha.

Sensitivity has been conducted at 60% and 100% water reliability as well as without the water allocation cap. The total land available for horticulture under each scenario is shown in Table 6.1.

Table 6.1. Land Availability

	60% Reliability	80% Reliability	100% Reliability	No Water Allocation Cap
Land Availability	80 ha	66 ha	83 ha	160 ha

Source: Queensland Treasury (2021)

The outcome of the scenario analysis is presented below in Section 6.7.1.

6.3 VARIETY SELECTION

There are three varieties considered in this analysis: Kensington Pride, R2E2, and Calypso. Each variety is anticipated to have the same capital and asset basis. Varietal difference will be evidenced through the orchard operations and structure. Honey Gold mangoes can be, and are, also grown in the Rookwood Weir catchment area, however, are not modelled in this analysis given the restricted commercial structure of the Honey Gold variety.

The three key differences modelled between the selected varieties are:

- Tree population
- Price
- Yield
- Harvest period

Table 6.2. Variety Summary

Variety	Tree Density (Tree/ Ha)	Price Grade One ($/ Tray)	Average Yield Mature Tree (kg/ Tree)	Harvesting Months
Kensington Pride	185	$24.17	56	5
R2E2	250	$20.00	47	4
Calypso	250	$19.84	46	3

Source: Australian Tree Crop (2020), Ausmarket Consultants (unpublished), Bally, I. et al (2002). DAF (1999), DAF (2014b) and DAF (2016), Consultation with Growers.

Financial evaluation has been undertaken for a typical Kensington Pride farm, with sensitivity analysis undertaken for R2E2 and Calypso varieties.

TREE POPULATION

There is a range of tree densities within mangoes can be farmed, all of which present unique array of benefits and costs which are largely unique to the variety. Kensington Prides are typically grown with the lowest tree density of the mangoes selected for analysis. The density of a Kensington Pride orchard can vary from a few as 111 to upward of 185 trees/ Ha, 185 trees per Ha has been used in this analysis based on industry advice.

It's noted that modern mango farms typically opt for moderate to higher density tree planting compared to older farms in order to balance the need for operating expenses such as pruning and harvesting with the potential yield.

Low-density farms are typically older, more mature orchards whereby the trees grow to relatively extreme sizes. Low-density farms allowing for large tree growth are atypical in modern farming given the inefficiencies associated with harvesting. Whereas high density farm incur higher than average capital investment and/or pruning costs which can mitigate potential benefits associated with increase yield or high harvesting efficiencies.

For a 66ha farm, this leads to a maximum tree population of 12,210 trees. A key assumption underlying the modelling is that there are no supply chain or regional capacity constraints in accessing and planting the saplings, that is, 12,210 trees will be able to be sourced and planted during orchard establishment

R2E2 and Calypso have a structurally different tree to the Kensington Pride in that they're typically narrower and taller with allows for increased density of trees.

PRICE

Prices for each variety and grade are presented in Table 6.3. Grades One and Two are typically sold as fruit or fruit products, Grade Four is typically sold as fruit products or juice.

Prices used in this analysis reflect the average Queensland proved for the past five year (FY2017- FY2021) to reflect prices changes influenced by weather events.

Table 6.3. Price Per Tray, by Variety and Grade

Variety	Grade One	Grade Two	Grade Four
Kensington Pride	$19.34	$11.85	$7.09
R2E2	$18.29	$11.68	$8.23
Calypso	$15.87	$12.27	$0.00

Source: Ausmarket Consultants (unpublished).

YIELD

All three varieties typically will not yield a harvest in the first three years of planting. The first year of harvest, all three varieties are assumed to yield approximately 16 kilograms per tree. The variance in variety is in the growth of the yield and, ultimately the maximum yield each variety typically achieves.

Kensington Pride will reach maturity by about age 10 of the tree. Bally, et al. (2002) provide evidence a Kensington Pride tree will increase production by about 23.3 kilograms per tree per year. The mature estimate under this assumption is 156 kilograms per tree per year. However, industry practice suggests a yield of 85kg per tree (or 12 trays) is exceptional. Modelling has been conducted based on a conservative mature estimate of 56 kilograms per tree per year at maturity (or 8 trays per tree). This yield estimate is based on anecdotal evidence from industry stakeholders.

R2E2 typically yield less per tree than the Kensington Pride. At maturity (10 years of age) the R2E2 will yield approximately 83.6% less than the Kensington Pride (Bally, et al., 2002). Based on the conservative Kensington Pride estimate, the yield of a mature R2E2 tree is 47 kilograms per tree per year. Calypso will yield at relatively similar rates to R2E2 (46 kilograms at maturity), however will reach maturity at approximately nine years of age (DAF, 2016).

All varieties are assumed to achieve the following yield by grade. However, achievement of yield by grade is highly depended on the land, orchard structure, and orchard management.

Table 6.4. Share of Yield by Grade

Grade	Share of total Yield
Grade One	45%
Grade Two	30%
Grade Four / Juice	20%
Spoilage	5%

Source: CRCNA (2021), Australian Mango Industry Association, Consultation with Growers.

HARVEST PERIOD

The harvest period in Australia varies for each variety. Each variety has been modelled on both the medium and high productivity months (refer to Table 3.4 for more detail). Kensington Pride is modelled as having five productive harvest months and is the first to start harvest in September. R2E2 follows with harvest starting from October, and Calypso is modelled with three harvest months, starting in November.

Table 6.5. Varietal Harvest Period

Variety	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Kensington Pride			■	■	■	■	■					
R2R2				■	■	■	■					
Calypso					■	■	■					

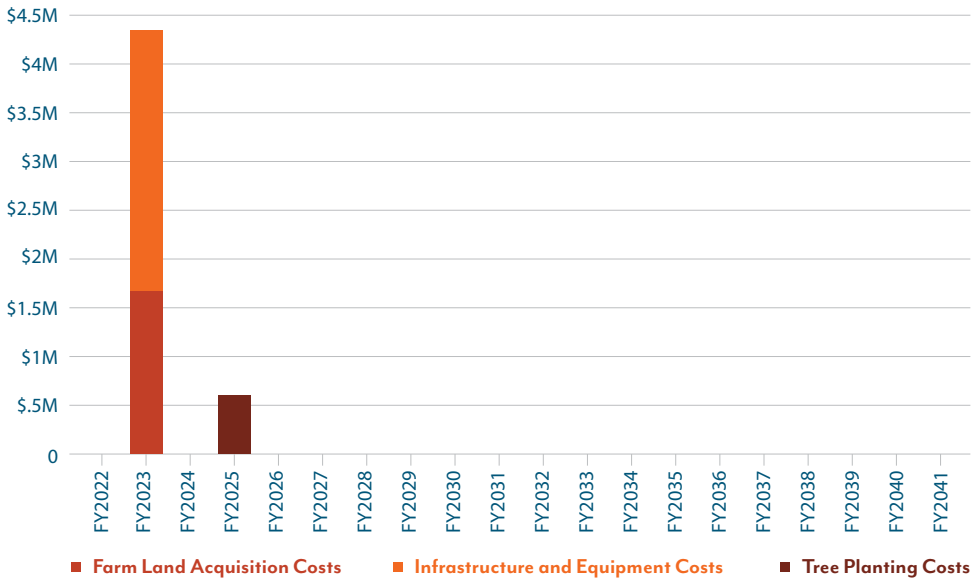
Source: Hort Innovation (2021).

6.4 ORCHARD CAPITAL INVESTMENT

6.4.1 ORCHARD ESTABLISHMENT

Mango orchard establishment requires three key capital investments, the land, the on-farm infrastructure and associated equipment and the trees. For the purpose of analysis, it is assumed the majority of the initial investment occurs across four months, starting 1 January 2023, with planting occurring over the spring months. Overall, for the 66ha farm, the initial capital investment is $4.9 million ($74,599/ha).

Figure 6.1. Total Orchard Establishment Costs (FY2022 – FY2041)



Source: AEC (2022), HTW (2022).

FARMLAND AND ACQUISITION COSTS

Farmland and acquisition costs include the price of land, the cost of land clearing, and the water entitlements. Total farmland and acquisition costs per farm are estimated to be $1.7 million.

Land suitability analysis shows each property within the Rookwood Weir Catchment Area has on average 160 available Ha suitable for growing Mangoes. At value of $3,810/ha in FY2021 terms (on advice from HTW) the total estimated land price for a typical allotment which has suitable land for mango production is approximately $626,715 in nominal terms.

Secondary capital costs associated with the land include the water entitlements. Water entitlements from the Rookwood Weir are priced at $1,500/ML (RFM, 2020), at a total allocation of 500ML the water entitlement cost for landholders will be approximately $771,056 in nominal terms.

Given the typical current land use within the catchment, it is assumed the land, upon purchase, will need to be cleared and prepared for orchard establishment. In cases where land requires clearing, an additional 12 months is typically added to the establishment timeline to allow for soil rehabilitation (DAF, 2004c). Based on anecdotal evidence from HTW and other key regional producers, and the typical terrain of the Rookwood Weir catchment area, the per Ha cost of clearing land would be approximately $4,000.

INFRASTRUCTURE AND EQUIPMENT COSTS

On-farm infrastructure includes storage facilities, require a capital investment to establish facilities such as irrigation and farming and harvesting equipment. The infrastructure and equipment investment are considered to be purchased or built in the same year of acquisition of the land.

To plant and grow mangoes on a 66ha farm, the necessary infrastructure and equipment will cost an estimated $2.7 million.

- This includes irrigation installation which, according to the Northern Territory Department of Primary Industries and Fisheries (DPIF, 2002), would cost about $8,581/ha (in FY2021 terms). It is noted, however, that this is an indicative estimate, the cost to landholders will vary depending on their location along the weir scheme and their distance from the river.
- Infrastructure such as storage sheds, equipment for activities such as pruning, harvesting, and fertilising, as well as other necessary machinery and (such a vehicles) are estimated to cost approximately $30,675/ha (DPIF, 2002, with clarification provided by Industry).
- It has been assumed that packing and sorting infrastructure would be centralised due to the significant capital associated with building a packing shed and acquiring NIRS based sorting and grading equipment.

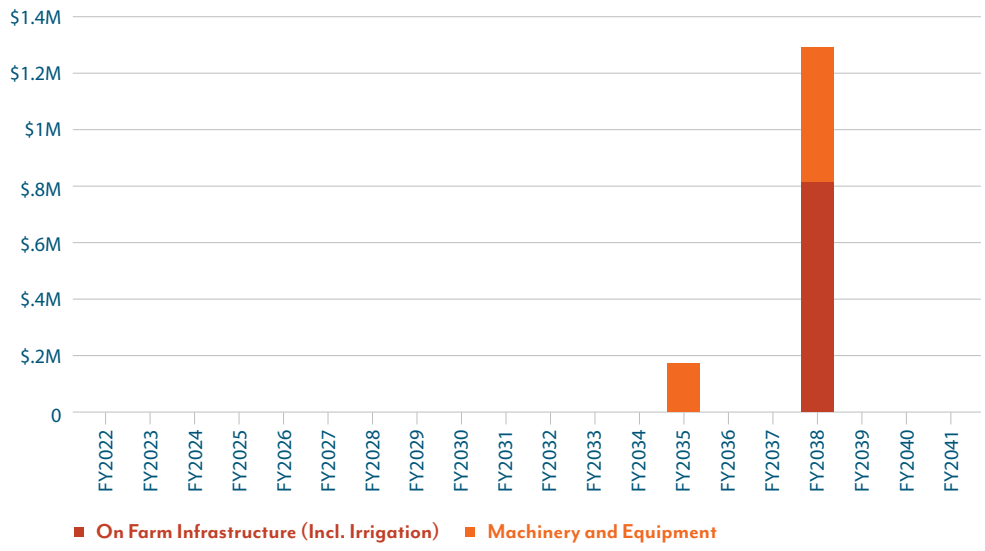
TREE PLANTING COSTS

Planting costs are incurred across spring – September to November. It is assumed mango saplings will be planted across spring in 2024 (FY2025) as the soil will need at least 12 months to rest after clearing. The capital investment associated with planting will also be incurred across this time-period. Based on anecdotal advice, the planting cost will total $584,858 at an estimated $45 per tree. Tree planting can cost up to $90 per tree, depending on the area to be planted and the associated labour and capital costs.

6.4.2 ASSET RENEWAL

As the on-farm infrastructure, general equipment, and the harvesting equipment all have useful lives less than the less than the evaluation period, they will be replaced at the expiration of their useful lives. The replace capital expense is assumed to be consistent with the cost structure and drivers the initial investment. There is an anticipated additional $1.5 million required to maintain operational farm assets over the evaluation period. This expense is show in Figure 6.2.

Figure 6.2. Total Asset Renewal (FY2022 – FY2041)

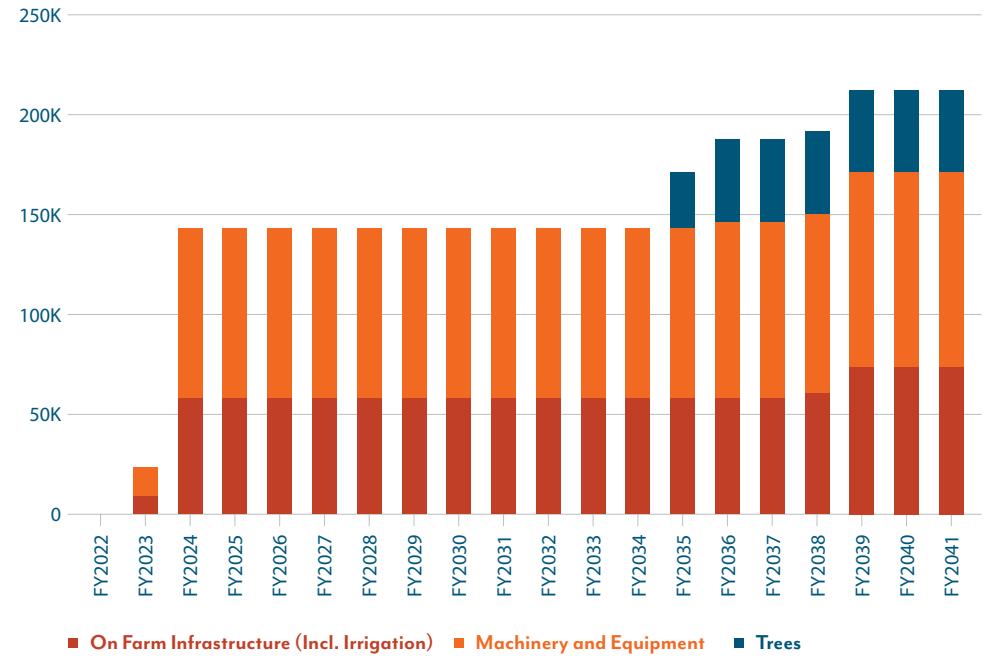


Source: AEC (2022).

6.4.3 DEPRECIATION AND AMORTISATION OF ASSETS

The capital investment required to establish the orchard form the depreciable asset base of the farm. The total depreciation and asset write-off expense over the evaluation period is shown in Figure 6.3.

Figure 6.3. Total Depreciation Expense (FY2022 – FY2041)



Source: AEC (2022).

Treatment of each asset type is outlined in Appendix B.

6.5 SOURCES OF INVESTMENT

Establishment of the Mango orchard require significant investment to cover the capital requirements and the operating shortfall until the trees start bearing harvestable produce. There are number of high-level assumptions, which guide the investment sources as a part of this analysis.

1. The capital investment is assumed to be funded at a notional gearing ratio of 40%. The total capital investment of $4.9 million, $2.0 million is debt funded. This gearing level is the upper band of the target gearing level in the agricultural sector, which usually target between 30% and 40%.
2. Debt repayment can be structured as either interest only or principal and interest, in all outputs present, interest only repayment structure has been assumed.
3. The debt facility only services the initial capital investment (that is, the land and acquisition costs, on-farm infrastructure and equipment and the cost of planting). The debt facility does not cover any operational cash flow shortfall (this is assumed to be covered by equity), nor does it cover any lifecycle capital replacement costs.
   As the debt facility is assumed to not cover any operating cost shortfalls over the evaluation period, these shortfalls are funded through additional equity injections, which increases the total equity invested and decreases the overall gearing ratio of the enterprise.
4. The debt facility is entirely drawn down in the first period of the capital investment. As such, interest is incurred from the first period of development. Interest is assumed to be incurred and paid monthly.

6.6 ORCHARD OPERATIONS

6.6.1 OPERATING STRUCTURE

Modelling of the operations of the example farm assumes the farm will be owner-operated. Labour operating costs of a managed farm will incur a might higher average labour cost. An owner-operated farm spends approximately $3,748/ha on labour, whereas a managed farm requires additional labour expense for the farm manager and will spend approximately $5,567 (in FY2022 real terms).

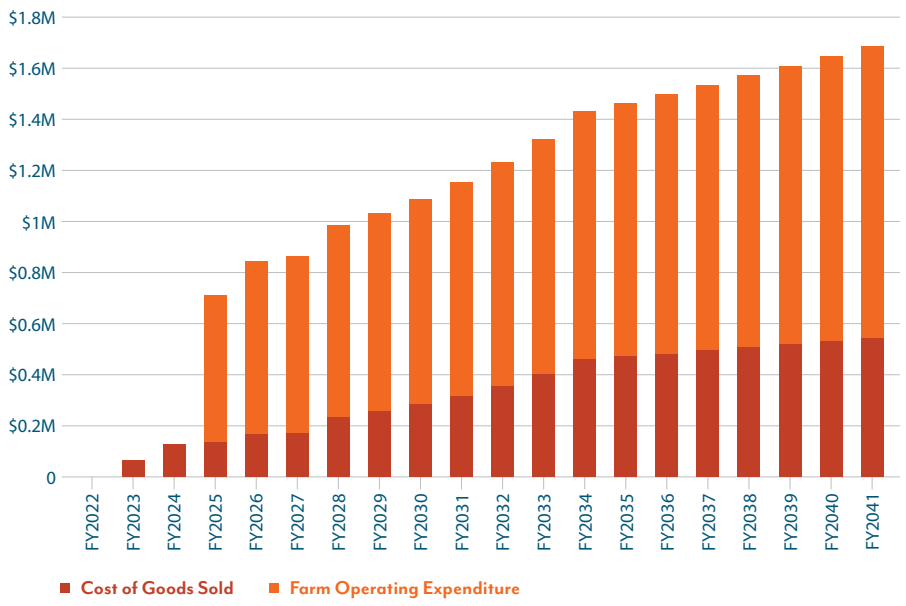
In this analysis it is assumed that the farm manager (the owner) will pay themselves a notional salary on an ongoing basis. Additionally, all positive net profit after tax (NPAT) positions are assumed to be paid out as a dividend to the farm owner (as the farm is an owner-operated enterprise). These dividends are paid out on an annual basis at the end of the financial year.

6.6.2 ORCHARD OPERATING COSTS

Orchard operating costs have been estimated on the basis of labour, non-labour, and overhead costs. Non-labour and overhead costs are escalated using the consumer price index, while the labour costs are escalated using the wage price index. Total operating cost forecast is presented in Figure 6.4 below.

The cost of goods sold (COGS) account for approximately 30.5% of total operating costs once the trees reach maturity. The COGS include costs such as packing, harvesting and materials.

Figure 6.4. Total Operating Costs (FY2022 – FY2041)



Source: AEC (2022).

Each operating cost is forecast based on a set of potential cost drivers – per Ha, per planted Ha, per ML of water used, per tonne or tray produced, or an annual fixed cost. Each operating cost and their cost driver are listed in the following table.

Table 6.6. Operating Costs

Mango Variety	Flavour	Peak Availability
Non-Labour Operating Costs		
Fuel	Trees	1.50
Tractors - R&M	Trees	0.36
Safety and P&E	Trees	1.38
Equipment	Trees	0.36
Irrigation	Trees	0.60
Non-Labour Operating Costs		
Materials - Fertilisers	Trees	5.40
Materials - Fungicides	Trees	1.80
Materials - Insecticides	Trees	4.35
Materials - Herbicides	Trees	0.66
Monitoring Services	Trees	1.35
Cleaning & Bins	Trees	0.30
License Fees & Subscriptions	Trees	0.60
Pest Control	Trees	0.06
Staff Amenities	Trees	0.09
Transport	Tray	1.40
Labour Operating Costs		
Picking	Tray	1.40
Harvesting	Tray	1.40
Packing	Tray	1.75
Employee - Farm Manager	Fixed	120,000
Employee - other	Trees	10.47
Pruning labour	Trees	6.39
Overhead Operating Costs		
Rego & Insurance	Trees	2.51
Marketing Costs	Tray	2.45
Ripening	Tray	1.05
General Overhead	Trees	14.56

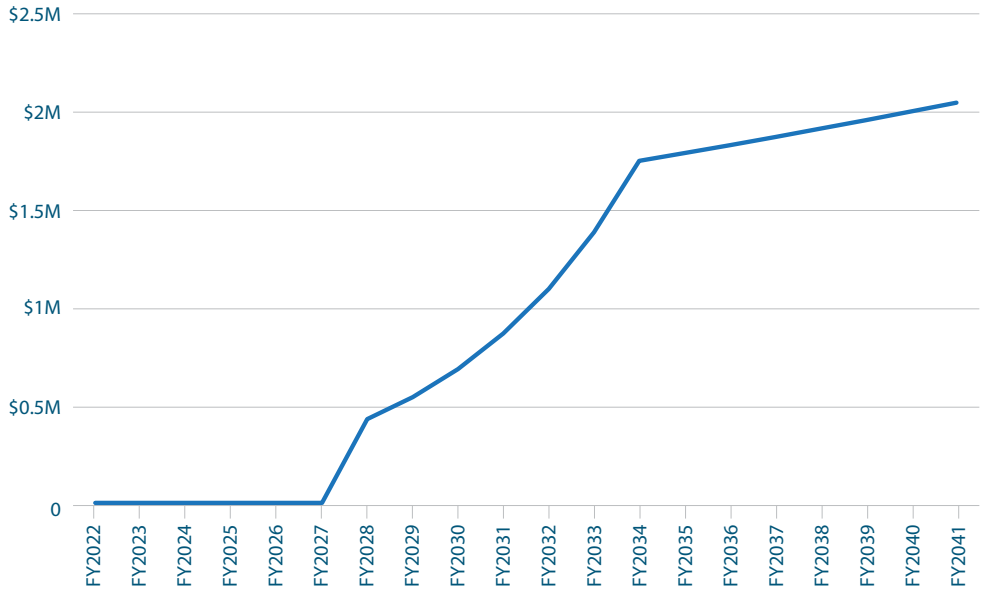
Source: CRCNA (2021), Ngo and Owens (2004). Consultation with the Australian Mango Industry Association, Consultation with Growers.

6.6.3 ORCHARD REVENUE

The orchard revenue consists of the operating income associated with the sale of mangoes, pursuant to the fruit's grade. The grade prices are listed in Table 6.3

The mango orchard will not receive operating revenue until the fifth year of operation, and at a yield of only 15.7 kilograms per tree, the farm will continue to operate at a loss until the tree is producing over 40 kilograms of fruit (ninth year of growth). The increase between FY2028 and FY2034 reflects the rapid increase in yield as the tree approached maturity. The forecast presented below does not consider price changes over time, refer to section 6.7.1 for price sensitivity analysis.

Figure 6.5. 20-year Revenue Forecast (FY2022 – FY2041)



Source: AEC (2022).

For the purpose of analysis, all revenue has been accounted for in the month after which the mangoes are harvested. Landholders will likely experience a different cash flow profile, depending on the terms and conditions of the processor to which they sell.

The revenue does not reflect future potential changes in quality of fruit harvest at the age of the tree increases.

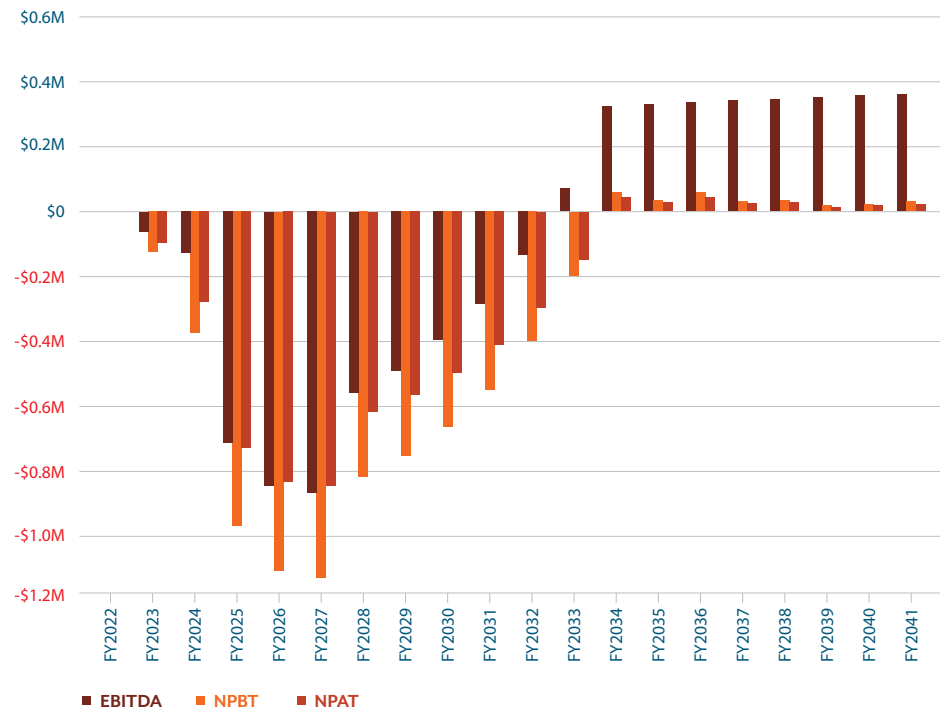
6.7 FINANCIAL FEASIBILITY

The assumed mango orchard in the Rookwood Weir catchment area would be anticipated to reach a positive annual operating position, that is, a positive net profit after tax (NPAT) ten years after orchard establishment, that is FY2034. The positive operating position is estimated to be held for a couple of years before increases in depreciation and asset write-offs increase and undermine the operating position. FY2035 is the year the biological asset write-off (that is, the trees in the orchard) begin being incurred.

The operating breakeven month for the example farm orchard modelled is March 2027 when the average age of the trees is four years old. This shows the price point for mangoes is sufficient to recover the cost of goods sold from the onset of harvesting. The farm will require another five years, and the trees mature to recover all operating costs, show in Figure 6.6.

By FY2041 the NPAT of the orchard is estimated to be $423,577.99. The NPAT profile over the FY2022 to FY2041 shows a stepped stark increase in profitability in FY2033, which indicates the operating profit is highly sensitive to the yield achieved.

Figure 6.6. Orchard Operating Profit (FY2022 – FY2041)



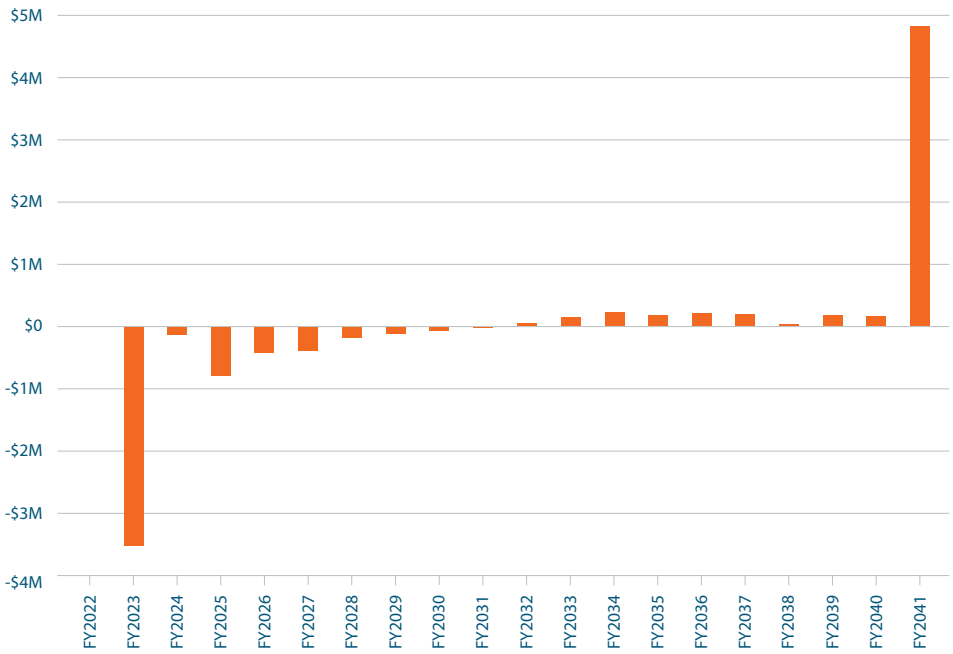
Source: AEC.

Total asset investment over the evaluation timeline shows that while there is significant up-front investment and quite a few years of negative cashflow before an operating profit can be made, an orchard establishment in the Rookwood Weir Catchment Area will ultimately provide a positive financial return to investors. However, this is a long-term investment.

To understand the value of the orchard investment, a discounted cash flow (DCF) has been calculated. This is shown below in Figure 6.7. The discounted cash flows include the terminal value of the farm in the final year of analysis (FY2041). The terminal value represents the value of the business past the evaluation period and is estimated based on the long-term historical growth rate of farmland in Queensland, which is 8.8% (Rural Bank, 2021).

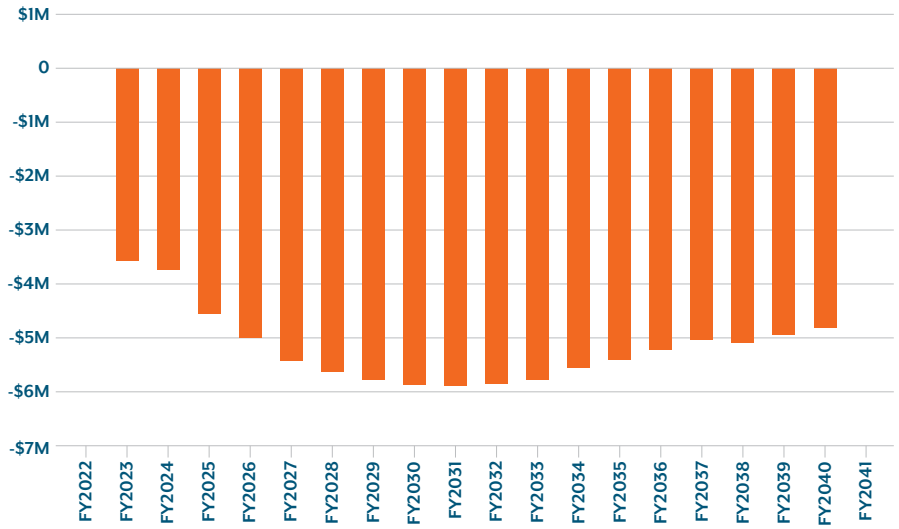
Given the large capital investment, and the periods of no returns (which ultimately increases the required capital investment), the cumulative discounted cash flows do not return a net positive income in the 20-year analysis, without consideration of the terminal value to reflect the future value of the orchard and land improvements at maturity (refer to Figure 6.8 below). Rather, the NPV for the investment is set at $0 to understand the implied internal rate of return, which is estimated to be 11.6%.

Figure 6.7. Discounted Cashflows, Including Terminal Value (FY2022 – FY2041)



Note: Discounted cashflows have been estimated on a 11.6% post-tax discount rate, which is the implied internal rate of return.
Source: AEC.

Figure 6.8. Cumulative Discounted Cashflows, Including Terminal Value (FY2022 – FY2041)



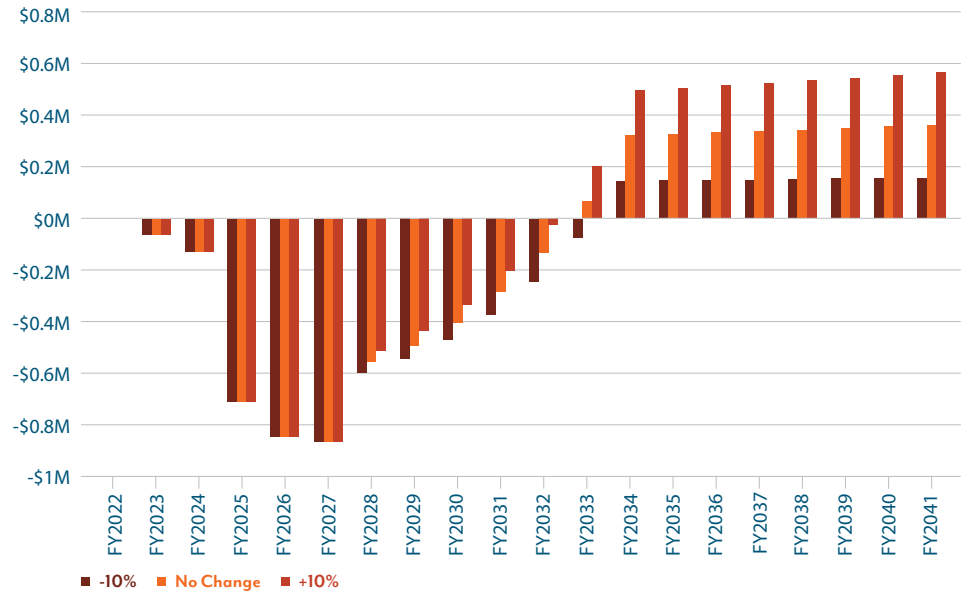
Note: Discounted cashflows have been estimated on a 11.6% post-tax discount rate, which is the implied internal rate of return.
Source: AEC.

6.7.1 SENSITIVITY ANALYSIS
PRICE SENSITIVITY

Historically, mango prices have not been swayed significantly through the global market, as a predominantly domestically produced and consumed product. To account for domestic influences on future mango prices, and to understand how these prices might impact profitability, price sensitivity has been conducted on a plus/ minus 10% basis.

All sensitivities return a profitable position, as per the charted EBITDA below. However, it is noted that a minus 10% price point will likely see a negative NPAT over the evaluation period. As depreciation expense is consistent across the three scenarios (at over $200 thousand by FY2041), the EBITDA under the lowest price point is not sufficient to cover the depreciation expense.

Figure 6.9. Kensington Pride Price Impact on Profitability (FY2022 – FY2041)



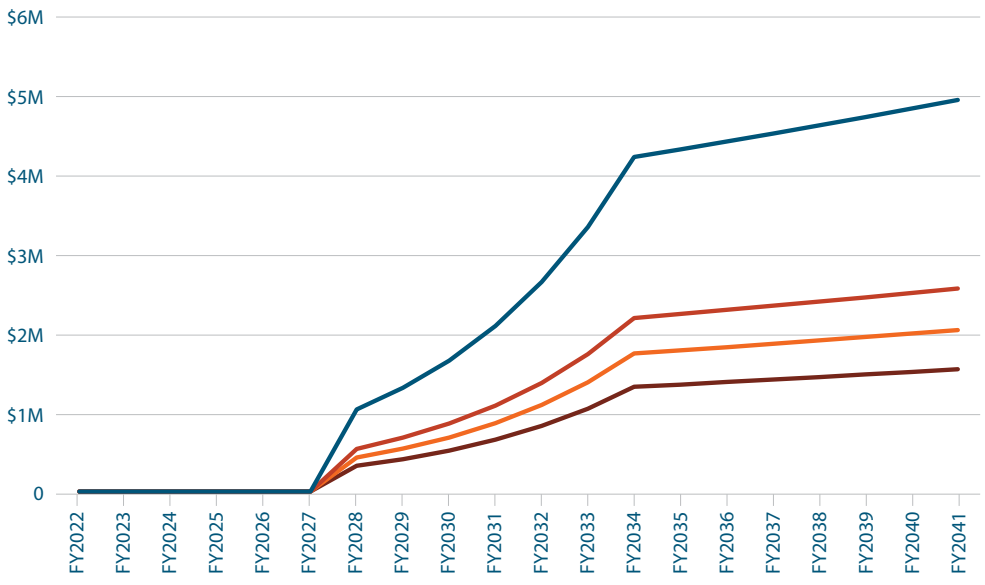
Source: AEC.

WATER SENSITIVITY

Water availability has a relatively linear relationship with the profitability of the example orchard modelled. This is because the majority of operating parameters are contingent on the land available to farm. There are very few operating costs which are not driven by the planted area, which means that as the land available for planting increases, so does the operating expenses. Similarly, there is a direct relationship between land planted and yield of the mango trees.

The variance in revenue is presented in the figure below.

Figure 6.10. Water Availability Impact on Revenue (FY2022 – FY2041)



Source: AEC.

The upfront capital costs will change, with changes to water availability. Any changes to the reliability of water will impact the irrigation, planting, and equipment costs. Whereas changes to the quantity of water available will impact both the irrigation, planting and equipment costs, and the water entitlement costs.

A key limitation in understanding the variation of revenue which could be achieved is there is no assumed loss in orchard establishment timing. In practice, by doubling the available land (such as under the No allocation cap scenario) there will be an increased time required to establish the orchard. This timing will impact the timing of when the trees are planted (and how quickly they are planted) which will ultimately impact yield. This timing is not considered in the sensitivity analysis and would likely result in a lower long term revenue profile as the orchard would have a younger average age of trees.

VARIETY SENSITIVITY

The variety influences tree population, yield per tree, and price per tray. The NPAT has been estimated for each variety, based on the assumptions outlined in Section 6.3, and is shown in Figure 6.11.

Price and yield pay a key role in the commercial success of each variety. Compared to the Kensington Pride, R2E2 and Calypso can grow an additional 35.1% of trees per Ha. Both varieties are expected to produce a fraction of what Kensington Pride can achieve at maturity on a per tree basis, with R2E2 producing 28.6% less and Calypso producing 17.9% less. With a higher tree density for both Calypso and R2E2 and lower yields, Calypso is able to produce a higher total yield, compared to Kensington Pride.

This total calypso yield, is counter balanced by a lower average price point, with the grade one Calypso mango selling for $15.87 per tray, $3.46 less than the Kensington Pride. R2E2 achieve both a lower total yield and a lower price per tray, and as such, is not anticipated to achieve the same profits as a Kensington Pride.

Table 6.7. Variety Production

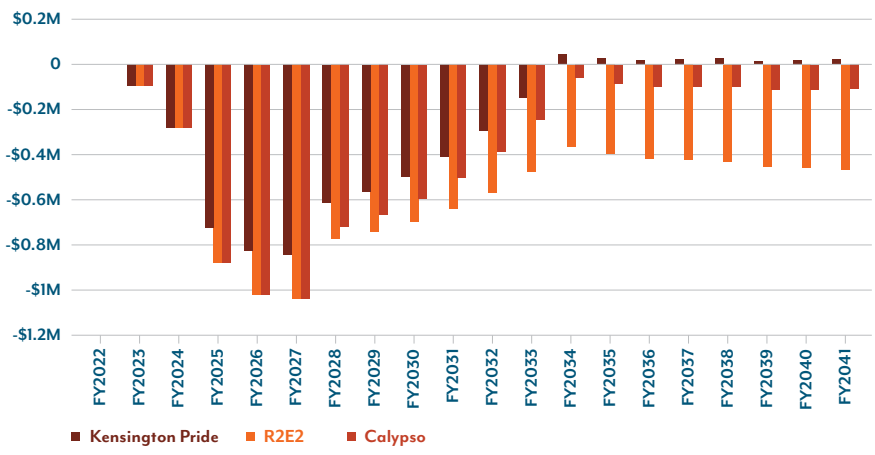
Variety	Total Trees	Total Tonnes Produced	Average Trays Produced Per Tree
Kensington Pride	12,210	683.8	8.0
R2E2	16,500	660.0	5.0
Calypso	16,500	759.0	6.6

Source: AEC (2022).

Operating costs such as levies and marketing and ripening costs are held consistent across all three varieties, however, it's important to note that some varieties may incur different overhead costs. Similarly, the orchard operation and management costs are assumed to remain constant, yet the change in tree density, tree shape, and tree size may require different costs – such as pruning and weed management.

The follow figure shows the NPAT for each variety.

Figure 6.11. Variety Impact on NPAT (FY2022 – FY2041)



Source: AEC.

6.8 ECONOMIC IMPACT

Investment in a mango enterprise will have an economic contribution to Fitzroy region, and more broadly Central Queensland. Economic modelling in this section estimates the economic activity supported by the orchard establishment and operations of the farm.

Input-Output modelling is used to examine the direct and flow-on activity expected to be supported within the Rockhampton local government area (LGA). A description of the Input-Output modelling framework used is provided in Appendix C.

INPUT-OUTPUT MODELLING DESCRIBES ECONOMIC ACTIVITY BY EXAMINING FOUR TYPES OF IMPACTS:

- Output – Refers to the gross value of goods and services transacted, including the costs of goods and services used in the development and provision of the final product. Output typically overstates the economic impacts as it counts all goods and services used in one stage of production as an input to later stages of production, hence counting their contribution more than once.
- Gross product – Refers to the value of output after deducting the cost of goods and services inputs in the production process. Gross product (i.e., GRP) defines a true net economic contribution and is subsequently the preferred measure for assessing economic impacts.
- Income – Measures the level of wages and salaries paid to employees of the industry under consideration and to other industries benefiting from the project.
- Employment – Refers to the part-time and full-time employment positions generated by the economic stimulus, both directly and indirectly through flow-on activity, expressed in full time equivalent (FTE) positions.

The economic contribution of a mango orchard enterprise in the Rookwood Weir Catchment Area is presented in Table 6.8.

Initial capital investment of the orchard is anticipated to cost approximately $3.4 million (in FY2022 Real terms), not including the purchase of land or the purchase of water entitlements (both of which are not contributing factors of the economic impact). Capital investment and operation of the orchard is anticipated to directly contribute to $2.7 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $1.8 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $1.1 million in production induced (i.e. supply chain) activity and $0.7 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

This level of industry activity is estimated to support the following within the Rockhampton LGA:

- A $1.9 million contribution to GRP including $1.1 million directly
- 16 FTE jobs (including 10 FTE jobs directly), paying a total of $1.3 million in wages and salaries ($0.8 million directly).

Table 6.8. Economic Activity Supported by a Mango Orchard Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$2.7	$1.1	$0.8	10
Production Induced	$1.1	$0.4	$0.3	4
Consumption Induced	$0.7	$0.4	$0.2	3
Total	**$4.5**	**$1.9**	**$1.3**	**16**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017), ABS (2020a, b, c and d), AEC.

7. CONCLUSION

Based on an analysis of 2021 sales data (HTW, unpublished), the estimated average land value is approximately $3,800 per Ha. In contrast, moving from non-irrigated land to irrigated agriculture could see value uplift range between $6,200 per Ha and $16,200 per Ha, depending on the commodity and quality of the land and infrastructure. This value improvement provides the foundation for existing regional growers to consider alternative land uses that are either supplementary or complementary to existing operations.

Mango orchards are a long-term investment, with the trees only bearing fruit in the third year after planting (DAF, 1999). The orchards take up to nine years to break-even operationally, depending on maturity and productivity of the trees. Due to the timeframe between orchard establishment and profitability, the long-term outlook of the mango industry is crucial for investment decisions.

The mango industry in Australia has historically been focused on supplying the domestic market, with exports to international countries being relatively opportunistic. A priority for the Australian market is to increase mango exports into the future, growing exports from around 12% of production currently to approximately 20% of production. To achieve this, the Australian Mango Industry Association are currently developing an export strategy which may lead to the identification of new markets which are currently not highlighted in the industry.

Focusing on an investing in the development of Australian mango exports provides positive signs for Australia's future export market. The Rookwood Weir catchment area has the potential to grow up over 18,000 Ha of mango based on constraints imposed by various production factors including slope, soil suitability and expected allocation of 7,500ML under this phase of scheme allocations. As a result of water availability, optimal farm size would around 66 Ha, presenting opportunities for capital efficiency, but also presenting risk.

Water rights have been estimated to range between $1,500 and $2,500, with the recent purchase of 21,600ML by Rural Funds Group, suggesting a price of $1,500 per ML to acquire the permanent entitlement. Details on expected access costs were unavailable at the time of publication, but based on comparable water access charges for the mango sector, the annual access price is expected to be $360 per Ha (i.e. $72 per ML). Actual water demand will be phased and really ramp up after the saplings are planted in the orchard. At 6ML per Ha, efficient water infrastructure and minimising the lift distance will be critical in managing this input cost.

Overall, the analysis demonstrates that mango orchards are an attractive, high-value opportunity for the region's landholders.

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APPENDIX A: MANGO GROWING CONDITIONS

GROWING CONDITIONS

ORCHARD ESTABLISHMENT

Establishing a mango orchard takes careful planning and design to ensure that the final development maximises yield at an efficient cost. Establishing an orchard has been broken down into 5 core components:

- Land Selection: soil type, slope and proximity to water sources
- Environment: temperature variation, rainfall and adverse weather events
- Infrastructure and Service Support: access to support services such as agronomic advisors, inputs and supply chain infrastructure (i.e. processors, transport etc)
- Nursey access: plantings will be dependent on access to grafted seedlings
- Capital Funding: mango trees only start bearing fruit in the third year after planting and reach maturity between the sixth and eighth year after planting (DAF, 1999). Reaching yield maturity could take as long as 10 years in the subtropics (DAF, 1999).

Land suitability is critical for establishing an orchard. The best conditions for growing a mango orchard are listed as follows:

- Soil depth: Mangoes require at least one to two meters of soil (ARGIC, 2017).
- Soil drainage: Mango orchards grow best in well-drained soil that is slightly acidic (ARGIC, 2017).
- Soil texture: Mangoes grow best on light, well-drained soils. It is best when these soils are relatively low fertility as highly fertile soils lead to the development of poor fruit colour (DAF, 1999).
- Optimum slope: With mango orchards, slopes between 1% and 15% are desirable to minimise soil erosion. Slopes that are greater than 15% provide an increase in risk for erosion and can provide difficulties for safety operating machinery (DAF, 1999).

ENVIRONMENT

As stated previously, mangoes are both a tropical and subtropical tree and are grown in nearly any warm climate around the globe. When choosing a site for mangoes, they grow best in warm wet summers which are followed by a cool dry winter and spring (DAF, 1999). It is important to note that periods of “heavy frost can kill trees but damage from light frosts on young trees may not be notice for several months” (DAF, p.9 1999).

Additionally, when choosing a site of a mango orchard, it must be noted that temperatures below 12 degrees Celsius during the flowering period (July to August) can affect the pollination of the fruit, resulting in a mango without a seed.

In Queensland, mango production is most suited to the environment in (DAF, 1999):

- The coastal dry tropics between Bowen and Townsville
- Drier areas of Atherton Tablelands and Rockhampton
- Drier areas of south Queensland.

Irrigated mango trees can tolerate temperatures up to 48 degrees Celsius without significant damage to the orchard (AGRIC, 2017). However, if temperature remain excessive for prolonged periods and is combined with low humidity then the fruit can become sun-damaged and drop (AGRIC, 2017). Generally mature mango trees can tolerate a multitude of climate ranges, spanning from warm to tropical.

WATER REQUIREMENTS

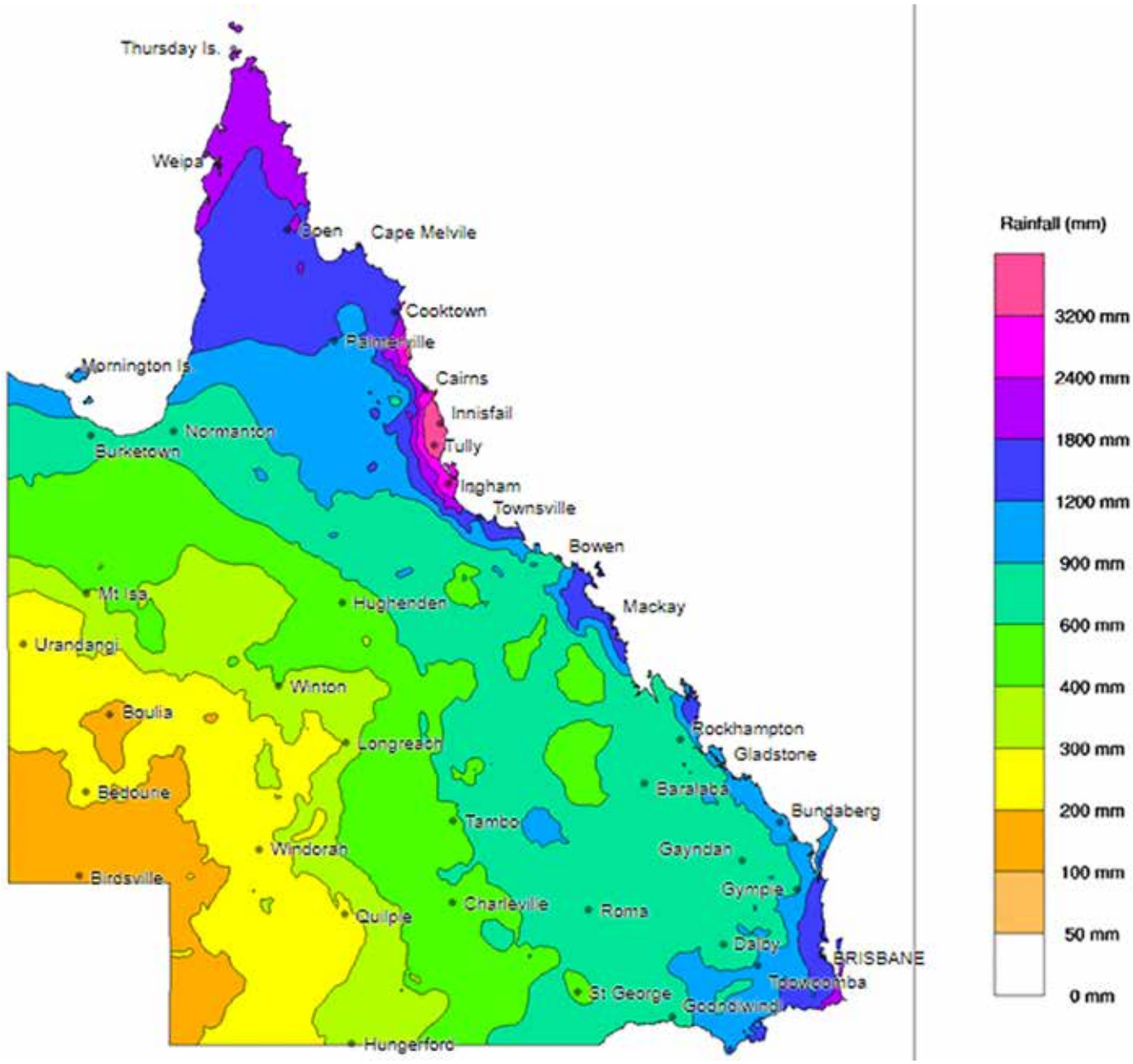
When considering a site for mango production, the Department of Agriculture and Forestry have highlighted that irrigating a mango orchard from flowering to harvest (from July to December depending on location and variety) significantly increases fruit size and set (DAF, 1999).

In the dry tropics in Queensland, fruit growth peaks during November to December which is also the hottest period throughout the year. During these periods of hot weather, it is expected that mature trees will require up to 1,500 litres of water per week (DAF, 1999). The Department of Agriculture and Forestry have highlighted that north Queensland requires around 6 mega litres (ML) of water per Ha throughout the year, while central and southern Queensland will require less (DAF, 1999).

ROOKWOOD WEIR CATCHMENT AREA

Throughout 2021, it was estimated that the Rockhampton region and more specifically, the Rookwood Weir catchment area, has experienced approximately 600mm of rainfall (refer to the figure below). This volume is in line with the 30-year average annual rainfall for the region, spanning from 1981 to 2010.

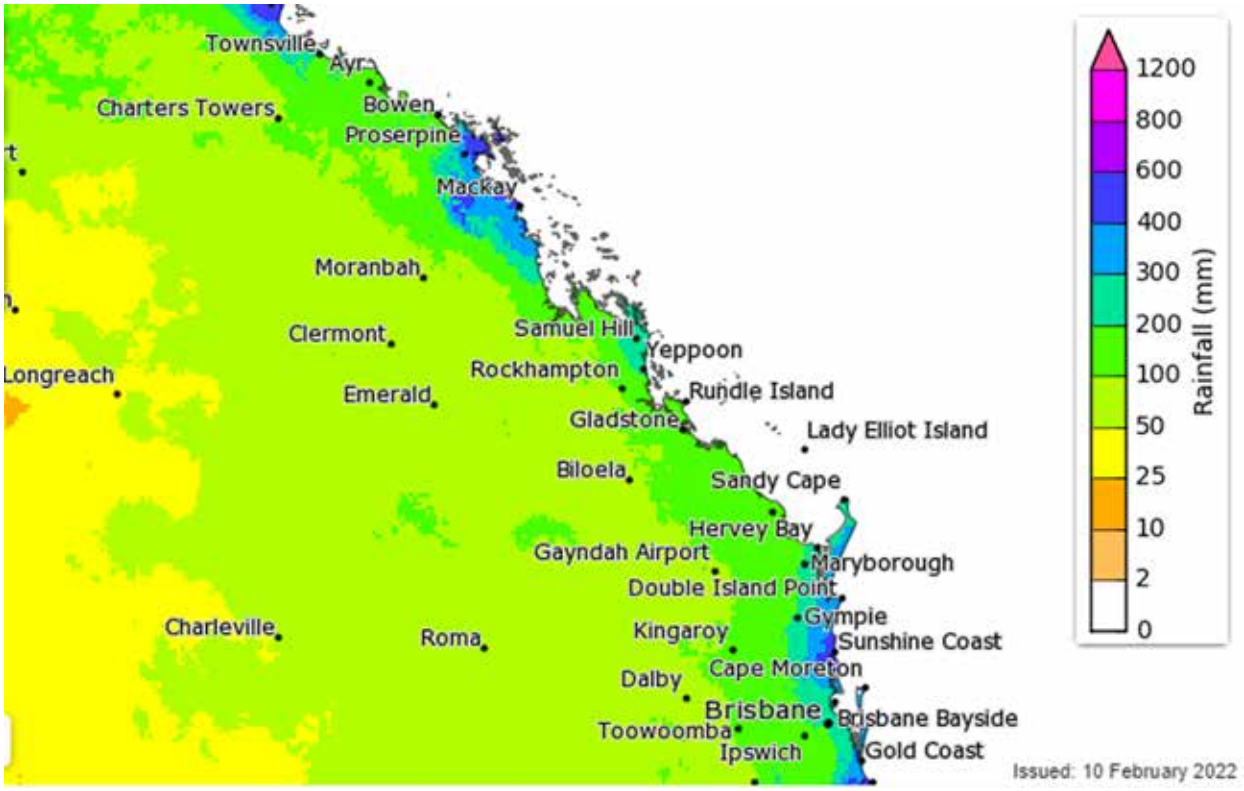
Figure A. 1. Rainfall Map Queensland, 2021



Note: Map highlights the rainfall totals for 12 months from January 2021 to December 2021.
Source: BOM (2022a).

Looking at the future rainfall forecast from the Bureau of Meteorology, the Rockhampton region is expected to receive around 100mm of rainfall between the months of March to May 2022. The figure below provides an indication on the outlook for the region.

Figure A.2. Climate Outlook, March to May 2022



Note: Totals that have a 75% chance of occurring for March to May.
Source: BOM (2022b).

PLANTING

Historically older mango orchards were planted at wider spacings of around 70 to 100 trees per Ha. However, orchard management practices have since changed with trees being kept smaller which allows them to be planted closer together.

Smaller trees do not provide as much yield per tree as larger trees, however the orchard is able to have a greater volume of trees per Ha. The smaller trees, although must be pruned regularly, are easier and cheaper to manage and harvest (DAF, 1999).

It is important to ensure the trees are planted wide enough to allow for machinery access and sunlight exposure. Ideally, the trees should have their canopy slightly touching or with a small gap in between to allow for air movement throughout the canopy (DAF, 1999). Tree spacing will vary with the different varieties as highlighted in the table below.

Table A. 1. Tree Spacing

Variety	Row Spacing (m)	Tree Spacing (m)	Trees per Ha
Kensington Pride	9-10	6-9	111-185
R2E2	7-9	4-6	185-357
Keitt	6-8	3-6	208-555
Palmer	7-9	4-6	185-357
Kent	7-10	4-8	125-357
Nam Doc Mai	9	4-6	185-278

Source: DAF (1999).

The average yield of a mature tree is estimated to total 70 kilograms of mangoes per year, assuming the orchard is heavily pruned and not allowed to exceed 4.5m in height (DAF, 1999). Mango trees will begin to bear fruit in the third year after planting, where yields can total up to 10 kilograms of mangoes per tree.

Table A. 2. Mango Yields (Kensington Pride)

Tropics		Subtropics	
Age (years)	Kilograms per tree	Age (years)	Kilograms per tree
0-4	0-10	0-3	0
5-8	10-120	5-10	20
8-12+	20-200	10+	35-70

Source: DAF (1999).

The table below provides an additional breakdown of yield by variety by tree.

Table A. 3. Yield by Variety & Tree Age

Variety	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Average Mature Tree
Kensington	6	19	32	45	57	70	70
Irwin	8	27	47	66	85	105	110
R2E2	0	11	22	33	44	55	71
Haden	3	12	21	30	39	48	104
Keitt	0	14	28	42	56	70	107
Kent	2	6	10	15	19	23	69

Source: International Tropical Fruits Network (2016).

ORCHARD MANAGEMENT

It is important build a strong healthy tree throughout the early stages of the mango trees life. These key steps include fertilising, watering, training and pruning, control flowering, control weeds and apply mulch, control pests and disease and prevent frost damage (DAF,1999). Once the mango trees begin to bear (around the third year of planting) the aim is to provide high quality and highly coloured fruit. To provide the high-quality commercial fruit, sound management practices are required (see figure below).

The table below provides a summary of orchard management methods, for a more detailed breakdown refer to the DAF information kit (DAF, 1999).

Table A. 4. Managing Mango Trees

Stage	Description
Young Tree Management	
Fertilising	After planting the trees, it is important to not apply fertiliser until the mango trees have started to grow and the first flush has started to harden. Fertiliser should be applied in a ring around the young tree, no closer than 20cm to the trunk.
Watering	Mango trees are considered drought-hardy; however, they still require a regular water supply especially when they are young. Water supply varies with different soil types, with an indication of water requirements per week provided below: • May to August: Year 1 (20 litres), year 2 (100 litres), year 3 (200 litres) • September to April: Year 1 (50 litres), year 2 (250 litres), year 3 (350 litres) Mango orchard irrigation is best suited for mini-sprinklers so water can be kept off the foliage
Training and pruning	Pruning is required to develop a strong framework with several branches. The more branches are important as it increases the potential yield of the tree

Stage	Description
Control flowering	Mango trees should not be allowed to produce fruit until after the second or third year of growth. If flowering occurs before this time, growers should let the flowers develop and set small fruit first before they are cut. This prevents re-flowering.
Control weeds and apply mulch	Weeds are best controlled by mulching (coarse hay or straw such as sorghum) or by applying herbicide. Mulching is largely used for younger trees, usually applied during the later winter.
Young Tree Management	
Control pests and diseases	The main pests for mango trees include tip borer, mango shoot, caterpillar, leaf miner, fruit spotting bug and mango scale. Some key diseases include anthracnose, bacterial black spot and mango scab on young leaves during growth flushes.
Prevent frost damage	Frost can kill young trees, however damage may not show up until several months after the damage was inflected. Trees can be protected from frost through protective installation materials at the planting stage.
Bearing Tree Management	
Fertilising	At the time of bearing, too much fertiliser that is applied at the wrong time can affect the quality of fruit. Application of nutrients include: • Nitrogen & potassium: applied after harvesting and at the end of the wet season, with a small amount before flowering. Extra potassium can be applied during active fruit development • Phosphorous: applied at anytime • Calcium, magnesium and boron: applied after harvest • Micro-nutrients: applied as foliar spray on young developing foliage
A general fertiliser program	Requirements will differ according to soil type, irrigation, rainfall, climate, cropping history and tree size (refer to the DAF information kit for further information)
Watering	The most crucial time for watering is from floral bud break to just before harvest. Water supply is also important for postharvest flush, after which has occurred, withholding water will support the trees through a dormant phase.
Pruning and canopy management	There must be a balance between fruit bearing potential efficient orchard management. Pruning can support a canopy which is small enough to pick easily and has multiple fruiting terminals.
Propping fruiting branches	If branches start to hang low from the weight of the fruit, stakes about 1m long can be tied to support the branch. This will support a decrease in blemishes and rots from being on the soil.
Growth regulators	For canopy management, chemical growth regulators can be used to induce flowering. Trees which are treated have the potential to flower up to three weeks earlier than trees which are untreated.
Pollination and fruit set	Poor fruit set largely stems from poor pollination. Cooler temperatures promote strong flowerings, however the fruit often fails to set due to low pollen viability or embryo death in early stages of development. In cooler locations (subtropics) the encouragement of late flowering during warmer months can improve fruit set.
Pest and disease management	Both wind and insects are key to pollinating mangoes, with the most effective insects including wasps, bees and large flies.
Insect and mite pests	Key components of pest and disease management include: • Pruning to allow sprays into the canopy • Ensure correct volume of spray and even coverage • Regular monitoring • Knowledge of pesticides
Diseases	Largely, disease control requires routine preventative spraying for protection from infection.
Fruit disorders	Some common disorders include internal breakdown, stem-end cavity, jelly seed and soft nose. It is important to pick the fruit as soon as they are matured to decrease the possibility of breakdown problems.
Vertebrate pests	These pests are commonly birds and fruit bats, however most growers do not need to control these pests (depending on seasonal conditions and location of the orchard).
Bagging fruit	Bagging protects the fruit against sunburn, diseases, blemishes, and producers an even fruit colour and blush. However, this method can cause a build up of pests if control measures are not put into place. This method is labour intensive and largely only feasible on small orchards with high quality fruit.

Stage	Description
Weed control and mulching	It is important to continue mulching and spraying the orchard as required.

Source: DAF (1999).

HARVESTING

Harvesting, packing and delivery to the market occurs before the mango ripens and becomes too soft. Because harvesting occurs when the mango is in a green mature state, it is important to recognise when the mango has become fully mature.

Mangoes can be damaged through handling and by contact with the mango sap. The sap is caustic and results in sap burn if it touches the skin of the mango, which will decrease fruit from Class 1 to Class 2, reducing the value of the fruit. There are two harvesting systems:

- To prevent sap release, the fruit is cut off the tree with 10 to 20 cm of stem still attached. The mangoes are transported to a shed where they are treated (either dipped or sprayed) with a solution of detergent or wetting agent before destemming the fruit by hand.
- De-sapping can occur when harvesting the trees through harvest aids, which could significantly reduce costs. The harvest aid includes a water bath to remove the sap, with the mango being rinsed off before being transported to a packing shed.

The table below provides the approximate maturity times for Kensington Pride, R2E2 and Keitt in Central Queensland. For Kensington Price mangoes, harvest times occur towards the end of December to January.

Table A. 5. Maturity Times

Variety	Central Queensland Maturity
Kensington Pride	Late to December to late January
R2E2	Early to mid-January to mid-February
Keitt	Mid-February to early March

Source: DAF (1999).

POST-HARVEST PROCESSING ACTIVITIES

After mangoes have been harvest, they are delivered to mango packing sheds located on farm to go through a sequence of operations. Throughout the packing line process, it is important to ensure mango bruising and abrasion is minimised. The equipment in the packing shed should be cleaned daily, while areas which are prone to collect direct and sap should be cleaned twice daily. The remaining post-harvest processing activities include (DAF, 1999):

- Treating fruit with a hot dip: For stem-end rot and anthracnose control, it is required to immerse the fruit for five minutes in a heated solution at 52 degrees Celsius.
- Treating fruit with a flood spray: A non-recirculating spray with prochloraz at ambient temperatures can also be used to control anthracnose.
- Treating for fruit fly: Insecticide dips are a common form for treating fruit fly. Treatments may include a dip (immersing the fruit for a minute), a flood spray or a low volume non-recirculated spray.
- Drying and brushing fruit: After post-harvest treatments, fruit must be dried before packing otherwise the fruit will be impacted by skin browning. After the fruit has been dried, it is normally brushed to give a brighter appearance.
- Grading: Fruit is graded depending on the level of blemish and any visible defects on the fruit (i.e., cuts, bruises, disorders or fruit rots). Mango grades include Premium, Class one and Class two.
- Sizing: Fruit is sized before packaging, normally mechanically using a weight grader.
- Packing and labelling: Mangoes for the domestic market are largely packed in seven kilogram packages, while fruit for export may be packed in smaller five kilogram cartons (i.e., mangoes exported to the US).
- Temperature management: It is important to understand the period from harvest to consumer, providing control over the shelf life of the fruit. For effective cooling, mangoes must be placed into a cool room at 18 to 22 degrees Celsius.
- Transport: For Australian mangoes in the international market, transport of the fruit is usually by air freight. Although air freight is an expensive option, it is also the most viable for ensuring quality product is delivered to the market.

Mangoes are usually ripened at the end market by ethylene gas to trigger the process.

APPENDIX B: FINANCIAL MODELLING APPROACH AND ASSUMPTIONS

The key modelling conventions used as a part of this analysis are detailed below. These conventions have been adopted to ensure consistency of treatment across all commodities evaluated.

EVALUATION TIMELINE

The financial and commercial evaluation spans a period of 20 financial years, starting from FY2022. All base cost assumptions used in the financial model are in Real FY2022 terms and have been escalated accordingly, across the timeline. The mango farm modelling assumes the farm establishment (after award of Rookwood Weir water allocation) will begin from 1 January 2023.

ESCALATION

A number of guiding financial assumptions underpin the financial analysis, such as the Consumer Price Index (CPI) and Wage Price Index (WPI). These assumptions are detailed in Table 7.1. All costs presented in the following sections are in nominal terms (i.e., accounts for inflation), unless otherwise stated.

Table 7.1. Escalation Rates

Variety	Central Queensland Maturity	Central Queensland Maturity
Consumer Price Index	1.75%	FY2022
	1.75%	FY2023
	2.00%	FY2024
	2.25%	Long-term Rate
Wage Price Index	2.25%	FY2022
	2.25%	FY2023
	2.50%	FY2024
	2.50%	Long-term Rate

Source: Queensland Treasury (2021)

DEPRECIATION AND AMORTISATION OF ASSETS

The depreciation/amortisation treatment of each asset type is as follows:

- Land and water entitlements – These assets are non-depreciable assets (ATO, 2021b). Water entitlements, as with land values, can appreciate or decline in value over time. The appreciation of water entitlements is dependent on a number of factors, such as seasonal and whether events. Any changes in the value of land or water entitlements have not been considered in the financial analysis and may provide an upside benefit to landholders.
- Irrigation system – The irrigation system is treated as a single asset in this analysis. It is depreciated on a straight-line basis, with a useful life of 15 years and a residual value of zero. The useful life applied is blended useful life of irrigation and pump systems pursuant to the ATO (2022) guidelines. This asset is depreciated in the first period after the completion of installation, that is, the first instance of depreciation for the irrigation system is May 2023.
- Storage and general farm equipment – These assets are not distinguished on a cost basis between built infrastructure and purchased machinery and equipment. In modelling the depreciation of this asset group, the total asset value has been depreciated on a straight-line basis with a residual value of zero. A notional 30-year useful life has been applied, to factor in the longer useful lives of built infrastructure (such as the sheds) and the shorter useful lives of mechanical machinery and equipment. The first incurrence of deprecation of this asset group is May 2023.
  A key defining feature of this group of assets is that without distinct asset list, the entire asset group is depreciated. This means any individual assets within this group which would fall within the taxable write-off threshold of $150,000 (assuming the 2021 taxation rules are the status quo for the forecast years) have been ignored (ATO, 2021a).
- Trees – As a horticultural asset, trees decline in value over their effective life (ATO, 2016). The declining value applies only to the capitalise value of establishing the plant, meaning the land, and the process of clearing land are not included in the asset value. The effective life of a horticultural plant typically begins at maturity and lasts until decline. For mango trees, this effective life for tax purposes often approximately 30 years. The ATO provides a schedule of annual write-off value, as a percentage of capitalised value. With an effective life of 24 years, the annual write off for a mango tree is 7%.

Some required assets can be depreciated at an accelerated rate for tax purposes. In this analysis, a straight-line depreciation rate has been applied and any consideration to asset write-offs or accelerated depreciation has not been considered. This places a limitation on the interpretation of the financial outlook and may not be reflective of individual circumstances.

APPENDIX C: INPUT-OUTPUT METHODOLOGY

INPUT-OUTPUT MODEL OVERVIEW

Input-Output analysis demonstrates inter-industry relationships in an economy, depicting how the output of one industry is purchased by other industries, households, the government and external parties (i.e. exports), as well as expenditure on other factors of production such as labour, capital and imports. Input-Output analysis shows the direct and indirect (flow-on) effects of one sector on other sectors and the general economy. As such, Input-Output modelling can be used to demonstrate the economic contribution of a sector on the overall economy and how much the economy relies on this sector or to examine a change in final demand of any one sector and the resultant change in activity of its supporting sectors.

The economic contribution can be traced through the economic system via:

- Initial stimulus (direct) impacts, which represent the economic activity of the industry directly experiencing the stimulus.
- Flow-on impacts, which are disaggregated to:
  - Production induced effects (type I flow-on), which comprise the effects from:
    - Direct expenditure on goods and services by the industry experiencing the stimulus (direct suppliers to the industry), known as the first round or direct requirements effects.
    - The second and subsequent round effects of increased purchases by suppliers in response to increased sales, known as the industry support effects.
  - Household consumption effects (type II flow-on), which represent the consumption induced activity from additional household expenditure on goods and services resulting from additional wages and salaries being paid within the economic system.

These effects can be identified through the examination of four types of impacts:

- Output – Refers to the gross value of goods and services transacted, including the costs of goods and services used in the development and provision of the final product. Output typically overstates the economic impacts as it counts all goods and services used in one stage of production as an input to later stages of production, hence counting their contribution more than once.
- Gross product – Refers to the value of output after deducting the cost of goods and services inputs in the production process. Gross product (e.g., GRP) defines a true net economic contribution and is subsequently the preferred measure for assessing economic impacts.
- Income – Measures the level of wages and salaries paid to employees of the industry under consideration and to other industries benefiting from the project.
- Employment – Refers to the part-time and full-time employment positions generated by the economic shock, both directly and indirectly through flow-on activity, and is expressed in terms of FTE positions.

Input-Output multipliers can be derived from open (Type I) Input-Output models or closed (Type II) models. Open models show the direct effects of spending in a particular industry as well as the indirect or flow-on (industrial support) effects of additional activities undertaken by industries increasing their activity in response to the direct spending.

Closed models re-circulate the labour income earned as a result of the initial spending through other industry and commodity groups to estimate consumption induced effects (or impacts from increased household consumption).

MODEL DEVELOPMENT

Multipliers used in this assessment are derived from sub-regional transaction tables developed specifically for this project. The process of developing a sub-regional transaction table involves developing regional estimates of gross production and purchasing patterns based on a parent table, in this case, the FY2019 Australian transaction table (ABS, 2021a).

Estimates of gross production (by industry) in the study areas were developed based on the percent contribution to employment (by place of work) of the study areas to the Australian economy (ABS, 2012; ABS, 2017; ABS, 2021b; DoESE, 2021), and applied to Australian gross output identified in the 2018-19 Australian table.

Industry purchasing patterns within the study area were estimated using a process of cross industry location quotients and demand-supply pool production functions as described in West (1993).

Employment estimates were rebased from FY2019 (as used in the Australian national Input-Output transaction tables) to current year values using the Wage Price Index (ABS, 2021c).

MODELLING ASSUMPTIONS

The key assumptions and limitations of Input-Output analysis include:

- Lack of supply-side constraints – The most significant limitation of economic impact analysis using Input-Output multipliers is the implicit assumption that the economy has no supply-side constraints so the supply of each good is perfectly elastic. That is, it is assumed that extra output can be produced in one area without taking resources away from other activities, thus overstating economic impacts. The actual impact is likely to be dependent on the extent to which the economy is operating at or near capacity.
- Fixed prices – Constraints on the availability of inputs, such as skilled labour, require prices to act as a rationing device. In assessments using Input-Output multipliers, where factors of production are assumed to be limitless, this rationing response is assumed not to occur. The system is in equilibrium at given prices, and prices are assumed to be unaffected by policy and any crowding out effects are not captured. This is not the case in an economic system subject to external influences.
- Fixed ratios for intermediate inputs and production (linear production function) – Economic impact analysis using Input-Output multipliers implicitly assumes that there is a fixed input structure in each industry and fixed ratios for production. That is, the input function is generally assumed linear and homogenous of degree one (which implies constant returns to scale and no substitution between inputs). As such, impact analysis using Input-Output multipliers can be seen to describe average effects, not marginal effects. For example, increased demand for a product is assumed to imply an equal increase in production for that product. In reality, however, it may be more efficient to increase imports or divert some exports to local consumption rather than increasing local production by the full amount. Further, it is assumed each commodity (or group of commodities) is supplied by a single industry or sector of production. This implies there is only one method used to produce each commodity and that each sector has only one primary output.
- No allowance for economies of scope – The total effect of carrying on several types of production is the sum of the separate effects. This rules out external economies and diseconomies and is known simply as the "additivity assumption". This generally does not reflect real world operations.
- No allowance for purchasers' marginal responses to change – Economic impact analysis using multipliers assumes that households consume goods and services in exact proportions to their initial budget shares. For example, the household budget share of some goods might increase as household income increases. This equally applies to industrial consumption of intermediate inputs and factors of production.
- Absence of budget constraints – Assessments of economic impacts using multipliers that consider consumption induced effects (type two multipliers) implicitly assume that household and government consumption is not subject to budget constraints.

Despite these limitations, Input-Output techniques provide a solid approach for taking account of the inter-relationships between the various sectors of the economy in the short-term and provide useful insight into the quantum of final demand for goods and services, both directly and indirectly, likely to be generated by a project.

In addition to the general limitations of Input-Output analysis, there are two other factors that need to be considered when assessing the outputs of sub-regional transaction table developed using this approach, namely:

- It is assumed the sub-region has similar technology and demand/ consumption patterns as the parent (Australia) table (e.g. the ratio of employee compensation to employees for each industry is held constant).
- Intra-regional cross-industry purchasing patterns for a given sector vary from the national tables depending on the prominence of the sector in the regional economy compared to its input sectors. Typically, sectors that are more prominent in the region (compared to the national economy) will be assessed as purchasing a higher proportion of imports from input sectors than at the national level, and vice versa.

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